INDUSTRIAL ENGINEERING AND MANAGEMENT

With an Appendix Introducing 'ISO 9000 Quality Systems'

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PREFACE

In a society, which is producing more technically qualified persons, *newer* materials, complex products and more information than ever before, Systematic and Organised Approach in every discipline, is indispensable to meet the challenge of complexity. A large industry or business organization cannot rely on 'Rules of Thumb' or 'Trial and Error' methods of judgement. The optimum operation of any Industrial organisation demands its staff to share the Administrative and Technical responsibilities efficiently and effectively.

Keeping the above facts in view, the book covers various topics of Industrial Engineering and Management with special emphasis on comparatively latest techniques, *i.e.* Systems Concept, Value Analysis, Operations Research, Network Analysis, Work Study, Computers, Business and Environment, Professional and Business Ethics, Management Information Systems, Group Technology, etc.

This revised edition of the book with its 39 chapters covers almost the complete syllabus of subjects such as *Industrial Engineering, Production Management, Management Science etc.*, being taught in various Universities and Engineering Institutes.

As such, this book will be of considerable value to both Practising Engineers and the Engineering Students.

New Year
Jan 1, 1999

Dr. O.P. Khanna
Faridabad

PUBLISHER'S NOTE

If this book does not cover any portion of your syllabus, please write to the Publisher/ Author.

Other useful books by Dr. O.P. Khanna

PRODUCTION TECHNOLOGY — Vol. I

Contents: (1) Introduction (2) Engineering Metals and Alloys (3) Heat Treatment Processes (4) Testing of Materials (5) Surface Cleaning (6) Finishes and Coatings (7) Painting (8) Plastics (9) Wood Working Machines (10) Foundry (11) Welding (12) Fasteners (13) Adhesive Bonding (14) Powder Metallurgy (15) Mechanical Working of Metals (16) Smithy and Forging (17) Metal Spinning (18) Fundamentals of Metal Forming (19) Metal Forming Processes (20) Press Work (21) Rolling (22) Extrusion (23) Drawing of Rods, Wires and Tubes (24) High Velocity Forming of Metals (25) Pipe and Tube Manufacture (26) Typical Examination Problems.

PRODUCTION TECHNOLOGY — Vol. II

Contents: (1) Introduction to Machine Tools (2) Kinematics of Machine Tools (3) Metal Sawing (4) Lathe (5) Turret, Capstan and Automatic Lathes (6) Shaping Machine (7) Slotting Machine (8) Planning Machine (9) Drilling and Reaming (10) Boring (11) Milling Machine (12) Gear Manufacturing (13) Broaching (14) Grinding Machine (15) Surface Finishing Processes (16) Metrology (17) Jigs and Fixtures (18) Newer Machining Processes (19) Automation and Transfer Machines (20) Numerical Control of Machine Tools (21) CAD/CAM, FMS and CIMS (22) Robotics (23) Testing of Machine Tools (24) Installation of Machine Tools (25) Machine Tool Vibrations (26) Machining of Plastics and Ceramics (27) Thread Manufacturing (28) Tool Making and Die-Sinking Machines (29) Automatics (30) Theory of Metal Cutting (31) Tool Wear and Machinability (32) Press Tool Design (33) Cutting Tool Design (34) Machine Tool Design (35) Machine Tool Maintenance (36) Repair of Machine Tools (37) Advanced Manufacturing Systems (38) Economics of Machining.

ENGINEERING MATERIALS & MATERIAL SCIENCE

Contents: (1) General (2) Structure of Metals and their deformation (3) Ferrous Materials (4) Non-ferrous Materials (5) Metallurgical Considerations (6) Identification of Metals and Alloys (7) Testing of Metals and Alloys (8) Selection, Specification, Forms and Availability of Materials. (9) Fundamentals of Heat Treatment (10) Plastic Materials (11) Insulating Materials (12) Ceramic Materials (13) Miscellaneous Materials.

WORK STUDY

Contents: (1) Introduction (2) Method Study (3) Work Measurement (4) Production and Work Study (5) Engonomics (6) Health and Occupational Safety (7) Job Evaluation and Merit Rating (8) Wage Payment Plans for Direct and Indirect Workers (9) Plant Layout (10) Material Handling (11) Organisation and Training of Work Study Department and its Place in the Organisation of an Enterprise (12) Work Content of a Job and Management Techniques to Reduce Work Content and Inefficient Time. (13) The Human Content of Work Study (14) Statistical Aids to Work Study (15) Measurement of Indirect Work (16) Value Analysis and Value Engineering (17) O & M (18) Question Bank.

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SHEETAL GAUTAM

1

Industrial Engineering and Management Science

1.1. CONCEPT OF INDUSTRIAL ENGINEERING

- The American Institute of Industrial Engineers (AIIE) has *defined* the special field of industrial engineering as

  "Concerned with the *design, improvement* and *installation of integrated systems* of people, materials, equipment and energy.

  It draws upon *specialized knowledge* and skill in the *mathematical, physical* and *social sciences* together with the principles and methods of *engineering analysis* and *design* to specify, predict and evaluate the results to be obtained from such systems".

  Industrial Engineering is engineering approach to the detailed analysis of the use and cost of the resources of an organisation. The main resources are men, money, materials, equipment and machinery. The Industrial Engineer carries out such analysis in order to achieve the objectives (to increase productivity, or profits, etc.) and policies of the organisation. An Industrial Engineer's techniques go beyond the mechanical cost factor. He is associated with organization structure, administrative techniques, human (labour) problems and at the same time he understands the relationship between efficiency and consent (of the working group).
- Essentially, the industrial engineer is engaged in the *design of a system* and his function is primarily that of *management.*
- If industrial engineer had to focus on only one concept to describe his field of interest and objective, it would have to be *productivity improvement.*

Productivity improvement implies: (i) a more efficient use of resources, (ii) less waste per unit of *input* supplied, (iii) higher levels of output for fixed levels of input supplied and so on.

The *inputs* may be (i) human efforts (ii) energy in any of its myriad forms, (iii) materials, (iv) invested capital etc.

Succinctly stated, the mission would be to try to produce more or to serve better without increasing the resources being consumed.

1.2. HISTORY AND DEVELOPMENT OF INDUSTRIAL ENGINEERING

- What industrial engineering is today and aspires to be in future is determined by what has gone before.
- Industrial engineering had its roots in the *Industrial Revolution* (around 1750); it was nourished by individuals who sought to advance organisation and management principles at an early date; it emerged as a separate discipline and was formulized in the late nineteenth and early twentieth centuries; and it achieved maturity after World War II.
- *The Industrial Revolution* resulted from the advent of new inventions, especially in the textile industry, then steam engine, advances in metal cutting and the production of machine tools. These led to factories with large number of workers.
- With the growth in the size of industries, came the beginning of *management* and management thinking.

- The application of the scientific method of analysis, experimentation and practical demonstration had been extended to the production of machine tools, more complicated processes, and better products. Now it was being extended to man's thinking on organisation and management principles and methods.

Scientific Management as a professional approach was yet to come, waiting on the works of pioneers in the field.

- Historians of science and technology might argue as to the beginning of *industrial engineering*. The generally accepted beginnings relate to the work done by *F.W. Taylor*, who was concerned primarily with concepts of productivity, even though he did not refer to it in those terms.
- Prior to Taylor's work, however, there were *others*, whose writings referred to concepts that ultimately became associated with industrial engineering, whose impact on Taylor is difficult to assess. One of the earliest of these is *Adam Smith's* treatise *The Wealth of Nations*, published in 1776.
- The concepts *Adam Smith* expressed concerning the proper *division of labor*, while not original, nevertheless became an important factor in the unfolding of the impending Industrial Revolution. The writings of Adam Smith and those of both his students and contemporaries were important milestones in the development of the factory system and of the Industrial Revolution which it created. Adam Smith was an economist not an engineer, and as a result, his writings came from this perspective.
- A more direct line to the pioneering in industrial engineering might be provided by *Charles W. Babbage* who wrote *On the Economy of Machinery and Manufactures* in 1832.

Perhaps one of the most important contributions to industrial engineering that *Babbage* made, although it was not so recognized at the time, was his attempt to build a *computer*--or as he referred to it, an *Analytical Calculating Machine*.

- During the latter half of the nineteenth century, there were others, primarily in United States, who clearly provided the impetus and thinking that led to interest in the start of formal education in the field of Industrial Engineering. One such person was *Henry R. Towne*. Towne emphasized the economic aspects and responsibilities of the engineer's job in a paper that he presented to the ASME.
- Another active worker and writer was *Frederick A. Halsey*, the father of the *Halsey premium plan* of wage payment.
- A third individual who laid much of the ground work for the developing activity-industrial engineering was *Henry L. Gantt*, the originator of the *Gantt Chart*.
- Probably the most often quoted and generally acknowledged instigator of studies that have led to the discipline of *Industrial Engineering* and who was himself a mechanical engineer, was *Frederick W. Taylor*. Though Taylor did not use the term industrial engineering in his work, his writings and talks under the aegis of ASME are generally credited as being the beginning of the discipline -- industrial engineering. Taylor, however, preferred the term *Scientific Management*. What Taylor was proposing, was a more rational and planned approach to the problems of production and shop management. Besides management problems, Taylor was active in research on metal cutting and the technical problems of production as well.
- The other giant of the early dates was *Frank Bunker Gilbreth*. He, too, was an engineer and obviously had been impressed by the work and writings of Taylor.

Taylor focused on planning and organization of work whereas Gilbreth (husband and wife) was interested in improving the efficiency through improvement of methods of doing a work i.e. *method study*.

- There were many others who should be recorded in any detailed history of the field of industrial

engineering, however, space limitations do not permit more than a mention of their names:

Hugo Diemer	Charles B. Going
H. Emerson	Robert Hoxie
D.S. Kimball	G.H. Shepard
A.G. Anderson	L.P. Alford
Alan Mogenson	R.M. Barnes
M.G. Mundel and	H.B. Maynard.

- As the result of the developments in the field of industrial engineering, in 1908, the first separate departments of Industrial Engineering were established at Pennsylvania State University and at Syracause University.

The first Ph.D. granted in the U.S.A. in the field of industrial engineering was the result of research done in the area of *motion study*. It was awarded to *Ralph M. Barnes* by Cornell University as recently as 1933.

Most of the leaders of the early work in industrial engineering focused their activities on motion study and related areas of work at the individual work place to make it more productive.

- The 1930s were a decade of economic hardship and social unrest. The great depression made management extremely *cost* conscious and created an environment in which industrial engineering principles and techniques were given serious consideration and fairly widespread application.
- At the close of the decade, the impact of World War II was beginning to be felt in terms of increased industrial production; this provided a further stimulus to industrial engineering precepts and practices.

Trade unionism grew extensively in the 1930's and workers felt less fear of wage rate cutting.

- Many modern industrial engineering techniques had their genesis during the period 1940-1946. *Predetermined time standards* (such as MTM and Work-Factor), *value engineering* and *systems analysis* are a few of these.
- One of the fascinating products of World War II was the activity which came to be known as *Operations Research* (O.R.), basically, which is a process of applying statistical and higher mathematical techniques to the solution of real-world problems.
- A highly significant era in the development of industrial engineering began after World War II. A great many new *activities* developed and the application of principles and techniques was vastly broadened. The activities were: (i) Industrial engineering and computer; (ii) Development of system analysis and design; (iii) Application of mathematical and statistical tools; (iv) Network planning techniques and their application; (v) value engineering; (vi)Behavioural science and human factors.
- It was primarily these two developments—the mathematical advances and their applications in the field of operations research and the development of high speed, stored programme digital computer—that literally changed *industrial engineering* from a non-quantitative empirical science to one of considerable mathematical sophistication and caused it to be considered a *hard science.*
- An *additional element* should be considered in reviewing the development of industrial engineering and that is—*human factors* or *human engineering* or *ergonomics*.
- As a result of these developments, the industrial engineer of today has many more sophisticated tools with which to analyse his problems and to design new and improved systems.

1.3. ROLES OF INDUSTRIAL ENGINEER

- *Given below* are different types of roles and functions, an industrial engineer may need to take

on. More than one may occur at one time e.g., advisor/analyst/reviewer in evaluating the effectiveness of a new factory built a year ago.

– *Roles and functions of an Industrial Engineer:*

1. *Advisor/Consultant* – available to others for interpretation of data, review etc.
2. *Advocate/Activist* – promote actively a process or approach.
3. *Analyst* – separate a whole into parts and examine them to explore for insight and characteristics.
4. *Boundary spanner* – bridge the information/interest gap between industrial engineering and user.
5. *Motivator* – provide stimulus and skill availability to a group or individual.
6. *Decision maker* – select a preference from among many alternatives for topic of concern.
7. *Designer/planner* – produce the solution specifications.
8. *Expert* – provide a high level of knowledge, skill, and experience on a specific topic.
9. *Coordinator and Integrator*
10. *Innovator/inventor* – seek to produce a creative or advanced technology solution.
11. *Measure* – obtain data and facts about existing conditions.
12. *Project Manager* – operate, supervise and evaluate projects.
13. *Trainer/educator* – in the skills and knowledge of industrial engineering.
14. *Data gatherer*
15. *Negotiator.*

1.4 APPLICATIONS OF INDUSTRIAL ENGINEERING

- Before 1940, Industrial Engineering was mainly applied to manufacturing industries for improving methods of production, to develop work standards or to formulate production control and wage policies.
- Later on, the use of industrial engineering also spreaded to non-manufacturing activities such as construction and transportation, farm and air-line operations and maintenance, public utilities, government and military operations.
- Still today, Industrial Engineering finds major applications in manufacturing plants and industries.
- In an industry besides the production, other departments utilising industrial engineering concept are Marketing, Finance, Purchasing, Industrial Relations etc.

1.5 PRODUCTION MANAGEMENT

- Production Management centers on two major areas :-

(1) *Design* of the production system which includes product, process, plant, equipment and so on, and,

(2) *Development* of the control systems to manage inventories, product quality, production schedules and productivity.

- *Operations* are at the center of the diagram because they are the dynamic *doing* elements of the production process. Yet, it is clear that we cannot dismiss any of the other elements of the PM cycle. Operations cannot exist without them. The process is a time-stream of operations which is kept under control, just as a car being steered along a winding highway must be controlled.

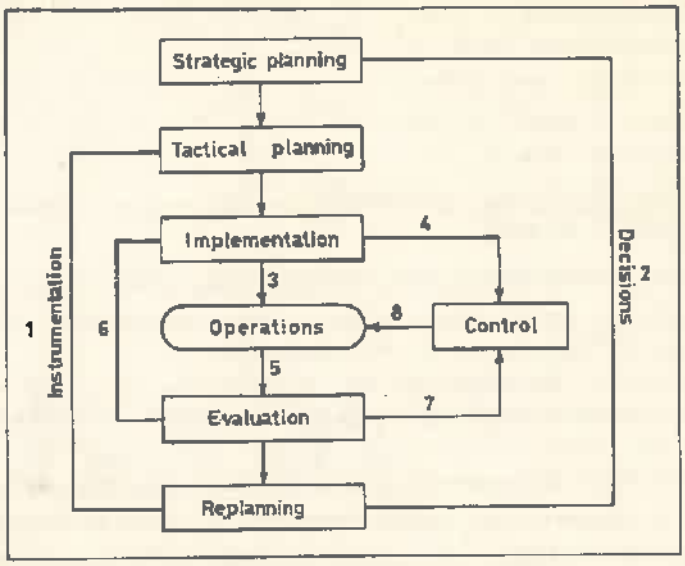


Figure 1.1 The Production Management cycle.

- If major investments in system design are at the core of our considerations, we say that a *strategic decision* is warranted. On the other hand, if implementation patterns are central to the manager's problems, then we say that a *tactical decision* is called for. This distinction is useful. *Tactics* are applied to the methods and instruments of implementation ; *strategies* refer to the design decisions.
- Minor design modifications characterize the tactical level.

For example, individual jobs can be redesigned, machines replaced and materials altered. Such changes are represented by loop 1 (fig. 1.1) which has a greater volume of usage than planning loop 2, which operates when start-up of a new process is required. Following the various connections of the figure, we observe that operations is engaged in a central way through a series of connections 3, 4, 5, 6, 7 and 8 to implementation, control and evaluation. And this control subset is essential to the organisation's planning system.

- Fig 1.1 also reflects the great variety of production-management responsibilites. It includes the facilities and abilities for the detailed consideration of such factors as related to *design* of production process :

1. Product design.
2. Job and process design.
3. Equipment selection and replacement.
4. Labor skills and training programs.
5. Input materials selection including raw materials and subcontracting.
6. Plant selection and layout.
7. Scheduling steps of the plan.
8. Implementing and controlling the schedule.
9. Operating the production system.

In addition Fig. includes consideration of *control system* such as :

1. Inventory control policies.
2. Quality control policies.
3. Production-schedule control policies.
4. Productivity and cost control policies.
5. Constructing control systems.
6. Implementing and operating control systems.
7. Modifying policies and designs.

1.6. PRODUCTION MANAGEMENT VERSUS INDUSTRIAL ENGINEERING

- *Production Management* attempts to familiarize a person with concepts and *techniques* specific to the analysis and management of a production activity.
- *Industrial engineering*, on the other hand, deals with the analysis, design, and control of productive systems. By a *productive system* is meant any system that produces either a product or a service.
- *Production management* tells how to *manage* (i.e., direct human efforts) in a production environment, with less attention paid to the analysis and design of productive systems.
- It is generally assumed that industrial engineers will not operate the systems they design.
- The *training* of an aircraft pilot is analogous to *management* education, whereas the designing of the aircraft is somewhat analogous to *industrial engineering* education.

1.7. OPERATIONS MANAGEMENT

- *Operations Management* which evolved from the field of production or manufacturing management is concerned with the application of the basic concept and principles of management to those segments of the organisation that produce the goods and/or services of the organisation.
- Traditionally the term *production* brings to mind such things as machine shops, manufacture of real goods etc.
- Operations management is concerned with the management of the *producing function* in any organisation.
- Specifically operations management involves designing the systems of the organisation that produce goods or services and with the planning and controlling of the day-to-day operations which take place within these systems.
- The overall focus of operations management is the effective integration of resources in the pursuit of organisational goals.
- In order to produce or transform various inputs into goods and/or services, an operating *system* is required.
- An *operating system* consists of the processes and activities necessary to transform various inputs into goods and services.
- Operating systems exist in all organizations and are composed of people, material, facilities and information. The end result of an operating system is to add *value* by improving, enhancing or rearranging the inputs.

1.8. MANAGEMENT SCIENCE – ITS HISTORICAL DEVELOPMENT

Definition and concept

- Management Science (MS) can be defined as :

  "A problem-solving process used by an interdisciplinary team to develop mathematical models

that represent simple-to-complex functional relationships and provide management with a basis for decision-making and a means of uncovering new problems for quantitative analysis".

- Management science encompasses, however, more than just the development of models for specific problems. It makes a substantial contribution in a much broader area : the application of the output from management science models for decision-making at the lower, middle, and top management levels.

A manager's experience, upcoming business conditions, and the output from a mathematical model form the best combination for planning, organizing, directing and controlling the company's activities.

- Management science is the application of the scientific method to the study of the operations of large, complex organisations or activities.
- Two disciplines intimately associated with management science are industrial engineering and operations research.

Historical Development

- The roots of management science extend to the work of F.W. Taylor, the father of *Scientific Management*.
- Taylor is known for his systematic development of management techniques which he started at the Midvale Steel Company in Philadelphia around 1880.
- Taylor developed what he called his four principles of management : *research, standardization, control* and *cooperation*. When installed at the Link Belt Engineering Company in 1905, the system included cost accounting, time study, inventory control, production control, planning, output scheduling, functional operation, standardized procedures, a mnemonic system of classification, and means for maintaining quality production.
- Associated with Taylor were other important pioneers of scientific management – Carl Barth, Gantt, Thompson, Hathaway and many others. Barth brought to the work of scientific management the use of research mathematics, which he merged with his extensive knowledge of machine tools. Gantt contributed the recognition of worker psychology, the development of a bonus plan, and the charts used in production scheduling.
- Out of this came the term *Industrial Engineering* which today is descriptive of the work of functional staffs responsible for such activities as incentive standards, methods analysis, quality control, production control, cost control and materials handling.
- During the ten years just after World War II, a great deal of management science was performed under the name of *operations research*. The influx of physical scientists many of whom were unacquainted with modern management administration into war technology and the pressures of total war with new and terrible weapons gave rise to a rediscovery of a kind of pragmatic scientific management. This merged with an increasingly popular acceptance of statistical quality control in America and the practical development of high-speed electronic calculators to give impetus to the operations-research approach.
- In brief, *management science* describes an integrated approach to operational control based on the application of scientific research methods to business problems. A systematic approach to problem solving received early impetus from Taylor's scientific management movement and is continued today by Industrial engineers and mathematical business analysts. This approach is characterized by a methodology of sequential investigation steps.

Characteristics of Management Science

The four major characteristics of management science are as follows :-

(1) Examine *functional relationships* from a systems overview.

(2) Use the *interdisciplinary approach.*

(3) *Uncover new problems* for study.

(4) Use a *modeling-process approach* to problem solving.

(1) The activity of any one function of a company will have some effect on the activity of each of the other functions. Therefore it is necessary to identify all important *interactions* and determine their impact on the company as a whole. Initially, the *functional relationships* in a management science project are expanded deliberately so that all the significantly interacting parts and their related components are contained in a statement of the problem. A systems overview examines the *entire area* under the manager's control. This approach provides a basis for initiating inquiries into problems that seem to be affecting performance at all levels.

(2) Management science makes good use of a simple principle : look at the problem from different angles and approaches. For example, a *mathematician* might look at the *inventory problem* and formulate some type of mathematical relationships between the manufacturing departments and customer demand. A *chemical engineer* might look at the same problem and formulate it in terms of flow theory. A *cost accountant* might conceive the inventory problem in terms of component costs (e.g. direct material cost, direct labour cost, overheads etc.) and how such costs can be controlled and reduced, etc.

Therefore, management science emphasizes over the interdisciplinary approach because each of the individual aspects of a problem can be best understood and solved by those, experts in different fields such as accounting, biological, economic, engineering, mathematics, physical, psychological, sociological, statistical etc.

(3) The third characteristic of management science, which is often overlooked, is that the solution of an MS problem brings *new problems* to light. All interrelated problems uncovered by the MS approach do not have to be solved at the same time. However, each must be solved with consideration for other problems if maximum benefits are to be obtained.

(4) Management science takes a systematic appraoch to problem solving. It may use a modeling process approach taking the help of *mathematical models*.

Other Characteristics of Management Science are :

(5) A primary focus on *managerial decision-making.*

(6) The application of science to decision-making.

(7) A dependence on electronic computers.

(8) An appraisal resting on criteria of *economic effectiveness.* Effectiveness may be defined as the extent to which goals are achieved. Effectiveness is evaluated by measures of effectiveness (also known as measures of performance).

1.9. THE TOOLS OF MANAGEMENT SCIENCE

The tools of management science developed specifically for solving managerial problems are listed below :

(a) *Decision matrices*

Allocation and investment problems involving a relatively small number of possible solutions can be presented in a tabular form known as decision matrix.

(b) *Decision trees*

The extension of decision matrices for situations involving several decision periods takes the shape of a tree.

(c) Mathematical Programming

It attempts to maximize the attainment level of one goal subject to a set of requirements and limitations. It has extensive use in business, economics, engineering, the military and public service, mainly as an aid to the solution of allocation problems. In this text some of the following models will be covered :

Linear Programming,
Transportation and assignment models,
Integer and goal programming.

(d) Branch and Bound

It is a step-by-step procedure used when a very large (or even infinite) number of alternatives exist for certain managerial problems.

(e) Network Models

This is a family of tools designed for the purpose of planning and controlling complex projects. The best known models are PERT and CPM.

(f) Dynamic Programming

It is an approach to decisions that are basically sequential in nature or can be reformulated so as to be considered sequential. It is a very general and powerful tool.

(g) Markov chains

They are used for predicting the outcome of processes where systems or units change their condition over time (e.g. consumers change their preferences for certain brands of commodities).

(h) Game Theory

It provides a systematic approach to decision-making in competitive environments and a framework for the study of conflict.

(i) Inventory Models

For certain types of inventory control problems, certain models that attempt to minimize the cost associated with ordering and carrying inventories have been developed.

(j) Waiting Line (Queuing) Models

For certain types of problems involving *queues*, special descriptive models have been developed to predict the performance of service systems such as car garages – cars standing in queue for servicing.

(k) Simulation Models

For the analysis of complex systems when all other models fail, management science uses descriptive-type simulation models.

Specially, five types of models may be employed:

1. Artificial Intelligence.
2. Heuristic programming.
3. Management games
4. Systems simulation, and
5. Monte Carlo simulation.

– *Artificial intelligence:* The behaviour of a computer, programmed to react to situations in much the same manner as a human being would.

– *Heuristic:* A heuristic approach to a problem makes use of methods which have been found in practice to be generally useful in attacking problems of a similar nature. Heuristics are often formulations of rules of thumb.

1.10. MANAGERIAL ECONOMICS

Introduction

– Business Management and Economics have always been closely related; in fact, most schools of business have their origins in departments of economics.

– Yet, the viewpoints of the economist and the manager have, until recently, been different.

The *economist* has been concerned chiefly with the functioning of the economy as a whole and social issues such as monopoly and competition, tax policy, the pricing system, and the distribution of income.

The *manager* has been concerned primarily with maximization of profits, from the viewpoint of the individual firm, and with such company policies as pricing, wage payments, market share and employment of resources.

Both the economist and manager, nevertheless, face similar problems of using scarce resources in the satisfaction of human wants. Both concentrate on the analysis of demand characteristics and supply factors, but the manager must orient his thoughts to making decisions in business operations.

– *Managerial Economics,* therefore, may be *defined* as the management's application of economic principles in the decision-making process.

Principles

– The four economic principles that managers should keep in mind daily are:

(1) *The incremental principle*

A decision is sound if it increases revenue more than costs or if it reduces costs more than revenue.

(2) *The principle of time perspective*

A decision should take into account both the short-run and long-run effects on revenue and costs, giving appropriate weight to the most relevant time period in each individual decision.

(3) *The Opportunity Cost principle*

Decision-making involves a careful measurement of the sacrifices required by the various alternatives.

(4) *The discounting principle*

If a decision affects costs and revenues at future dates, it is necessary to discount these costs and revenues to present values before a valid comparison of alternatives is possible.

Techniques

– The manager should have a knowledge of the following:

(1) *Break-even Analysis*

(2) *Demand Analysis*

(1) *Break-even Analysis* has been discussed in Chapter 27

(2) *Demand Analysis*

– *Demand* : A schedule that shows the amounts that would be sold at various prices, in a given place, and on a given date.

- Forces that determine the demand for a firm's product include (a) the desires of the customers, (b) the income of the customers, (c) the prices of substitutes, and (d) the characteristics of the market.
- Any estimate of demand for a given product must be based upon estimates of expected national and international activity and estimates of the factors that effect the demand of the industry.
- The manager is interested in demand because of the need to understand the external factors that affect decisions and policies.
- Specifically, *three subjects* are important as background for price decisions:

(a) Elasticity of demand

(b) Determinants of changes in demand

(c) Forecasting demand.

(a) Keeping in mind that demand is a schedule of price-quantities, the most important concept in demand analysis is *elasticity*. In general, elasticity may be defined as the percentage change in a dependent variable determined by a given percentage change in an independent variable.

- *Price elasticity of demand* is the most common application of this concept: it describes the effect of a given percentage change in price (P) on the percentage change in quantities (Q) that would be purchased, i.e.

$$E = \frac{Q_2 - Q_1}{Q_2 + Q_2} \Big/ \frac{P_2 - P_1}{P_2 + P_1}$$

where Q_1 and Q_2 are quantities that would be taken before and after a price change, and P_1 and P_2 are the corresponding prices. Price elasticity indicates the *responsiveness* of a change in quantity to change in price.

- Elasticity of demand is an important concept in the determination of price policies.

(b) *Determinants of changes in demand*

- Elasticity describes the nature of demand at a given time; changes in demand refer to shifts during a period of time. Managers should be aware of those factors that cause changes in demand.
- A primary means by which a manager can attempt to increase demand is through *advertising* and *sales promotion*.

(c) *Forecasting demand*

- The manager must forecast future demand.
- Forecasting may be oriented to (1) estimating economic conditions in the near future or (2) it may be directed toward estimation of specific quantities that will be sold in various markets.
- The individual demand for a given firm depends upon the health of the total demand in the economy; therefore a *first step* is to forecast the conditions of the economic environment.
- A *second step* in forecasting the demand for a given product usually concentrates on the total demand for the industry. The demand for the industry can be analyzed by individual components such as (1) sales of products to new customers (for example, sales of refrigerators to people who do not have it) (2) sales of additional products to old customers (for example, a second refrigerator) (3) replacement sales for products that have worn out, and (4) sales affected by recent technological developments (e.g. frost-free refrigerators).
- A *third step* in forecasting the demand for a given company is the estimate of the market share of the particular company. Past shares of the market may serve as the basis for this step. Adjustments, however, should be made by forecasting the effect of new programs planned by the company, expected reactions of competitors to the company's actions and to industry conditions and detailed reports by salesmen in different localities.

1.11. MANAGERIAL ACCOUNTING

Introduction

- Management and Accounting have been closely associated for a long time. Historically, the functions of accounting have been to record, analyze, and report the results of business operations in various units of measurement, such as rupees, units of production, standard hours and kilowatts.

  With such information, management can

(1) *Plan* future operations,

(2) *Control* key variables,

(3) *Decide* among alternative courses of action, and

(4) *Analyze* past performance.

- The viewpoint of managerial/management accounting is different from that of financial accounting. The management accountant's purpose is to provide information for one user – the firm's management; the financial accountant's purpose is to provide information for a variety of users.
- In this article, we will concentrate on managerial accounting and the functions of planning, controlling, decision-making and analyzing with the use of accounting data.

(1) Planning

- Business *budgets* are the principal financial means by which the manager can formalize and express a *plan.*
- Moreover, once budgets are established, they serve as a control technique by setting predetermined criteria against which managers can compare actual results. In addition, the budgeting process serves as a tool for coordinating the activities of various functions and operating segments of the firm.
- Fig. 1.2 shows that comprehensive budgeting consists of a number of budgets with the sales budget, based upon a sales forecast, usually serving as the starting point in the process. The production budget is based on the sales budget and, all others are, in turn, constructed on consistent assumptions concerning the future.

(2) Control

- Control involves the comparison of actual performance with some predetermind criterion. Obviously *budgeting* is a control device, because management compares the actual costs and revenues with the budgeted amounts.
- Other accounting techniques that provide management with control information are

  Standard Cost

  Responsibility Accounting
- *Standard Costs* are *predetermind costs* developed from past experience, motion and time study, expected future manufacturing costs, or some combination of these. They contrast with *actual costs,* which are the amounts actually incurred in the manufacturing process.

  Examples of Standard Costs are – standard labour costs, standard material cost and standard overhead costs.
- In *responsibility accounting,* costs are identified with those individuals who are responsible for their control. The authority of the person being considered must be recognized; thus, responsibility accounting classifications must fit the organization structure. Furthermore, a minimum of cost allocation should be employed; that is, consideration should be given only to those costs that are clearly influenced by a particular individual.

(3) Deciding

- The manager can obtain accounting information designed to aid him in deciding between alternative courses of action in two ways:-

(i) The routinized collection of relevant data for certain types of anticipated decisions is called *programmed* analysis.

(ii) *Non- programmed analysis* develops special cost information for specific decisions.

The relevant cost information for decision-making should pertain to those costs that will be different under alternative actions not yet taken. Thus the central idea in accounting for decision-making (whether programmed or non-programmed) is the *incremental concept* – that is – the analysis of changes in total costs and in total revenues.

(4) Analysis of past performance

- Financial accounting statements contain valuable information that managers can use to analyse past performance.
- Management can analyze financial data by

(i) Comparisons of two or more periods and

(ii) Comparison within one period.

The *former* includes the analysis of successive balance sheets and income statements to determine trends in individual items.

The *latter* involves the analysis of current financial statements to determine the state of the firm with respect to its solvency, stability and profitability.

- Another very useful technique of the managerial accountant is called *source and application of funds analysis.* This technique involves the determination of where funds (working capital) have come from and how they were used, that is, a focus on cash flow.

Most of the information needed for analysis can be obtained from a comparison of two balance sheets plus some supplemental information added to reflect the flow of funds.

From managements point of view, the value of the analysis of source and use of funds is that it gives valuable insight on the efficiency of management in allocating funds.

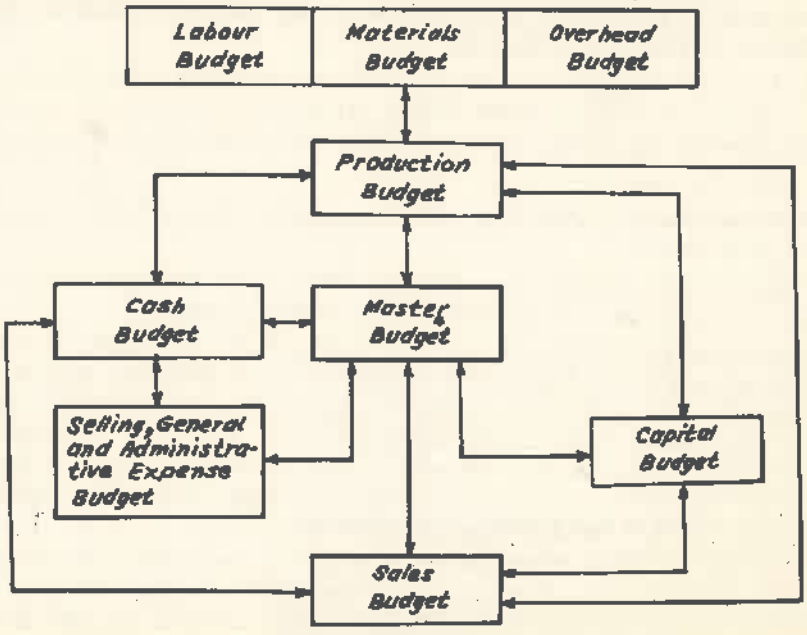


Fig 1.2 Budgeting

2

Production and Productivity

2.1. PRODUCTION

Concept

Production is any process or procedure developed to transform a set of input elements like men, materials, capital, information and energy into a specified set of output elements like finished products and services in proper quantity and quality, thus achieving the objectives of an enterprise. The essence of production is the creation of goods, may be by the transformation of raw material or by assembling so many small parts (as in television or scooter manufacturing). Production in every day life can be noticed in factories, hospitals, offices, etc. There are four recognized factors of production.

Factors

1. Nature (land and other natural resources),
2. Labour (human efforts),
3. Capital (factory building, machinery, tools, raw materials etc.), and
4. Enterprise (activity that organises other factors of production into an operating unit).

2.2. PRODUCTION FUNCTION

A Function is the expression of the relationship amongst a number of variables. The value of one variable depends upon the value of the other.

Production Function is concerned with the creation of a product. It establishes the relationship between the quantity of output furnished or given out by a productive process and the quantities of different inputs used in that process. Algebraically a production function can be written as:

$$y = f(c_1, c_2, c_3 \ldots c_n)$$

where quantity 'y' of the product Y which is produced depends upon the quantities $c_1, c_2, c_3 \ldots c_n$ of the inputs $C_1, C_2, C_3 \ldots C_n$ respectively.

A production function thus involves a wide range of activities from the plant location to the packing of products to be distributed by the marketing division of an organisation.

The modern evolution of the production function started with the Industrial Revolution. The new machinery was developed which helped in starting new and big industries and alongwith this, the era of mechanisation began. A major momentum to the improvement of production function was supplied after 1880 by the advancements in management techniques. F. W. Taylor was the renowned pioneer to contribute management theory to the production function. He is considered as the father of Scientific Management. He developed a number of management principles. Other persons associated with the scientific management were Gantt, Emerson, Gilbreth, etc.

Various factors like labour charges, dearth of skilled operators, human errors, etc., led to *automation, i.e.*, the automatic operation and control of machinery and processes. The first stage in the *evolution* of automation is *Detroit Automation*, second stage *Feed Back Control*, and third stage is *Computer Technology*.

Related to production, an always difficult managerial decision is regarding the selection of *Plant Site* and then *Plant Layout.* Plant location should be such that production and distribution costs are minimum but the profit is maximum. After locating the site, the facilities (equipments, etc.) have to be laid out. A good plant layout permits the materials to move at the desired speed and at minimum cost. This subject has been dealt in the fourth chapter of the book.

Before starting the actual production, one has to plan the same. *Production Planning and Control,* considers the determination and regulation of production processes and has different functions like routing, scheduling, dispatching, progress control, etc. This topic has been covered under chapter seven of the book.

Another important function is *Research and Development.* Research means the critical investigation into natural sciences in order to acquire new knowledge. Applied research explores facts and informations for the practical problems in mind and thus aims at achieving immediate results to practical problems; whereas pure research is carried out to add to the knowledge in a particular field without expecting its immediate use to any practical problem. Development comes after applied research. It involves design and fabrication of new or modified products and then testing them to find their usefulness.

2.3. PRODUCTION SYSTEM

- The production system is a part of a larger system – the business firm.
- The production system can be viewed as a framework or skeleton of *activities* within which the *creation of value* can occur.

  Briefly, the difference between the value of inputs and the value of outputs represents the *value created* through production activities.
- At one end of the production system are the *inputs* and at the other end are *outputs.* Connecting the inputs and outputs are a series of operations or processes, storages and inspections. Fig. 2.1 represents a simplified production system.

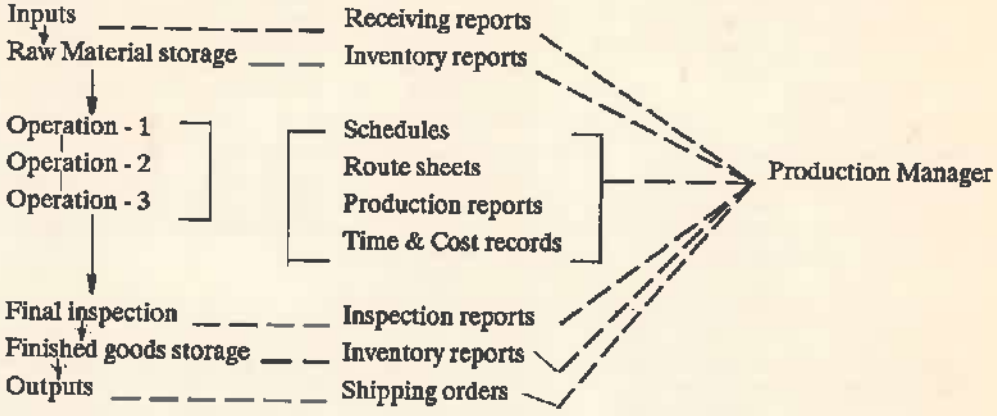


Fig. 2.1. A simplified production system.

- The concept of production system is applicable to both production of *components* and production of *services* as well.
- The production of any *component* or *service* can be viewed in terms of a production system. For

example, the manufacture of furniture involves such *inputs* as wood, glue, nails, screws, paints, sand paper, saws, workers etc. After these inputs are acquired, they must be stored until ready for use. Then several operations, such as sawing, nailing, sanding and painting can occur through which inputs are converted into such *outputs* as chairs, tables, etc. After the finishing operation, a final inspection occurs. Then the outputs are held in stock rooms until they are shipped to the customers.

Examples of *service* industries which use production concepts are *hospitals*, railroads, airlines, supermarkets, automobile repair shops, etc.

ANALYSIS OF PRODUCTION SYSTEMS

FACTOR	JOBBING 	BATCH 	MASS 	PROCESS 
1 Equipment	Standard machinery size depending on whether the factory is engaged in light, medium or heavy engineering	Similar to Jobbing Production but there may be some special purpose equipment	Machinery designed for one range of product, largest product generally not greater than medium engineering	The entire 'factory' is completely integrated at all stages. Generally no isolated items of equipment
2 Type of building	In heavy and medium engineering will be single storey and either single or multi-storey for light engineering. Floor area per worker will be high	Similar to Jobbing Production	Similarly to Jobbing Batch Production the mass manufacture of light engineering products will be single or multi-storey buildings	Quite often the equipment in process manufacture will not be enclosed inside buildings
3 Layout of factory	Similar machines will be arranged in groups-known as process or functional layout	Same as Jobbing Production but in some factories different machines may be grouped together to suit families of parts	All machines and processes will be arranged in operation sequence to suit the product – known as Line Layout	The entire factory will be designed like one huge machine and to produce a certain rate of a specific product
4 Type of flow	Because of the difficulty of balancing demand with capacity work will wait between operations – known as Intermittent Flow	Similar to Jobbing Production but a family grouping type of layout may reduce waiting but will also reduce machine utilisation	Demand and capacity will be reconciled so flow wil be continuous	As the complete layout has been designed for a specified flow production will be continuous
5 Cost and time required to make product	Cost of one product in relation to turnover will be high. Total time to make will be high and can be expressed as : $\frac{\text{Total Operation Time}}{\text{Total Time to Make}}$ This will always be less than 1	Similar to Jobbing Production but the ratio of total operation time to total time to make will be better	Cost of one product in relation to turnover will be small. The total time to make will be low and the ratio of total operation time to total time to make will be near to 1	Cost of one unit of output in relation to total output will be very small and the ratio of total operation time to total time to make will be theoretically near to 1
6 Work-in-progress	The amount of W.I.P. in relation to total output will be high	Similar to Jobbing Production	The amount of W.I.P. in relation to total output will be small	There will theoretically be no W.I.P. between operation stages

7 Materials handling	Standard equipment and will depend on whether the factory is engaged in light, medium or heavy engineering	Similar to Jobbing Production but there may be some special purpose equipment	Extensive use of expensive specialised equipment	Materials handling and processing will be completely integrated
8 Foremen	Large technical content in Supervisory Function. Ratio of supervision to operators about 1:30	Specialists in the functions supervised e.g. Milling or Capstans Ratio of Supervision to operators about 1:50	Specialists in a particular aspect of flow production. Ratio of supervision to operators about 1:50	Concerned with co-ordinating and communicating. Ratio of supervision to operators about 1:15
9 Sales and design	Technical, large staff orders made to customers requirements	Product and Jig and Tool Design, Orders made to customer's requirements	Research and development Product testing Market Research to test customer's requirements	Research and development for products and processes Market Research to test customer's requirements
10 Type of industry	Ship building, Civil Engineering, Process Equipment, Castings	Machine tools, Furniture, Clothes, Drop forgings	Food, cigarettes, T.V. electric lamps vehicles	Chemicals, oil petrol

Fig. 2.2. Analysis of Production Systems

2.4. INPUT OUTPUT MODEL

– It is one of the basic models of the production system. A production system is the set of interconnected input-output elements and is made up of three component parts namely inputs, process and outputs (Fig. 2.3). A wide variety of inputs are transformed so that they give out a set of outputs. The transforming process can be complicated and the design of an actual input and output system for manufacturing may be expensive and difficult.

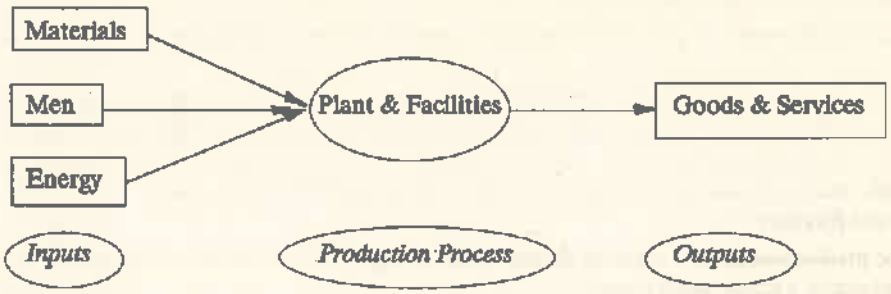


Fig. 2.3. Input-Output model.

– The efficiency of an engineering system (a machine)

$= \frac{\text{Output}}{\text{Input}} \leq 1$, and a system with output equal to input is considered to be ideal. But in a system of Production Management this definition of efficiency means utter failure and ultimately the end of the business. In economic system, the efficiency has to be greater than one – which means a state of profit. A production management system comprehends and integrates both engineering and economic criteria in its activities.

2.5. MICRO-ECONOMICS, APPLIED TO PLANTS AND INDUSTRIAL UNDERTAKINGS

Economics is the science which studies human behaviour as a relationship between ends (objectives) and scarce means (limited resources) which have alternative uses.

Economics can be divided into two parts:

(a) Macro-economics, and

(b) Micro-economics.

Both macro and micro-economics have two types of approach:

1. Positive, and
2. Normative.

Macro-Economics deals with whole economy. It studies the growth of national income, level of government spending, the balance of payments, etc.

Micro-Economics deals with smaller units of the economy like behaviour of individual customers, plants or industrial undertakings.

Positive Approach involves either straightforward *description* (like operation of ABC chemical industry) or positive economic *Theory, i.e.,* a theory which explains how ABC chemical industry operates and why it got developed in a particular way.

Normative Approach includes two aspects, *i.e.,* what to do and how to do it. For example what an industrial undertaking should do in order to take good decisions.

It is the normative micro-economics which is most useful to plants and industrial undertakings. It tells what should be the objectives and policies of the industrial undertakings. What objectives a plant should pursue and how they should be set. In case the objectives and policies are predefined then the micro-economics determines how best to achieve them in particular situations. In other words, normative micro-economics will tell how to take business decisions so as to reach preset objectives and policies. At micro-economic level, on the basis of recent thinkings, managerial economics, now helps decision-taking in plant management. Managerial economics may be defined as management's application of economic principles in the decision-making process.

In a plant or industrial undertaking it may be required to take decisions on the following *goals or objectives:*

(1) The inventory goal. The main aim is to have optimum inventory at all times. Large inventory will tie up a big working capital, whereas less inventory will involve hazards of running out of stock. The inventory level is decided by striking a balance between the cost of running out of stock and the cost of holding stock. Besides inventory group, other sections connected with such a decision are sales, production and finance.

(2) The production goal. It involves decisions on setting the level of output, low production costs, and maintenance of a stable work force.

(3) The market goals. They are considered while taking decisions on saies strategy, *i.e.*, when, deciding a level (amount) of sales and the (market) share of a particular concern in the total market sale.

(4) The profit goal. In simple words *profit* may be defined as the revenue that is left over after all costs are subtracted. Profit is actually a measure of performance and an excellent indicator of the general efficiency of a plant or industrial undertaking. The decision involved in profit goal is the determination of the aspiration level of the concern with regard to profits. Taking from shareholders to the workers everybody is interested to maximize the profits.

There is continuous search process to optimize all the goals described above and solve problems connected with them (if they arise). A decision taken with regard to one goal will naturally effect the other goal/goals.

The following *Concepts* of economics play a major role in decision-making:

(1) Demand. It is a schedule which shows the amount or number of goods that would be sold at various prices in a predecided place and on a preset date. Demand describes the relationship between prices and quantities. The demand of a particular item can be estimated from the income and tastes of consumers, prices of similar items in the market and the market characteristics.

(2) Types of market. There can be the following five types of markets:

(*i*) A monopolist seller and a monopolist buyer,

(*ii*) A monopolist buyer and a group of oligopolist sellers,

(*iii*) A monopolist seller and a group of oligopolist buyers,

(*iv*) A group of oligopolist buyers and another group of oligopolist sellers, and

(*v*) A monopolist or a group of oligopolists as buyers and a monopolistically competitive industry as seller.

A monopolist (selling) firm is one which has no close substitutes for its products. For example, a large chemical concern may have its monopoly over a few specific chemicals or drugs. Monopoly means only one producer whereas oligopoly means a small number of producers. Oligopoly involves much less impersonal competition as compared to that in monopoly and thus a price reduction by one producer will exercise a significant effect on the market share of one or more of the other producers or sellers.

(3) Costs. Cost implies various elements of expenses incurred in different plant activities like production, distribution, etc. The various costs in business decisions are implicit or explicit costs, fixed or variable costs, book costs or out of pocket costs, long run or short run costs, controllable or non-controllable costs, incremental or sunk costs, etc.

(4) Discounted cash flow. Money is invested on a plant or industrial unit in the present with a hope to get profits in future. The sum of money invested today and that received afterwards in future cannot be taken at their face values. The money after two years is not worth the same as money today. The buying power of the money changes with time. Such problems can be handled with the use of discounted cash flow techniques.

(5) Probability and expected value. Concepts of probability and statistical theory are used to take decisions under uncertainty. Uncertainty means that there is a chance that some of the events may or may not occur at all or they may not occur as thought of. Under such conditions the likelihood of occurrences of those events can be presented in the form of probabilities. In actual business decision problems uncertainty plays a significant role.

The various business problems on which a plant or industrial unit has to take *decisions* are as follows:

(*i*) *Resource Allocation Problems.* Such problems involve loading, routing and scheduling of men, materials and machines (refer Chapter 7). Allocation problems also include transportation problems which are solved by using Linear Programming methods.

(*ii*) *Queuing Problems.* Such problems occur wherever a queue forms. For example, a plant manager may have to decide about the additional powered trucks (material handling equipment) required (to be purchased) so that the in-process inventory, waiting to be shifted from one work station to another is neither too small nor too large.

(*iii*) *Inventory Problems.* The decision required on inventory problems is as regards the optimum level of stocks of raw inventories or finished products (for an industrial unit) to hold at a time.

(*iv*) *Pricing Problems.* The plant or industrial unit has to decide the selling price of the products and the amount which it has to pay for materials and labour. Pricing problems are also associated with allocation, marketing, inventory and queuing problems.

(*v*) *Investment Problems.* Investment problems involve decisions such as the amount of money to be spent on a new plant building and machinery, or to decide even the source from where to collect funds, etc.

Operations Research techniques can be employed to solve business decision problems. Operations Research and other decision techniques involve the following steps:

(*i*) Stating the objectives clearly,

(*ii*) Building a model of the problem,

(*iii*) Estimating the values of model parameters and variables (collecting adequate data), and

(*iv*) Using logic to solve the problem.

2.6. PRODUCTIVITY

- Productivity of a production system is analogous to the efficiency of a machine. Just as it is desired to increase the efficiency of a machine, it is also aimed at to raise the productivity within the available resources.
- Productivity may be defined as the ratio between output and input. Output means the amount produced or the number of items produced and inputs are the various resources employed, e.g., land and building, equipment and machinery, materials, labour, etc.

Example. 2.1. **Calculation of productivity :**

	Plant A	*Plant B*
No. of workers	200	300
No. of items produced per unit time	10	20
Therefore productivity	$= \frac{10}{200} = \frac{1}{20}$	$= \frac{20}{300} = \frac{1}{15}$

Purpose to Increase Productivity

(*a*) *For Management :*
1. To produce good earnings (profits),
2. To clear the debts or loans acquired from different sources,
3. To sell more, and
4. To stand better in the market.

(*b*) *For Workers :*
1. Higher wages,
2. Better working conditions,
3. Higher standard of living, and
4. Job security and satisfaction.

(*c*) *For Customers :* Reduced price of the articles.

In the true sense, the productivity can be said as increased if more products can be obtained from the same amount of resources, *i.e.,* available resources.

2.7. FACTORS AFFECTING PRODUCTIVITY

(a) Factors affecting National Productivity

1. Human Resources
2. Technology and Capital Investment

3. Government Regulation

(b) Factors affecting productivity in Manufacturing and Services

1. Product or System Design
2. Machinery and equipment
3. The skill and effectiveness of the worker
4. Production volume.

A-1. Human Resources

- The general level of education is an important factor in national productivity. The use of computers and other sophisticated equipment and systems requires better educated employees.

  Government can help by sponsoring more education, especially in fields that directly affect productivity.

- Employees need to be *motivated* to be productive. Pay is not enough; they need to have good, safe, working conditions and to be recognized as the most vital part of the enterprise.

- Labour unions and management may be adversaries in negotiating pay and benefits but can cooperate in seeking productivity improvements, to the benefit of all.

A-2. Technology and Capital Investment

- The major factor in *long range* continuing productivity improvement is technology, and new technology depends on Research & Development.

- For industry or services to put new technology into use they must invest in new machinery and equipment.

- The government can do the following:

(*i*) Promote R & D in Industries and Universities.

(*ii*) Encourage personal savings and reduce taxes on profits so that people invest in new facilities.

(*iii*) Allow depreciation rates that will provide cash flow for new investment.

(*iv*) Directly encourage new investment through increased investment tax credits.

A-3. Government Regulation

- An excessive amount of government regulation may have a detrimental effect on productivity.

- Government can do much to eliminate unneeded regulations and to make cost-benefit analysis to determine the necessary regulations such as those on health and safety.

B-1. Product (or System) Design

- If through better product design, a product can be simplified by eliminating some of its parts, it is obvious that the material these pieces are made of will no longer be needed. Nor will the equipment, tooling, and labour to make them be required. *Value Analysis* can bring out many product design changes that improve productivity.

- *R & D* is a vital contributor to improved product design.

- *Standardization* of the product and the use of *group technology* are other design factors that make possible greater productivity in the factory.

B-2. Machinery and Equipment

- Once the product is designed, then how it is made offers the next opportunity for productivity improvement. The equipment used—machines, tools, conveyors, robots, the way the factory is laid out—all are important.

- Computer has helped design the products (CAD), it helps operating complicated machine tools (CNC machines) and it controls the inventory of material and parts. It has become an essential ingredient in productivity improvement.

B-3. Skill and Effectiveness of the Worker

- The trained and experienced worker can do the same job in a much shorter time and with far greater effectiveness than a new one.

  However, even the well-trained employees must be motivated to be productive.

B-4. Production Volume

- Assume that the volume of output is to be doubled. The number of direct workers would have to be doubled and a few indirect workers might also be needed. But there would probably not be a need for more engineers, research scientists, headquarters staff people or other support personnel. So if the output is doubled, the productivity of these support people is in effect doubled.

2.8. INCREASING PRODUCTIVITY OF RESOURCES

It implies, getting more number of goods (output) from the same amount of resources (input), as explained under:

(*a*) *Material.* Industries in which the cost of raw material is a big percentage of the cost of finished goods, higher productivity can be achieved through proper use of materials, *i.e.*, by reducing scrap. Sometimes a little change in the design of the component or component layout may save a lot of material. Productivity of materials can also be increased by using correct process, properly trained workers, suitable material handling and storage facilities and proper packaging. All these factors reduce scrap rate.

(*b*) *Labour.* A little change in the design of component parts so as to facilitate final assembly, can increase the number of products assembled per day with the same amount of labour.

Work methods if improved through workstudy techniques, can substantially increase the rate of production.

(*c*) *Plant, Equipment and Machinery.* Productivity can be increased through the use of improved tools (*e.g.*, cutting tools in a machine shop), simple attachments and other devices. Total production times can be cut short considerably by improving machine setting up methods, thereby reducing set-up times. Proper maintenance will (avoid sudden breakdown and) add to the productivity.

(*d*) *Land and Buildings.* A suitable plant layout can accommodate more machinery in the same space and thus raise productivity. Proper orientation, construction and inside conditions of a building definitely affect productivity.

Example *2.2.* There are two industries manufacturing two types of plugs. The standard time per piece is 1.5 minutes. The output of the two industries is 300 and 200 respectively per shift of 8 hours.

(*a*) What is the productivity of each per shift of 8 hours?

(*b*) What is the production of each per week (6 days) on the basis of double shift?

Solution :

	Industry 1	Industry 2
(*a*) Productivity =	$\frac{\text{Actual production}}{\text{Standard production}}$	
Therefore	Productivity of factory-1 $= \frac{300}{\left(\frac{8\times60}{1.5}\right)}$	Productivity of factory-2 $= \frac{200}{\left(\frac{8\times60}{1.5}\right)}$
	$= \frac{15}{16}$	$= \frac{5}{8}$
(*b*)	P_1 = Production of factory-1 $= 300\times6\times2$ $= 3600.$	P_2 = Production of factory-2 $= 200\times6\times2$ $= 2400.$

Practices advocated to improve worker's productivity

(*i*) Have shorter 3 or 4 day workweeks by lengthening shifts to 10 to 13 hours.

(*ii*) Tie wages more closely to output and use merit awards.

(*iii*) Develop and utilize more standard times in service industries.

(*iv*) Redesign the content of jobs to make them more interesting and challenging.

(*v*) Improve communications to encourage everyone to work toward the same desired objectives.

2.9. KINDS OF PRODUCTIVITY MEASURES

(1) Labour Productivity

– The resource inputs are aggregated in terms of *labor hours*. Hence this index is relatively free of changes caused by wage rates and labour mix.

(2) Direct labour cost productivity

– The resource inputs are aggregated in terms of direct labor costs. This index will reflect the effect of both wage rates and changes in the labor mix.

(3) Capital productivity

– Several formulations are possible. In one, the resource inputs may be the charges during the period to depreciation; in another, the inputs may be the book value of capital investment.

(4) Direct cost productivity

– In this formulation, all items of direct cost associated with resources used are aggregated on a monetary value basis.

(5) Energy productivity

– In this formulation the only resource considered is the amount of energy consumed.

(6) Raw material productivity

– In this formulation, the numerators are usually weight of product; the denominators are the weight of raw material consumed.

Sources of Information for developing measures of productivity

– An examination of the various measures of productivity as described above, indicate three major sources of information for constructing such indexes:

(*i*) Product Identification Information

(*ii*) Accounting Information

(*iii*) Work Measurement Information

(1) Product Identification Information

– The product catalogs and drawings serve to provide a framework for identifying the different kinds of products prior to weighting each kind of output in the mix. Only after proper weighting can the outputs be aggregated.

(2) Accounting Information

– Depending on the sophistication of the accounting system in use, the weighting of each kind of output may or may not be feasible from accounting records alone. With a detailed cost accounting system (having data of allocating labour, material and overhead costs to each kind of product) all the requisite information may be available.

In the case of *service* or *indirect activities* for which *output identification* is seldom available, even sophisticated cost accounting systems tend to lump together functional costs regardless of the product mix or its change from period to period. Hence subsequent to the use of some technique for identifying the different kinds of service outputs, some type of *work measurement* is usually necessary to assist in allocating the different costs (weightings) to the different kinds of products prior to aggregation.

(3) Work Measurement Information

– Work measurement is used here to refer to the use of any technique to determine the amount (and kind, if desired), of *labor* required to produce each kind of output in a base period. Such information is needed to complete almost all productivity computations other than those for raw materials.

Productivity Measurement System

– A productivity measurement system has the following basic components. These components are phrased in a manner that enables them to be applied to any kind of organization i.e., manufacturing, mining, service, government–profit seeking or non-profit seeking.

Components:

1. A statement of the objectives of the organisation.
2. A list of the units of output of the organisation.
3. Standard time, standard cost, raw material use, equipment use, tool use etc., for each kind of output.
4. A method of building a zero base budget using forecasts of outputs, standard times and forecasts of the productivity.
5. A means of computing the productivity indexes at selected intervals.
6. A means of comparing output forecasts with actual output at selected intervals.
7. A means of adding resource usage data and associated productivity indexes in a meaningful fashion related to outputs to reduce the details in reports as data go to higher-and higher-level managers.

SHEETAL GAUTAM

3

Organisation

3.1. CONCEPT OF ORGANISATION

- Almost any business manager will affirm that sound organization is highly important to business success.
- Many will characterize organisation as the foundation upon which the whole structure of management is built.
- Organisation is a *mechanism* or *structure* that enables living things to work effectively together.
- Organisation may be defined as the process of (i) *identifying and grouping* the work to be performed, (ii) defining and delegating *responsibility* and *authority* and (iii) establishing *relationships* for the purpose of enabling people to work most effectively together in accomplishing objectives.
- Organisation is the pattern of ways in which a large number of *people* engaged in a complexity of *tasks, relate* themselves to each other in systematic establishment and *accomplishment* of mutually agreed purposes.

Organisation :

(*i*) establishes the pattern of relationship by giving duties and responsibility to an individual or group;

(*ii*) demarcates the authority, responsibility and duties of each individual or group;

(*iii*) provides adequate communication; and

(*iv*) coordinates or integrates and controls the activities of individuals or groups to achieve common objectives or objectives of the business enterprise.

For more details refer article 15.3.

3.2. IMPORTANCE OF ORGANISATION

- Sound organization can contribute greatly to the continuity and success of the enterprise.
- The importance of organization can be judged from the following words of *A. Carnagie,* an American Industrialist:

  "Take away our factories, take away our trade, our avenues of transportation and our money. Leave nothing but our *organisation*, and in four years we shall have re-established ourselves".
- *Facilitates Administration*: A properly designed and balanced organisation facilitates both management and operation of the enterprise; inadequate organisation may not only discourage but actually preclude effective administration.
- *Facilitates growth and diversification* : Sound organisation permits organizational *elaboration.*
- The organization structure can profoundly affect the people of the enterprise. Proper organisation *facilitates* the *effective use of the manpower.*

- *Stimulates creativity*: Sound organisation stimulates independent, creative thinking and initiative by providing well defined areas of work with broad latitude of the development of new and improved ways of doing things.
- *Optimum use of resources*: Sound organisation structure permits optimum use of *technical* and *human* resources. The organization can introduce latest technological improvements e.g. computers, computerized machines etc. It can also make optimum use of human efforts through specialisation, by placing right persons in the right positions etc.
- A sound organization leads to *specialization*.
- A sound organization minimizes *corruption* and inefficiences.
- A sound organization does not generate *confusion*. There is less *wastage* and *expenditure*.
- A sound organization facilitates the *training* and *managerial development* of personnel.

3.3. CHARACTERISTICS OF ORGANIZATION

The characteristics or essential features of an organisation are:

(*a*) Organisation is a group of people, small or large.

(*b*) The group works under an executive leadership.

(*c*) Organisation is a tool of management.

(*d*) It leads to division of work and responsibilities.

(*e*) It defines and fixes the duties and responsibilities of employees.

(*f*) It establishes a relationship between authority and responsibility and controls the efforts of the group.

(*g*) Organization is a step towards the achievement of established goals.

3.4. ELEMENTS OF ORGANIZATION

By *elements* of organization, we mean the main parts or *components* of an organization.

- The main components of the organisation are:

(*a*) Well defined objectives.

(*b*) Well organised and coordinated group of people.

(*c*) Proper division of work and labour.

(*d*) Clear and well defined policies and procedures.

(*e*) Proper division of Authority and Responsibility.

(*f*) An effective system of communication.

3.5. THE PROCESS OF ORGANISATION

The process of organisation may be described as the managerial function of organising. The important steps involved in the process of organisation are:

(a) Determination of objectives

- Objectives decide as to why the proposed organisation be set up (purpose) and what will be the

nature of work to be accomplished through the organisation.

(b) Deciding various activities

– To achieve the objectives, the process of organisation is divided into functions, sub-functions and further sub-functions to be performed by an *individual*. The principles of division of work, specialization etc. are followed. This avoids duplication, confusion and wastage of men, machine, money and material.

(c) Grouping of activities

– Activities of similar nature (or closely related ones) are grouped under departments, sections or divisions. These may be grouped on the basis of use, coordination, policy and control etc. There may be different departments in an enterprise like Personnel, Finance, Purchase, Production, Sales etc.

(d) Assignment of responsibilities of definite persons

– Specific job assignments are made to different persons (subordinates) for ensuring a certainty of work performance. Right man is put on the right job.

(e) Delegation of Authority

– Corresponding to the responsibility given to a subordinate, authority is delegated to him, to enable him to show work performance.

(f) Providing physical facilities and proper environment

– Provision of right type of physical facilities and environment is essential for the smooth running and prosperity of the organisation.

– *Physical facilities include* – Proper machinery, tools etc.

– *Right environment* means proper lighting, ventilating and heating/cooling arrangements at the place of work, reasonable hours of work, rest intervals, safety devices, job security, job satisfaction and above all human approach by management.

3.6. ORGANISATION THEORY

Concept

– Organisation theory may be defined as the *study* of (i) structure (ii) functioning and (iii) performance of organisations AND (iv) the behaviour of groups and (v) individuals working in organisations.

– Organisation theory explains how organisations are actually *designed* and it offers suggestions as how they can be *constructed* to improve organisational effectiveness.

– Organisation theory helps people understand, diagnose and respond to *organisational needs* and *problems*.

Objectives/usefulness of

– The basic *objective of organisation theory* is to (i) furnish a general frame of reference for understanding and explaining behaviour of patterns in organisations, and (ii) for providing scientific basis for managerial actions concerned with predicting, controlling and influencing these behaviours, with a view to improve organisational effectiveness.

- Organisation theory helps managers in exploring, analysing and explaining what is happening in the organisations.
- In a very real sense, organisation theory can make a manager more competent and more influential. Understanding how and why organisations act, lets managers know how to react.

Different Organisation Theories

Various organisation theories have been and are being evolved. These theories may be grouped into three broad categories namely :-

(A) Classical Organisation Theory

(B) Neo-classical Organisation Theory

(C) Modern Classical Theory.

3.6.1. CLASSICAL ORGANISATION THEORY

Concept

- The classical writers have viewed organisation as a *machine* and persons as different *components* of that machine.
- The classical theory has its origin in the writings of Taylor. However the main ideas of this Theory have been developed by Mooney, Brech, Allan and Urwick.
- As per Classical Theory, where organisation is treated as machine, the efficiency of the organisation can be increased by making each individual efficient in it. For instance, Taylor emphasised on division of labour, fixing every day's work etc.
- The emphasis is more on specialisation of performance and coordination of various activities.
- Classical theory completely ignores the *human aspects* of organisation and deals exclusively with the formal structure that should be in an organisation.

Key Pillars (or Characteristics) of Theory

(*i*) *Divison of Labour*

- It refers to the division of the organisation task into subtask and then allot these subtasks to individuals in such a way that each individual would have the narrowest task so that he can specialise himself in that task with a view to improve the efficiency of the organisation.

(*ii*) *Scalar and Functional Processes*

- Scalar and functional processes deal with the *vertical* and *horizontal* growth of the organisation respectively.
- The *scalar process* deals with the *vertical* elaboration of organisation. The scalar process refers to the growth of the chain of command, the delegation of authority and the unity of command from the top (chief executive) to the bottom (first line supervisor); and obligation and reporting from the bottom to the top. Whenever there are two persons in an organisation existing in a superior subordinate relationship, there is a *scalar* relationship.
- The *functional* process focuses on the *horizontal* elaboration of the organisation. The functional process refers to the division of organisation into *specialised* parts and the regrouping of the parts into compatible units. Two experts such as a Legal Adviser and a Manager Industrial Engineering working in the same organsation have *functional* relationship.

(iii) Structure

- Structure is the framework of the formal relationship among various persons (tasks and activities) in the organisation.
- Proper structure, by introducing logical and consistent relationship among various functions, determines how effectively and efficiently an organisation will perform. The basic structural element in the classical theory is the *position*. These positions are grouped together in various ways – either horizontally, vertically or both *line* and *staff* relationships.
- People and departments that are authorized to determine the basic *objectives* of the organisation and assess the achievements constitute the line function, for example, a production manager. The *staff function* is that part of the organisation which assists and advises the line function on specialized matters. For example, an Industrial Engineer or a Personnel Manager is a staff function.

(iv) The Span of Control

- In order to achieve the objectives of the organisation, a manager has to look after the works of several subordinates in a large organisation. However, a manager cannot effectively supervise unlimited number of subordinates because he has a limited time and energy.
- The span of control refers to the number of subordinates a manager can supervise effectively.
- Classical theory puts a limit on the span of control. According to *Urwick*, no superior can supervise directly the work of more than five or six subordinates.

Criticisms of Classical Theory

(i) Criticisms of principles

- The classical principles are mainly based on experience and not tested by researches.
- Lack of universality.
- The classical theory is based upon the hierarchical structure that establishes the authority (superior-subordinate) relationships between individuals in an organisation. Today, not this concept, but the technological specialisation with authority is gaining importance.
- Classical theory suggests unity of command i.e., each person has only one superior. Today, due to introduction of specialized staff functions, work is carried out under *multiple command*.

(ii) Unrealistic assumptions

- The Classical Theory assumes the organisation – a closed system – a house that, once created will work smoothly.
- Static view of organisation. That the organisation is not dynamic and it does not adopt any change whatsoever.
- Unrealistic assumptions about human behaviour. The theory assumes human beings as inert machines.
- That people at work can be motivated solely through economic rewards.

(iii) Excessive reliance on the strength of key pillars

- Division of labour causes depersonalisation of work at the operative level which results in loss

of human relationships.

- Narrow span of control is not fit for the present environment.

(*iv*) *Bureaucratic behaviour*

- *Weber's* ideal bureaucracy, the main constituent of classical theory, suggests the strict adherence to rules and regulations through mindless application of the letters of the rule. In today's world where problem-solving ability, innovativeness and creativity are required, the bureaucratic approach appears to be inadequate.

(*v*) *Neglect of human factor for focus on Anatomy of Organisations*

- The Classical Theory does not envisage the development of informal groups and there is no room for emotions and sentiments of people at work. The Theory recognises tasks and not the people.

(*vi*) *Little scope for integration*

- The Classical Theory provides little scope for integrating people with the organisation. Goal setting and decision-making is by the *top* without consulting the subordinates.

3.6.2. NEO-CLASSICAL ORGANISATION THEORY

Concept

- The neo-classical theory has introduced the *human relations* approach in the classical theory of organisation.
- The *neo-classicists*, view organisation as a combination of formal and informal forms of organisation. The informal part (form) was missing in classical approach.
- The inspiration of the neo-classical theorists were the *Hawthorne Experiments* conducted by Mayo and his associates from 1924 to 1932.

Difference between Classical Theory and Neo-classical Theory

	Basis	*Classical Theory*	*Neo-classical Theory*
1.	Structure	Impersonal, mechanical	Organisation is a social system.
2.	Focus	On work and economic needs of workers	On small groups. On emotional and human qualities of employees
3.	Emphasis	On order and rationality	On personal, security, and social needs of workers while achieving objectives of the organisation.
4.	Behaviour	Orgnisational behaviour is a product of rules and regulations	Behaviour is a product of feelings and sentiments and attitudes.
5.	Practices	Authoritarian practices, elaborate rules and regulations to obtain results.	Democratic practices. Involvement of employees in decision-making. Recognises the importance of human dignity and values.
6.	Results	Work alienation, dissatisfaction	Happy and satisfied employees trying to increase production.

Propositions of Theory

The main propositions of Neo-classical Theory are listed below:

(1) The organisation in general is a social system composed of several interacting parts.

(2) The social environments on the job affect people and are also affected by them.

(3) Besides formal organisation, informal organisation also exists and it affects and is affected by formal organisation.

(4) Integration between organisational and individual goals is a must.

(5) People are interdependent and their behaviour can be predicted in terms of social factors.

(6) Money is only one of the motivators but not the sole. Men are diversely motivated and socio-psychological factors are more important.

(7) Man's approach is not always rational. He behaves irrationally as far as rewards from the job are concerned.

(8) Both way communication is necessary for sound functioning of the organisation.

(9) Team work is essential for higher productivity.

Criticisms of Neo-classical Theory

Though, neo-classical theory is an improvement over the classical theory, it offers a more humanistic view towards people at work, recognises informal group, group norms, informal leader, non-economic retwards etc, even then it is subject to certain *criticisms* as explained below.

(1) *Certain assumptions are not true* and as a result there are conflicts in the interests of various groups in the organisation.

(2) The Theory has limited applicability and is not suitable for all organisations.

(3) It lacks unified approach of the Organisation Theory.

(4) The Theory lays more emphasis on human aspect and other aspects of the organisation have been ignored or neglected.

3.6.3. MODERN ORGANISATION THEORY

Concept

- The Modern Organisation Theory is of recent origin having developed in sixties and flourished in seventies. The source of inspiration for modern theory is the Systems Analysis.
- The modern theory has an *analytical base*, it relies on *empirical research* and above all has, *integrating* nature. It is highly constructive.
- The theory views the organisation as a *system* and studies it in its totality as a complex system of human interrelationships.
- The theory gives answers of many complex questions ignored by classical or neo-classical theorists. The important questions are

(*i*) What are strategic parts of the system ?

(*ii*) What is the nature of their interdependency ?

(*iii*) What are the processes which link various parts of the system and facilitate their adjustment to each other ?

(*iv*) What are the goals of the system.

(*i*) Parts of the System

– Organisation being a system has the following five parts :-

(1) *Individual*

– An organisation is nothing but collection of individuals who have united to achieve its goals.

– Individuals enter the organisation with varied backgrounds, attitudes, motives and sentiments. They interact and influence each other and the things in the environment and are also influenced by them.

(2) *Formal Organisation*

– Formal organisation structure is the vehicle for uniting the individuals and their efforts to achieve organisational goals.

– Formal organisation has certain laid down principles, rules, regulations, procedures and norms of conduct for its proper functioning.

– A well defined structure of the organisation provides the guidance, consistency and control essential to achieve a productive unified effort.

(3) *Informal organisation*

– It comes into existence automatically alongwith the formal organisation because, while at work, individuals interact and develop certain relations and sentiments – positive, negative or indifferent.

– The informal organisation has its own goals, objectives and authority patterns and these factors may or may not coincide with those of the formal structure.

– Informal organisation is the primary source for the information and furtherance of *social ties*.

– Informal groups satisfy many of the social needs, remained uncared for by the formal organisation.

(4) *Status and Roles*

– Every organisation has a prescribed pattern of *roles* the individuals play. The roles differentiate one *position* from another.

– *Role* may be defined as a pattern of actions expected of an employee in the organisation.

– According to the roles, the individuals perform, their *status* or rank is determined.

(5) *Physical setting/environment*

– Physical setting implies the physical conditions (say shop floor conditions) under which a person has to do the work.

– Physical environment or working conditions affect efficiency level.

(ii) Nature of interdependency

– The above explained five parts of the system, work unitedly, cooperatively and in collaboration with each other. They interact within and between themselves. Such interactions are of two types :

(1) *Interpart interactions* in which each part of the organisation interacts with all other parts. An individual may mould the group according to his point of view and then the group may put their viewpoint before the organisation.

(2) *Intrapart interactions* in which an individual performs a minute part of the total job and even for that limited task he is to seek assistance from others, such as a lathe operator needs the services of maintenance-man. The individual's job may be a part of the series of processes involved.

(iii) Linking Processes

No part of the system works in isolation. They are interdependent and interlinked. The *linking* is achieved by three linking processes namely :-

(1) *Communication*

Through communication process, various parts are able to get, store, retrieve and feed information. The communication may be formal-informal, vertical-horizontal and line-staff.

(2) *Decision-making*

– All parts of the system make decisions and most of the decisions, especially the important ones are the result of joint efforts of various parts. Thus, the decision-making process links the various parts.

– Two classes of decisions are important viz. *decisions to produce* and *decisions to participate*.

Interaction between employees and demands of organization results in decisions to produce.

Decision to participate depends on the demands and rewards of organization.

(3) *Balance*

Balance refers to an equilibrating mechanism whereby the various parts of the system are maintained in a harmoniously structured relationship to one another.

(iv) Goals

– Every system including the organisational system has certain goals.

– Almost all organizations have at least *three major goals* namely *growth, stability* and *adaptability*.

– *Interaction* is essential ingredient so that all the subsystems in combination produce the output.

Appraisal of Modern Organization Theory

(A) The *validity* of the modern theory is appreciated on the following grounds :-

(1) Modern theory considers organizational unit as *open system*. It essentially consists of five basic elements – input, transformation process, output, feedback and environment.

– Being open system, it continually interacts with the external environment ; the basic purpose of interaction is *survival*.

– Unlike closed system, the open system operates even in the event of dynamic and ever changing environment.

(2) Unlike *classicists* static structure, modern theory is *dynamic* in interaction with the structure. It is constantly subject to change as environment changes. Organisation *adapts* itself suitably to the changing environment and it survives.

(3) Modern Theory is both *macro* and *micro* in its approach. It is micro when considered with respect to the entire nation or industry. It is macro with respect to internal parts of the organisation. Hence the theory is *multi-level* and *multi-dimensional.*

(4) In contrast to *classical, modernists* view individual as complex being who can be motivated in multitude of ways. Modern Theory is thus *multi-motivated.*

(5) Modern Theory is *multidisciplinary* in the sense that it heavily draws its concepts from the various disciplines such as economics, sociology, engineering, psychology, anthropology etc., for problem solving and decision-making.

(6) Modern Theory does not dispute the principles of both the earlier theories but suggests that they are incomplete in the sense that they deal only with structural aspects and overlooked the totally integrative systems approaches to human process in the organisations.

(7) According to system's approach, the total system should be studied as a whole and not in parts.

– Though the Modern Theory has contributed a lot to the organisation, yet it is not free from criticisms:

(1) The Theory has not lived up to the expectations it raised at the beginning. It promised to provide an adequate and comprehensive explanation of organisation, but this promise does not seam to be fulfilled.

(2) Though critics regard it an important theory of organisation, it has not yet developed sufficiently as a theory of explanation in the relam of human behaviour.

3.7. PRINCIPLES OF ORGANISATION

Introduction

– A principle is a general rule or truth that may be expected to apply under similar conditions anywhere.

– Organising being a universal problem for all business concerns, many principles have been designed as guidelines in considering the organisational needs of a concern and for successful organisational relationships.

– Principles of organisation assist in arriving at the final structure of an industrial organisation to carry out the basic objectives of the organisation.

A few common **principles** *of organisation have been listed and explained below :*

1. Consideration of objectives.
2. Relationship of basic components of the organisation.
3. Responsibility and authority.
4. Span of control.
5. Dividing and grouping work (including coordination).
6. Effective delegation.
7. Communication.
8. Line and staff relationships.

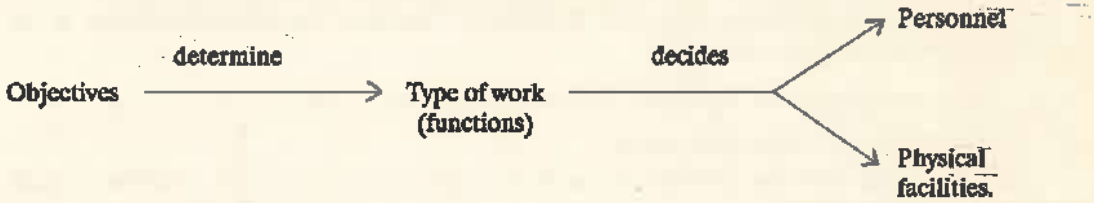
9. Balance, stability and flexibility.

(1) Consideration of Objectives

- Since the objectives of the enterprise have an important bearing on the organisation structure, only those objectives should be taken up and accomplished for which there is real need in the organisation e.g., measures may be taken to increase productivity, improve product quality etc.

(2) Relationship of Basic Components of the Organisation

- Objectives as decided in step-I above determine the work to be performed and the type of work dictates the selection of Personnel and physical facilities.



(3) Responsibility and Authority

- *Responsibility* means accountability. It may be considered as the obligation of a subordinate to his boss to do a work given to him.
- *Authority* means right (to command) and power to act.
- Since the top man in the organisation cannot do each and everything himself alone, a definite chain of responsibility and authority is provided from the top executive to each employee, of course through several levels or layers in between.

  As far as possible a person should take direct orders from only one superior and he should know to whom he is accountable.
- Lines of responsibility should be made very clear in order to facilitate ready flow of communication and control.
- Authority empowers the superior to make a subordinate to do the work. Everybody in the organisation, from top level downwards, possesses some authority to secure cooperation from subordinates.
- Lines of authority should be very clearly established in the structure of organisation in order to avoid overlapping actions, omission of acts etc.
- Authority and responsibility must go together if the goals of the organisation are to be achieved efficiently and effectively.
- Whenever an employee is made responsible to accomplish a particular task, he must be given due authority also to control and direct efforts towards completing the task.
- When an employee is authorised to take up a job, he is held responsible for its performance also.
- Whereas authority to command and act can be delegated, the responsibility cannot. The responsibility of the boss for the acts of his subordinates is absolute. The chief executive is still held responsible for poor quality of the products made by his subordinates.

- Since every action involves an element of risk in decision, the best course of action would be that a decision should be arrived at from the pooling of judgement of all those (*e.g.*, chief executive and a team of staff specialists) who share in authority and responsibility for the situation in question.
- Everybody in the organisation structure must understand the limits of his authority and responsibility, *i.e.*, he should know where his responsibility and authority start and stop.

(4) Span of Control

(*i*) *Span of control* or *span of management* refers to the number of subordinates that report to an executive or the number of subordinates that an executive can supervise directly.

(*ii*) An executive should not have more subordinates looking to him for guidance than he can reasonably be expected to serve ; because

(*a*) the executive has limited time available for his activities, and

(*b*) he has limited available energy.

(*iii*) Depending upon the conditions of the business enterprise, the span of control may be any number varying from 2 to 20.

Some writers have concluded that ideal span is between four and eight ; but it is fairly common to see as many as twelve or more workers reporting to a foreman.

(*iv*) If the span is small, an executive may tend to oversupervise and may do even spoon feeding to his subordinates. On the other hand if the span is large, the executive may not be able to supervise his subordinates efficiently and they may start thinking that they are too remote from the point of control and may become careless or they may feel that they are impersonal and unimportant part of the organisation machinery.

(*v*) The *span of control varies with and depends upon the following considerations:*

1. Trained and experienced subordinates need less directions and hence a large number of them can work under one executive.

2. Span of control can be large for workers, all doing specialised and same work at one table or very close to each other. For example, wider spans are suitable for assembly line work or routine clerical jobs.

3. For maintenance and R & D departments and other departments which require many policy decisions and coordination with the work of others, a small span of control is the ideal.

4. A small span of control is also ideal when a number of employees are working in isolated areas, doing different type of works and require close supervision and control.

5. Complex nature of work demands a small span of control.

6. Span of control even for the same nature of job varies from executive to executive and depends upon his capacity to guide and work.

7. Wider span of control can be employed if the organisation and its control system are efficient and communication is good.

8. Span of control can be widened by providing personal assistant to an executive ; because a good P.A. can offset a good amount of routine work-load associated with a wide span of control.

9. Span of control is decidedly small for an executive who goes to the extent of checking each and every action of his subordinates.

10. A wider span of control can be employed in an organisation which has clear and definite objectives, policies and plans with no confusion in the minds of employees ; and if each employee knows about his job (work), duties, responsibility and authority.

11. Besides certain weaknesses of a wider span and control [refer (iv) above], it has an advantage also (but not always) ; since the executive personally is unable to supervise the actions of all his subordinates, he will have to delegate authority to his subordinates who in turn will be forced to learn their jobs better and hence acquire a sense of accomplishment, responsibility and high morale.

(5) Dividing and Grouping Work (including coordination)

(*a*) **Dividing.** Divisionalisation provides a broader perspective, a greater sense of responsibility on the part of the personnel and more clear-cut control over profits. Head of each division has a considerable freedom to act and adopt to local needs.

(*b*) **Grouping.** Departmentation i.e., the process of grouping is essential for *specialisation* and *coordination*.

(*c*) **Specialisation.** Specialisation may be in terms of product, process, labour etc. Specialisation is essential for attaining familiarity and proficiency within a particular area of activity. A specialised person understands his job thoroughly and is in a better position to do and further improve the work or product etc.

(*d*) **Coordination**

- Coordination means weaving together the segments of an organisation into a coherent whole in such a way that all parts operate at the most efficient level and produce maximum profit.
- Coordination is necessary to hold the specialised parts together and to have one suitably big team than a lot of little ones.
- Coordination unifies the purposes and efforts of the employees working in a concern.
- *Coordination can be achieved through :*

1. *Cooperation* of both executives and subordinates.
2. Good *human relations*.
3. *Understanding* of the goals or objectives of the organisation (common to everybody in the organisation).
4. *Communication*, i.e., effective means of communication among the people working for the organisation.

- An organisation makes use of the following tools for achieving coordination:

(*i*) Organisation chart

- An organisation chart helps understanding organisational relationships.
- An organisation chart shows the groupings of major activities into departments and the main lines of authority and responsibility among these departments.

(*ii*) Organisation Manual

- Whereas an organisation chart shows only job titles and their relationship to each other, organisation manual outlines in detail all the duties and responsibilities for different positions the chart shows.
- **Organisation Manual**

(*i*) makes everybody clear as what he is to do and what is his authority ;

(*ii*) eliminates overlapping of duties and responsibility, and

(*iii*) is valuable in training new personnel.

- An organisation manual is written information about the various positions in an organisation and is generally kept in loose leaf form to facilitate revision which is very necessary if the (organisation) manual has to remain useful and purposeful.

(*iii*) **Standard Practice Instructions**

- They describe how the various tasks are to be performed in the organisation.
- Examples of various tasks and operations are—receiving materials from the suppliers, calculating vacation salaries, requisitioning supplies etc.

(6) Effective Delegation

- Effective delegation is said to be existing when an executive instead of doing all the thinking for the unit himself, passes down to his subordinates any task on which they can take decisions themselves and perform it efficiently and effectively.
- By doing so, the executive gives a chance to his subordinates to think and to develop and at the same time keeps himself free to deal with managerial responsibilities such as handling special problems that arise, co-ordinating, planning improvements etc.

(7) Communication

- Communication serves as a linking process by which parts of an organisation are tied together.
- Communicating means transmitting instructions and information within the organisation and to outside customers, suppliers, etc., *i.e.,* to all those who are affected.
- Since, employees in any organisation possess different levels of education and ability, an ineffective and improper communication may lead to fears, mistrust, confusion and even strikes.
- Good communication is essential if all employees are to know what to do in order to achieve the goals of the organisation.
- For better results, it should be a free two-way communication. Not only the executive should pass down information to the subordinates, there should be feedback, *i.e.,* replies should come from those also who are given instructions.
- A narrow span of control improves communication, helps implementing decisions correctly, and the executive can visualise a clear picture of the effects of his decisions.
- **Types of Communication**

(*i*) *Downward communication i.e.,* the transmission of instructions and information from top executive downwards to the lowest grade employee.

(*ii*) *Upward communication i.e.,* the transmission of feedback, orientation, complaints, suggestions for improvements etc., from the lowest grade employees to top executive.

(*iii*) *Horizontal communication i.e.,* the transmission of information between persons having the same level of authority in the organisation.

(*iv*) *Unofficial communications* or rumours which are inevitable in any organisation, sometimes, may be correct but they present the distorted picture. The damaging effects of such unofficial communications can be minimized by effective official communication.

- *Communication systems and equipments.* Communication systems and equipments have been

discussed in chapter 7.

(8) Line and Staff Functions

– All activities of an organisation can be classed into two main categories :

(*a*) Primary activities, and

(*b*) Supporting activities.

For example, in Army, Infantry and Artillery perform primary activity, i.e., fighting whereas Corps of EME, AMC (Army Medical Corps), ASC (Army Supply Corps) etc., perform different supporting activities.

Primary activities or line functions are those which contribute directly and vitally to the objectives of an organisation. Examples of line functions in a business organisation are production, sales, etc.

Supporting activities or staff functions are those that aid the line or are auxiliary to line functions. Examples of staff functions in a business organisation are Accounting, Administration, Personnel, Maintenance, etc.

The concept of line and staff functions is very valuable in organisational planning.

(9) Balance, Stability and Flexibility

(*a*) **Balance.** All units of an organisation should be balanced (i.e., developed in proportion to its contribution to the overall success of the organisation).

– In the absence of such balance (between different units or departments), the goals of the organisation cannot be achieved economically and effectively.

– For example, if the purchase department is underdeveloped (i.e., it has neither adequate staff, nor resources, nor authority, etc.) as compared to other departments, it will seriously handicap the firm that may otherwise be very strong and modern in Production and Sales.

(*b*) **Stability.** Organisational stability refers to the capacity to withstand the losses of key personnel (if they leave to join another concern) without serious loss to the effectiveness of the organisation in performing its work.

– A long range planning programme with regard to manpower requirements accompanied by positive executive training and development programmes will add to the organizational stability.

(*c*) **Flexibility.** Organisational flexibility specifies the capacity to adjust work assignments, personnel and facilities to temporary changes in the volume of work. Flexibility is the ability to bend and blend without (and before) experiencing any serious setback.

3.8. ORGANISATIONAL STRUCTURE

Concept

– No organisation can work without people. *Organisation structure* simply means the *systematic arrangement* of the people working for the organization in order to achieve predecided goals.

– *Organisation structure* is concerned with the establishement of positions (persons) and the relationships between positions.

– The structure provides an appropriate framework for authority and responsibility relationships between various positions.

– The organisation structure is generally shown on an *organisation chart.*

– The structure has *two* dimensions i.e., horizontal and vertical.

The *horizontal* dimension defines the basic *departmentation*. Departmentation is the process of division of the enterprise into different parts i.e., smaller, flexible administrative units.

The *vertical* aspects of the structure relate to the creation of a hierarchy of superiors and subordinates, leading to the establishment of a managerial structure.

Taken together, horizontal and vertical aspects set the formal structure of the organisation (Fig. 3.1)

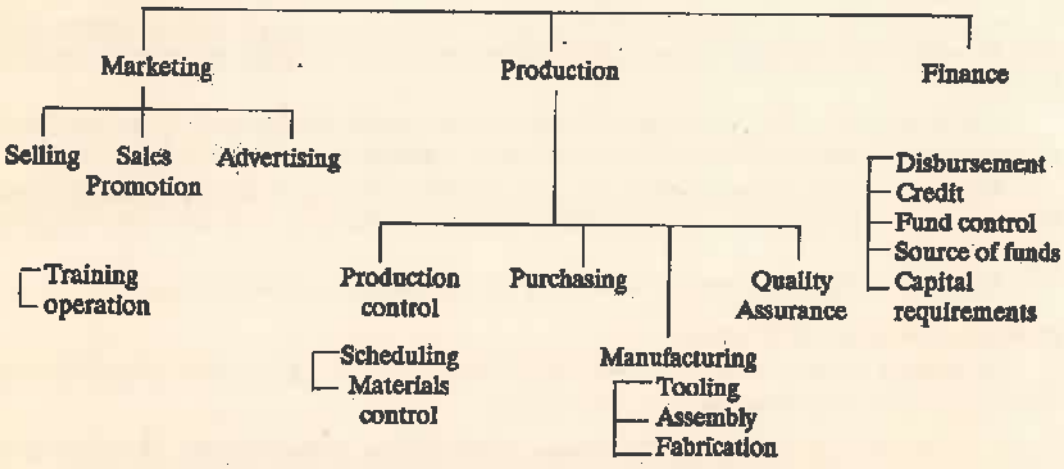


Fig. 3.1. Organisation structure of a manufacturing concern.

– Organisation has *informal structure* too which arises spontaneously out of the activities and interactions of people.

Need for

1. The organisation structure is designed by the management to achieve *specific goals*.
2. The organisation structure facilitates in fixing the *responsibility* departmentwise, sectionwise or on individual basis. It is necessary for timely completion of work.
3. It is necessary for the establishment of *authority*. It also clarifies one's authority.
4. It helps in achieving the desired level of *coordination*.
5. It promotes *division of work* and leads to specialisation.
6. Since organisation structure clearly defines the authority and responsibility, it avoids confusion, duplication, wastage and inefficiencies.
7. Organisation structure facilitates the flow of information and decision-making from one level to another.
8. Organisation structure defines the positions and units within the organisation.

3.9. DESIGN OF ORGANISATION STRUCTURE

Introduction

– In designing the structure of an organisation, there are two main *considerations:*

1. *Differentiation*
2. *Integration*

- *Differentiation* means *differences* in cognitive and emotional orientations among managers in different departments and the differences in the formal structure of these departments.
- *Integration* refers to the quality of the state of *collaboration* that is required to achieve unity of effort. Various departments are integral part of the whole system.
- Design structure of one department may be different from that of the other, because each department is interacting with the *environment* in a different way. Environments are of two types:

(*i*) *Internal environment :* Everything within the organisation, including its workers, managers, working conditions and culture.

(*ii*) *External environment :* The environment outside the organisation, for example suppliers of raw material and energy, customers, competitors, government agencies etc.

- The overall objective of organisational designing should be integration of activities and authority roles and relationships existing in different departments.

Steps involved in Organisation Design

The procedural steps involved are:

(*i*) Understand and formulate the objectives and goals of the organisation and the nature of business to be carried out.

(*ii*) Determine the functions necessary to achieve the objectives of the organisation.

(*iii*) Related functions e.g., Inventory Control, Production Control and Quality Control, can be grouped together.

(*iv*) Examine all the functions and outline the various positions to be filled to take up those functions.

(*v*) Prepare job descriptions, duties and responsibilites of each position.

(*vi*) Fill up all the positions by recruiting suitable persons either from outside or from within by upgrading the existing personnel after giving them extensive appropriate training.

3.10. ORGANISATION CHART

Concept

- Organisation chart is the result of organisation design.
- Organisation chart portrays graphically the structural relationship among the different functions (departments) and the positions (persons) in the enterprise who are responsible for those functions.
- Organisation chart shows – how the dynamic activities of a concern are coordinated into a working unit.
- Organisation chart which is also known as *organisation tree* is nothing but a map or drawing of the organisation. Fig. 3.2 shows an organisation chart.

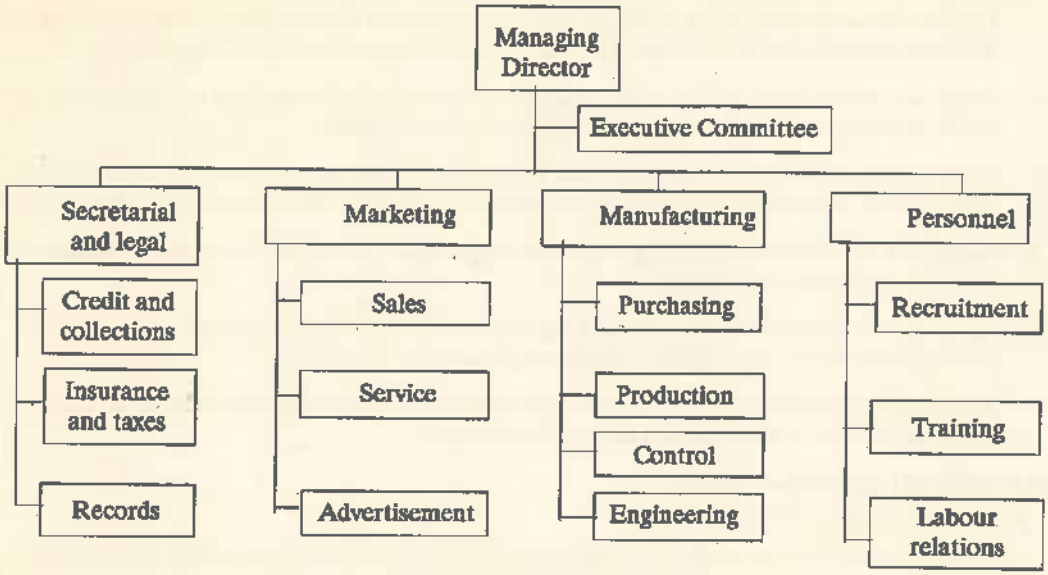


Fig. 3.2. Organisation chart.

An Organisation Chart shows

1. The interrelationship and relative position of each department of the company.
2. The lines of command, *i.e.,* Authority and Responsibility.
3. Relationships between different managers (*i.e.,* by virtue of their status in the organisation).
4. Kinds of managerial relationship which exist (*i.e.,* line, staff and functional).
5. Sometimes, the names of managers along with the number of persons they supervise.
6. And brings to notice an illogical grouping of functions.
7. And pinpoints the omission of a particular function.

Advantages of Organisation Chart

1. An organisation chart tells quickly as who is responsible for a particular function.
2. It pinpoints the weakness of the organisation (refer points 6 and 7 above).
3. Information contained in the organisation chart suppplements the details available in organisation manual.
4. An organisation chart can serve as a training device and as a guide in planning for expansion.
5. An organisation chart is useful in showing the nature of organisation, and changes, if any, in the existing staff and the new-comers.

Limitations of Organisation Chart

1. An organisation chart needs frequent updating.
2. It shows a static picture of the dynamic business.
3. It induces certain structural rigidity and may encourage red tape. This is because an organisation chart marks definite channels through which information must flow. Short cuts, sometimes, may improve efficiency.
4. It is very difficult to portray human relationships on an organisation chart.

Use. Besides certain weaknesses, an organisation chart serves very useful purpose especially when it is drafted by an expert.

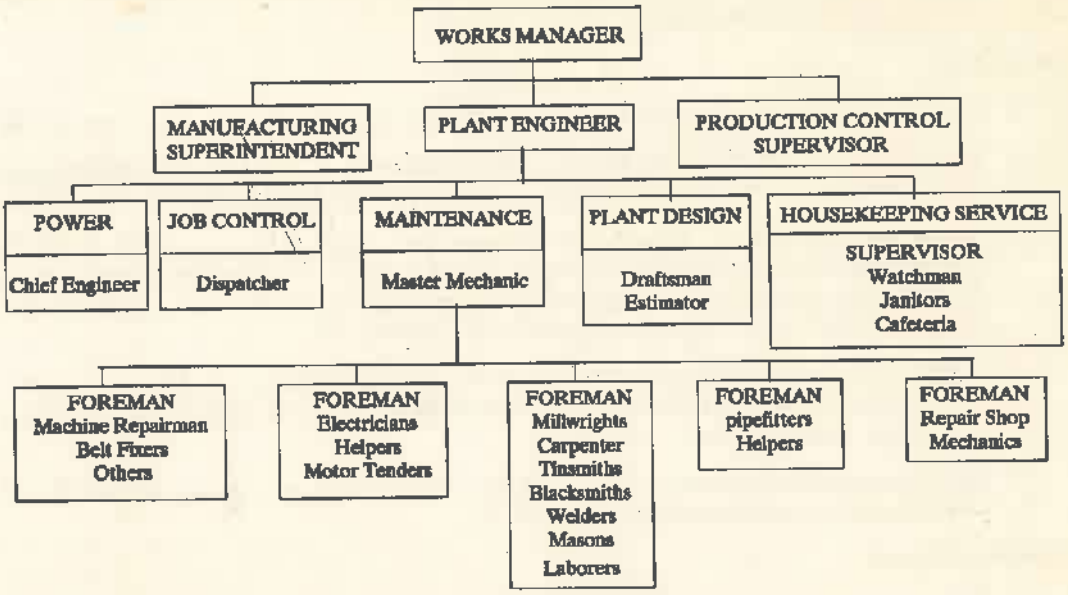


Fig. 3.3. Organization chart of a plant maintenance department.

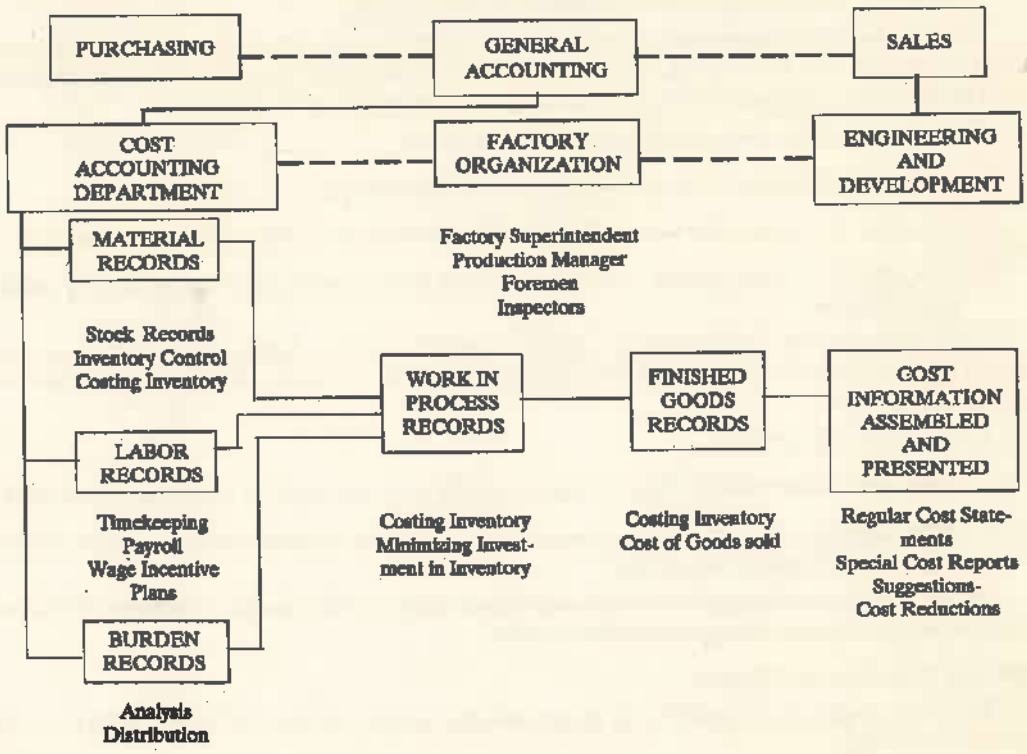


Fig. 3.4. Functional chart of the organization of a cost department.

3.10. ORGANIZATIONAL MANUAL

Introduction

- *Organization charts* are sometimes supplemented in large organizations by *organization manuals.*
- *Organization manuals* may simply be in the form of brief notes, accompanying the departmental charts to explain the functions of each department and its relationships with other departments.
- At the opposite extreme, organization manuals may consist of volumes which detail the responsibilities and authority of different posts and the procedures to be adopted in carrying out different tasks. Clearly this is only appropriate where a high degree of control is both desirable and practicable. This is true of some governmental departments.
- In brief, organization manual sets down in the form of a booklet all the details of the organization, its objectives and policies, authorities, functions, duties and responsibilities of each unit and all information relating thereto.
- Copies of organization manual should be available with top managers and also be available for inspection within each department and division.

Contents of Manual

- It is particularly important to include all pertinent material related directly to the company organization in the manual, so that managers at all levels can use it as a convenient source of reference. The manual should contain the following data:

1. *Statement of Company objectives and policies.* Organisation objectives and policies, in particular, should be spelled out. These state, the Company organization aims and specify those management decisions related to organization which are binding on all managers in the Company.

The Company *organization objectives* may be as follows:

(*a*) To arrange *functions* so that personnel can perform their job most effectively.

(*b*) To create an organization which will offer the greatest opportunity for individual *development.*

(*c*) To organize each unit so that the corporation may take full advantage of growth and expansion opportunities.

2. *Glossary of terms.* To establish a common nomenclature for administrative terms used in the manual, it is advisable to establish a glossary of management terms such as Accountability, Executive, Supervise, Work etc.

3. *Organization procedures*

- What standard methods will the Company require of all managers in organization matters?
- What organization work must be done the same in all units so that it will fit the pattern of over-all company organization activity?

Organization procedures prescribe such uniformity. They may be prepared to include such matters as reporting organization changes and similar matters.

Reporting Organization Changes

If effective organization control is to be maintained, there should be clear channels for reporting organization changes.

In most cases, changes should be approved by the accountable manager but cleared through the organization planning specialized staff.

Organization Manual

Introductory part	Administrative part	Procedural part
– Nature of enterprise	– Purpose of manual	– Instructions related to the performance of standardized jobs
– Objectives of enterprise	– Policies of management	– Instructions related to the performance of non-standardized jobs
– Location of enterprise	– Discussions of major organizational problems	– Specimen forms to be used
– Organization structure	– Job descriptions	
	– Rules and regulations	
	– Organization charts	

Types of Organization Manuals

(*i*) *Policy manual* states the policies of the enterprise. It describes the overall limitations within which activities are to take place.

(*ii*) *Operations manual* informs employees of established methods, procedures and standards of doing work.

(*iii*) *Organisation manual* explains the duties and responsibilities of various departments and their respective sub-divisions, responsibilities and authorities of different employees, etc.

(*iv*) *Rules and regulations manual* informs about the operating rules and employment regulations such as hours of work, procedure for taking leave etc.

(*v*) *Departmental practice manual* deals in detail with the internal policies, organization and procedures of a particular department.

Advantages of organization manual

(*i*) Since it contains rules, regulations and various instructions, it enables the employees to learn the various procedures and practices in short time.

(*ii*) Since instructions and policies are clearly stated, it is easy and quick to take decisions.

Drawbacks of Organization Manual

(i) Manual preparation is costly and time-consuming.

(ii) Since rules, regulations etc., are all predecided, it leaves little scope for individual's initiative and discretion.

3.11. TYPES OF ORGANISATION (FORMAL)

Concept

– The structure of one industrial organization differs from that of another organisation and it (*i.e.*, structure of an organisation) depends upon:

(*i*) Size of the organisation.

(*ii*) Nature of the product being manufactured.

(*iii*) Complexity of the problems being faced.

- Organisation structure marks lines of authority, responsibility and co-ordination.
- A few commonly known forms of organisation structures or types of organisations are:

(*a*) Line, Military or Scalar Organisation.

(*b*) Functional Organisation.

(*c*) Line and Staff Organisation.

3.11.1. Line, Military or Scalar Organisation

- It is the simplest form of organisation structure, (Fig. 3.5).
- It was called military organisation because it resembled to olden military organisations.
- Line organisation is based upon relative authority and responsibility rather than on the nature and kind of operation or activities.
- The authority flows directly from the Works Manager (WM) to Superintendent to Foremen (F/M) and from them to workers.
- Line organisation is direct and people at different levels know to whom they are accountable.
- The immediate superior (or boss) gives orders to the subordinates, assigns duties, dismisses and takes disciplinary action against them.
- Any enterprise that starts small probably starts with a line type of organisation.

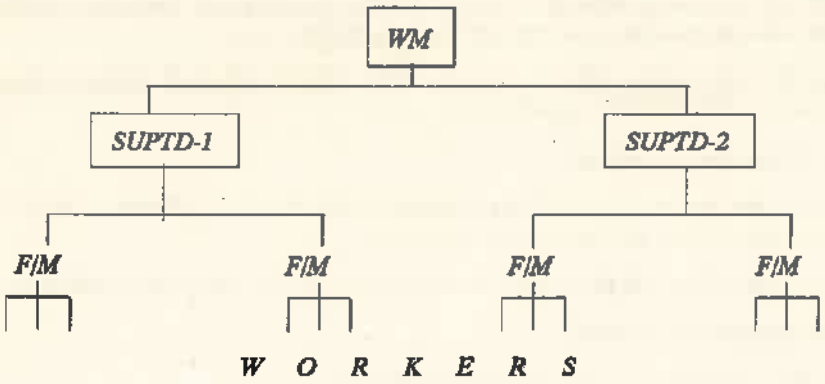


Fig. 3.5. Line Organisation.

Advantages

(*i*) It is simple and easy to understand.

(*ii*) It is flexible: easy to expand and contract.

(*iii*) It makes clear division of authority.

(*iv*) There is clear channel of communication, with no confusion at all.

(*v*) It encourages speedy action.

(*vi*) It is strong in discipline as it fixes responsibility on an individual.

(*vii*) It is capable of developing the all-round executive at the higher levels of authority.

Disadvantages

(*i*) It neglects specialists.

(*ii*) It overloads a few key executives.

(*iii*) It requires a high type of supervisory personnel to meet the challenges imposed in the absence of specialists as advisors.

(*iv*) It is limited to very small concerns.

(*v*) It encourages dictatorial way of working.

(*vi*) In line organisations provisions are seldom made to train, develop and replace top executives.

(*vii*) Due to lack of specialisation perhaps there is more wastage of materials and manhours.

Applications. Line organisation is suitable for,

(*i*) small concerns free from all complexities; and

(*ii*) automatic and continuous process industries such as paper, sugar, textile, etc.

3.11.2. Functional Organisation *(Fig. 3.6)*

- F.W. Taylor suggested functional organisation because it was difficult to find all-round persons qualified to work at middle management levels in the line organisation.
- Functional organisation is also a line type of organisation with the difference that instead of one foreman (which being master or specialist of everything and therefore hard to find) there are eight functional foremen; four of them located on the shop floor and remaining four in the office, but everyone having direct and equal authority over the workers.
- Each functional foreman who is a specialist in an acitivity is incharge of one function, *e.g.*

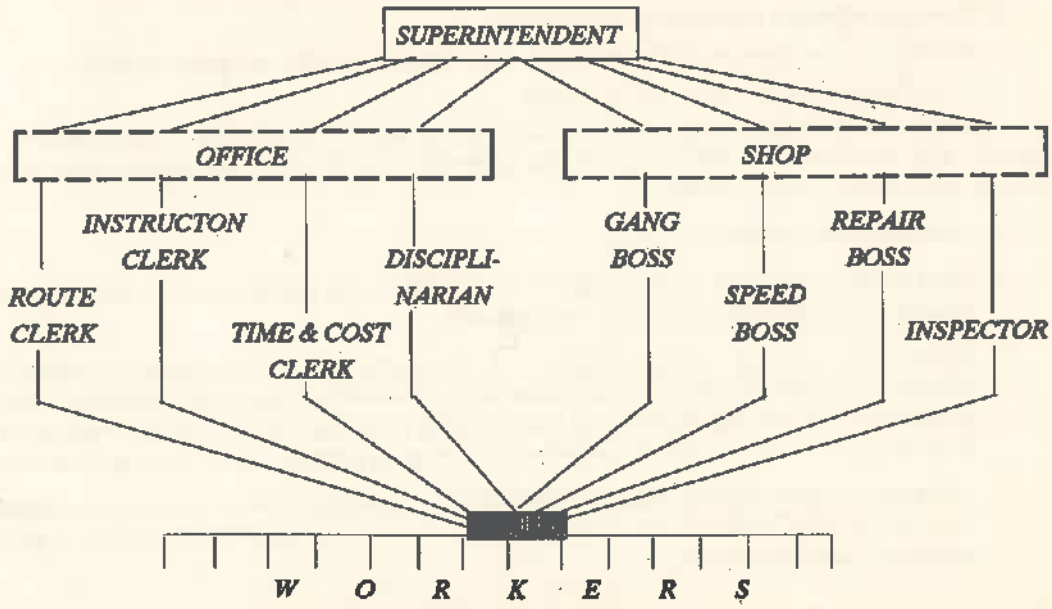


Fig. 3.6. Taylor's functional organisation.

1. Route clerk or order of work and route clerk was incharge of issuing work orders and routing the jobs.

2. Instruction clerk would issue specifications and instructions related to jobs to the workers.

3. Time and cost clerk keeps records pertaining to the time (the workers have spent in doing work) and cost (*i.e.*, worker's wages etc.)

4. Disciplinarian keeps personal records of the workers and handles cases of insubordination.

5. Gang boss has the charge of the preparation of all work up to the time that the work piece is set in the machine.

6. Speed boss ensures that proper cutting tools are being used, cut is started at right place in the workpiece, and the optimum speeds, feeds and depths of cut are being employed.

7. Repair boss is responsible for adequate repairs and maintenance of equipment and machinery.

8. Inspector or Inspection boss looks after and is responsible for the quality of the product.

Advantages of Functional Organisation

1. Since a foreman is responsible for one funtion, he can perform his duties in a better manner.
2. Functional organisation makes use of specialists to give expert advice to workers.
3. It relieves line executives of routine, specialised decisions.
4. Expert guidance reduces the number of accidents and wastage of materials, man and machine hours.
5. It relieves pressure of need to search a large number of all-round executives.
6. Quality of work is improved.

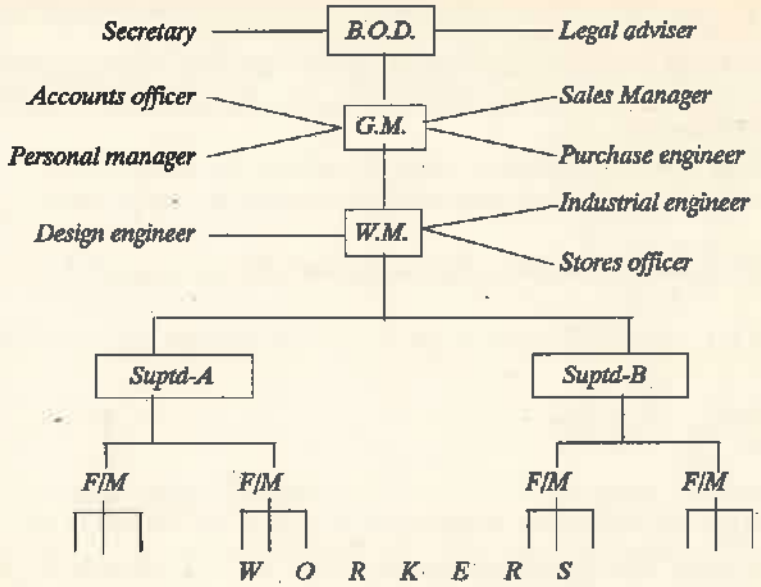
Disadvantages

1. Coordination of the efforts of various functional foremen is difficult.
2. It is difficult to maintain discipline as each worker is responsible to eight foremen.
3. It is very difficult to fix up the responsibility to any one foreman in case something goes wrong.
4. Workers always remain confused about the authority and activity of each foreman.
5. It makes industrial relationships more complex.
6. Workers are not given opportunity to make use of their ingenuity, initiative and drive.
7. All-round executives cannot be developed.

Applications. For these reasons (disadvantages), the functional organisation as such is obsolete ; however in the modified form, employing the principles explained above, it is frequently used in some most modern and advanced concerns.

3.11.3. Line and Staff Organisation

- The line organisation gradually developed to shape as the line and staff organisation ; Taylor's functional organisation hastened its development.
- As the industry grew in size and complexity, the line executives could not perform properly all other functions (besides looking after production) such as R & D, planning, distribution, legal, public relations, etc. This necessitated the employing of special executives to assist line executives and they were known as *staff* as they were recruited to perform staff or specialist functions.
- The line executives retain supervisory authority and control over the work of their subordinates whereas the staff executives relieve line executives of certain specialised work and advise them on matters referred to them.



B.O.D. : Board of Directors
G.M. : General Manager
W.M. : Works Manager
Suptd. : Superintendent
F/M : Foreman

Fig. 3.7. Line and staff organisation.

- The final decision whether to accept and implement the recommendations of the staff executive remain in the hands of the line executive.
- Fig. 3.7 shows a line and staff organisation. The line executives are marked vertically whereas staff executives are placed horizontally.
- A variation of line and staff organisation is **Line and Functional Organisation** in which the staff or specialist executive has full authority (i.e., a higher degree of authority than in a line and staff organisation) over his particular function which may be inspection, work study, purchasing, employment, etc.

Advantages of Line and Staff Organisation

1. Expert advice from specialist staff executives can be made use of.
2. Line executives are relieved of some of their loads and are thus able to devote more attention towards production.
3. Less wastage of material, man and machine hours.
4. Quality of product is improved.
5. There is no confusion as exists in functional organisation.
6. Line and staff organisation possesses practically all the advantages of both the line and functional organisations.

Disadvantages

1. Product cost will increase because of high salaries of staff executives.

2. At times the staff department may infringe upon the rights and responsibilities of the line organisation, thus weakening the line organisation when its (i.e., staff department's) true function is to strengthen this organisation.

3. Line and staff organisation may get confusion in case functions are not clear.

4. Frictions and jealousies if developed between line and staff executives may cause harm to the enterprise.

5. Line executives if they start depending too much on staff executives may lose their initiative, drive and ingenuity.

Application. Line and staff organisation is very common among the medium and larger enterprises.

3.12. COMMITTEES

Concept and Need

- A committee is a group of people who work collectively, discuss, decide and recommend solutions to the problems (of a concern) which possibly cannot be solved by an individual.
- A committee consists of a group of men conversant with a subject; naturally their advice will be much superior to that of one man.
- Committees work very well in large complex corporate organisations having multifaceted problems too big and too complex to be dealt effectively by one person.
- In a committee, ideas put forth by several persons are pooled and offered for criticism; the ideas are developed and thus recommendations are made as regards procedure and policies.

Principles

1. The number of persons in a committee should depend upon the need and be optimum minimum (about 5 to 10 persons).

2. Responsibility, authority, objectives and duties of the committee should be clearly defined.

3. Agenda of the committee should be prepared and communicated to the committee members at least a week before they meet for discussions.

4. Problems which can be taken care of by an individual should not be included in the agenda of the committee.

5. Committee meetings should begin and end on prefixed timings.

6. Problems not related to the subject-matter at hand should not be discussed because it will simply waste time.

7. The operation of the committee should be a cooperative development.

8. The recommendations made by the committee should be published and circulated to interested and concerned persons.

The committee should be apprised of the action taken based upon its recommendations.

9. A committee must be dissolved after its purpose is over.

Types

(*a*) A Standing or Permanent Committee.

(*b*) A Temporary Committee.

(*c*) The Committee in Control

(*d*) The Coordination and Discussion Committee.

(*e*) The Advisory Committee.

(*f*) The Educational Committee.

(*a*) A *standing or permanent committee* is needed in a complex organisation experiencing multifaceted problems almost all the times.

(*b*) A *temporary committee* is formed to face and solve problems arising occasionally.

(*c*) *The committee in control* has full powers to act and may assume a position that could be manned by one individual.

(*d*) *The coordination and discussion committee* discusses problems and gives its advice. It has no power to act.

(*e*) *The advisory committee* explores various aspects of a problem and suggests courses of action to the concerned executive, thereby helping him to reach the decisions for which he is held responsible. The committee does not have power to act. Advisory Committee is used extensively in business.

(*f*) *The educational committee* aids in getting information about company problems, policies and projects to major individuals concerned. It also gives an insight into the ultimate company organisation, etc.

Advantages

1. A committee often performs worth while tasks since two experts are better than one.

2. A committee coordinates the efforts of the departments which are represented (e.g., sales, production and engineering) in development of a new product.

3. A committee is of special value in broad policy determination and rounding out plans.

4. A committee reduces the work load of management.

5. Committees are especially good at innovation or *brain storming*.

6. A committee helps securing co-operation of various personnel.

7. A committee is effectively used to appoint persons to fill vacant positions in the enterprise.

8. Committee meetings may be called to train younger executives and to give them a keener insight into the operation of the business.

Limitations

1. Sometimes it turns out to be true that what a committee finishes in a week, a good individual may complete in a day.

2. It may be said that committee operations are slow and committees tend to hang on for a considerable time.

3. An executive afraid to stand behind his own decisions may use a rubber-stamp committee and thereby share his responsbility with others.

4. In a committee, no individual can be held responsible for anything.

5. Committee decisions represent generally a compromised position and do not truly reflect the real feelings of the individual committee (or group) members.

3.13. PROJECT ORGANIZATION

Introduction and Concept

– When an already existing organization finds it difficult to cope up with the new situations, it

decides to launch a *project organization*.

- In order to accomplish the project goals, a separate division is created for each project. Project organization is created when the project is big in size and subject to high standards of performance.
- A project organization is solely responsive to the planning, design, development, production, evaluation, and support of a single system or product.
- A project organization is timelimited, directly oriented to the life cycle of that system, and the commitment of the varied skills and resources required is purely for the purpose of accomplishing system tasks.
- A project team is created consisting of specialists from different departments of the existing organization. The specialist of each department gets the services and support of its members as and when required. The activities of the project team are co-ordinated by the *Project Manager*. The project team which consists of the best talent is meant to achieve a specific and complex undertaking within time, cost and/or quality parameters.
- In brief, the project structure is a vehicle for bringing specialised people together in flexible groups for as long as a particular need exists, but no longer.

The project structure reduces the inflexibility and inefficiency of traditional organization structures in which permanent departments tend to remain even after they have outlived their utility.

Need for project organisation

Running enterprises go for project organisation if :-

(1) The project is a one time task with well defined specifications and the firm wants to continue to concentrate on its regular activities.

(2) The project presents a unique or unfamiliar challenge.

(3) Successful completion of the project is critical for the enterprise/organisation.

(4) The project is to be completed within the given time limit.

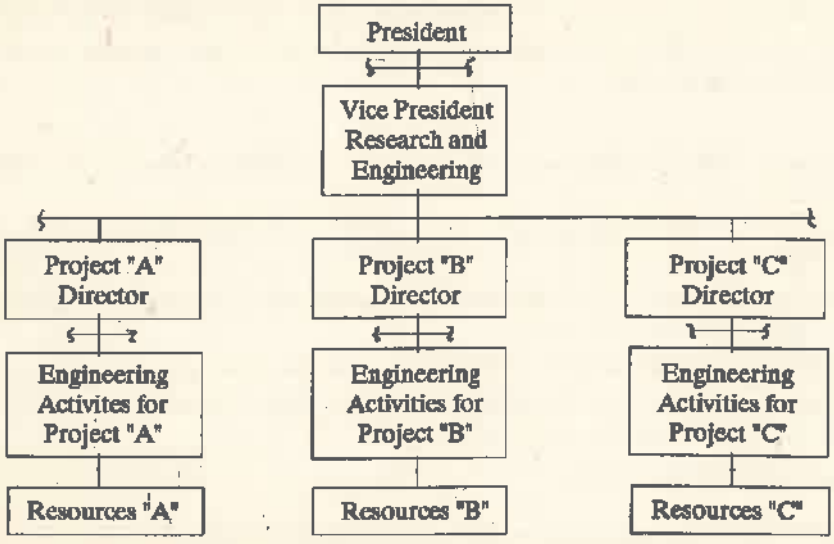


Fig 3.8. A simplified pure project organization.

Advantages of project organisation

(*i*) It does not interfere with the existing organization.

(*ii*) It provides concentrated attention that a complex project demands.

(*iii*) It allows maximum use of specialists available in the enterprise.

Limitations of project organization

(*i*) Project manager has to deal with persons of varied nature and interest.

(*ii*) Every one working in the existing organization is attracted to the projects.

(*iii*) Since work differs from project to project, experience gained in one project may not be relevant to other projects.

(*iv*) Project work being temporary, there is quite uncertainty and insecurity of job for specialists hired from outside.

(*v*) Decision-making is very difficult because there are unusual pressures from specialists from diverse fields.

(*vi*) There may be conflicts among the specialists.

3.14. MATRIX ORGANIZATION

Introduction and Concept

- Matrix organization is used when an organization has to handle a variety of projects, ranging from small to large.
- When a *pure project structure* is superimposed on a *functional structure*, the result is a *matrix structure*.

In other words, the *matrix organization* is a *project organization* plus a *functional organization*.

The *project structure* provides a horizontal lateral dimension to the traditional vertical orientation of the *functional organization* structure (Fig. 3.9).

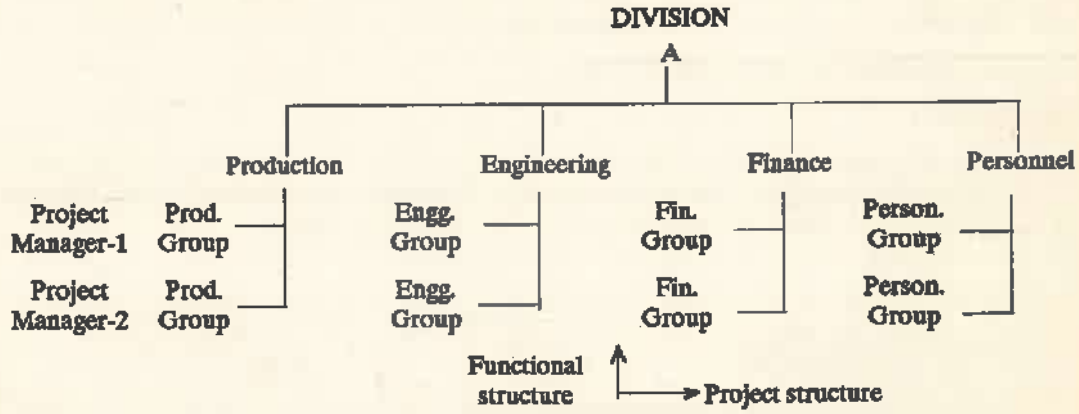


Fig. 3.9. Matrix Organization.

To conclude, matrix organization is created by merging (two complementary structures, namely) pure project organization and functional organization.

– The project teams are composed of *persons* drawn from the functional departments for the duration of the project. When their assignment is over, they return to their respective departments.

– During continuation of the project, such *persons* have two bosses – one, from the functional department and second of the concerned project.

Advantages of matrix organization

(*i*) If effectively focuses resources on a single project, permitting better planning and control to meet deadline.

(*ii*) It is more flexible than a traditional functional hierarchy.

(*iii*) Services of specialists are better utilized as more emphasis is placed on the authority of knowledge than rank of the individuals in the organizational hierarchy.

Limitations of matrix organization

(*i*) Matrix organization violates the principle of unity of command as a person works under two bosses e.g., project manager and functional boss. This may give rise to conflicts in the organization.

(*ii*) Organisation relationships are more complex and they create problems of coordination.

(*iii*) Since persons are drawn temporarily from different departments, project manager does not have line authority over them.

(*iv*) Project group is heterogeneous and due to which morale of the personnel may be low.

Use of matrix organization

– The matrix organization is used in the following industries:

Electronics	Aerospace
Chemicals	Banking
Industrial products	Insurance
Advertising	Hospitals etc.

3.15. THE INFORMAL ORGANIZATION

Introduction

– Fig. 3.10 shows informal relationship (shown dotted) on top of a formal organization chart. In every organization there also comes into being a set of informal relationships through which the employees attempt to fill needs which are largely personal in nature.

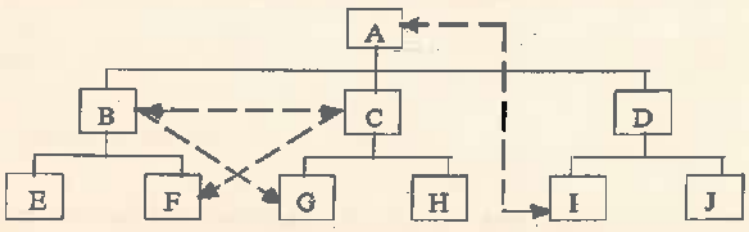


Fig. 3.10. Informal organization (shown dotted).

- Informal relationships are developed due to a number of reasons. Some persons are natural leaders and other persons go to them for advice regardless of the position they occupy in the formal organization (shown in firm line in Fig. 3.10 above).
- Some persons band together in small informal groups drawn by common interest. Such groups take tea and lunch together; they meet one another after the working hours also.
- Social activities are probably the largest cause of informal relationship.

Advantages

1. Informal relationships, many times, result in things being done quickly and more efficiently.

2. Such relationships fill employee needs for social acceptance and provide needed diversion from work pressure.

3. Labour problems may be minimized by recognising natural leaders of the employees, keeping them well informed and consulting them in making decisions which influence the interest of the employees.

Disadvantages

1. Fig. 3.10 shows that there is an informal relationship between employee *A* and employee *I* though there is a large difference between their positions in their formal organization. This may create favouritism to the detriment of overall employee relations and animosity may make for inefficiency and breakdown of respect for superiors.

2. Confidential information may leak from a top level executive to a comparatively much lower level employee and then spread among many other employees.

3. Rumours may spread very fast in the organization.

3.16. ORGANISATION STRUCTURE AND ITS COMPATIBILITY TO MANAGEMENT OBJECTIVES

Organisation Structure

- *Formal Organisations* are contrived social entities designed to fulfill specific purposes.
- Organizations constitute a group of individuals of varying levels of expertise combined into a social structure of some type to accomplish one or more functions.
- The purpose of organising is to achieve the most effective utilization of human, material, and monetary resources by the establishment to accomplish specific objectives. The purpose, of course, is to maximise the productive output and minimize waste.
- The *organization structure* consists simply of those aspects of the *pattern of behaviour* in the organization that are relatively stable and that change only slowly.
- *Structure* implies the *pattern* in which various parts are interrelated or inter-connected. *Organisation Structure* establishes the relationships among various *positions* and *activities* in the organization and as because such positions are held by individuals, it prescribes relationships among people in the organization.
- All organizations have a structure.
- Organization structure will vary with the organization and the *functions* to be performed. The results will depend upon the *goals* and *objectives* established, the resources available, the communications and working relationships of the individual participants, motivation and many other factors.
- The organisation structure is the result of conscious planning process and is typically expressed in *Organization Charts, manuals* and *position descriptions.*
- Organization structure is designed by the management to achieve specific *objectives.*

Management Objectives

- Before a definite organization structure can be established, the applicable firm's top management must first develop the *overall* goals and objectives for the firm so that there is *compatibility* between the organization structure and the management objectives.
- Overall goals and objectives may be, for example, the following:

(*i*) What technology should the firm attempt to develop?

(*ii*) What product lines should be pursued?

(*iii*) What is the desired market position? Productivity? Profitability and growth? Product leadership?

- Overall goals may be stated both qualitatively and quantitatively and may include *financial objectives, marketing objectives, research and engineering objectives* and *production objective*. A few characteristic examples are noted below:

(*i*) Achieve a 15% return on investment for the next fiscal year.

(*ii*) Reduce the yearly operating cost by 12%

(*iii*) Complete the design and development of a new prototype in 12 months within a cost of Rs. 600,000.

(*iv*) Develop three new product lines within the forthcoming fiscal year, with a forecasted sales of not less than Rs. 2,000,000.

(*v*) Increase the production yield of product Z by 10% in 3 months.

- Initially, goals and objectives must be identified for the overall firm. Based upon the results it is possible to determine what activities need to be accomplished, which in turn leads to the grouping of these activities and the definition of an organization structure.
- Goals and objectives may be stated in rather general terms or in a specific manner. Actually, to be meaningful, they should be as specific as possible and related in quantitative measures where appropriate, to allow for a realistic assessment of organisational status and trends.
- The process of establishing goals and objectives often is quite dynamic, since changes may occur as a result of economic and social conditions, technology advances, and so on.

Structuring the Organization

- Once overall goals and objectives have been initially established, the next step is to develop an organisation structure that will be compatible with the goals and objectives. The organization structure should be such that it will respond to the requirements and in accomplishing the goals and objectives set by the management.
- The establishment of organization patterns, or the *development of an organization structure*, generally evolves from the following:

(*i*) The identification of work to be performed (e.g. research, preliminary system design, detailed design of a unit etc.) and the breakdown of this work into specific tasks are accomplished initially through product planning. These tasks are organised into work packages and the designed work packages are evaluated from the standpoint of task type, complexity, and the required completion schedule.

(*ii*) The individual work packages are then grouped on the basis of similarity and homogeneous characteristics to determine positions.

The positions, in turn, are arranged within an organization structure. This arrangement should be compatible with the goals and objectives discussed on page 3-31 and the principles of organisation described on page 3-10.

Additional factors should include the projected available resources required for staffing and support, past history (i.e., success and failures), and the geographical divisions of acitivity that will directly influence the results.

3.17. DEPARTMENTATION

Introduction

- When the size of an enterprise grows, the number of employees (persons) also increases. There is a limitation on the number of persons an enterprise can manage directly. This limitation restricts the size of enterprise if the enterprise does not opt for the device of *Departmentation (i.e. horizontal differentiation).*
- Departmentalisation is the process of breaking down an enterprise into various departments.
- Hence, departmentation or grouping of activities into departments is very essential because it limits the number of subordinates (man power) to be supervised by a manager ; it would have otherwise been very difficult to manage a team of large number of subordinates by a single superior and thus the size of the business enterprise would be very limited.
- Identifying and grouping of similar activities on some logical basis so that a team of persons can be organized in order to attain the objectives of the enterprise may be called *departmentation.*
- A department is a work group combined together for performing certain functions of similar nature. The process of division of the enterprise into different parts is broadly called *departmentation* or *departmentalisation* and it is done for the purpose of administration.

Aims of Departmentation

(*i*) To group activities and personnel to make manageable units.

(*ii*) To bring specialisation in the performance of various activities.

(*iii*) To fix responsibility of the heads of various departments for the achievement of organization goals.

Advantages of Departmentation

(*i*) Since every-one knows precisely his duties and authority, the *efficiency* of the enterprise increases.

(*ii*) As jobs are well-defined and responsibilities well clarified, it is easy to fix accountability for the results.

(*iii*) The departmental managers are given opportunity to take initiative and learn new managerial skills.

(*iv*) Departmentation provides a basis on which top management can coordinate the activities of different departments.

Methods of Departmentation

Departmentation is the process which is used to group the activities of the enterprise into various divisions for the purpose of efficient management. Different methods of creating departments in an enterprise are discussed below :-

(a) By Function

- Departmentalization by function is shown in Fig. 3.11, wherein the activities of the organization are divided into the primary *functions* to be performed—*manufacturing, marketing, engineering, research and development, employee relations and finance.*

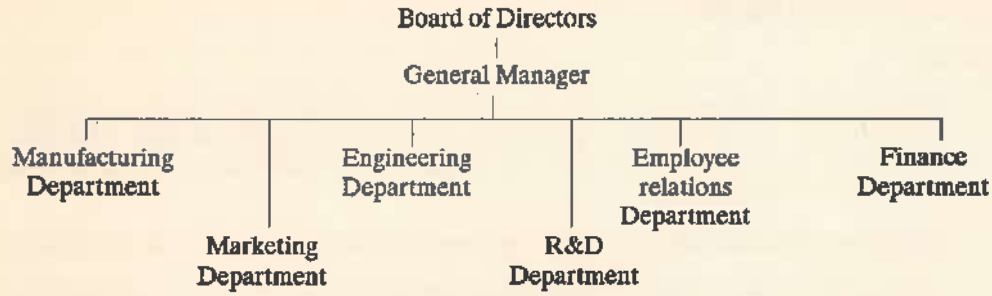


Fig. 3.11. Departmentalization by Function.

- This arrangement has the *advantage* of the specialization and concentration of similar activities within a departmental unit. It is the most prevalent form of departmentalization and is seen not only in business enterprises but in hospitals, government agencies and many other kinds of organizations.
- The major *problem* associated with this form is the coordination of the specialized activities.

(b) By Product

- Product departmentalization has become increasingly important, especially for large, complex organizations.
- Under this category, large organizations, have major product divisions with substantial autonomy.
- In departmentalization by product, product lines are segregated and each product line has its own manager, its own manufacturing, selling etc.
- An automobile industry, for example, may departmentalise its activities as follows :-

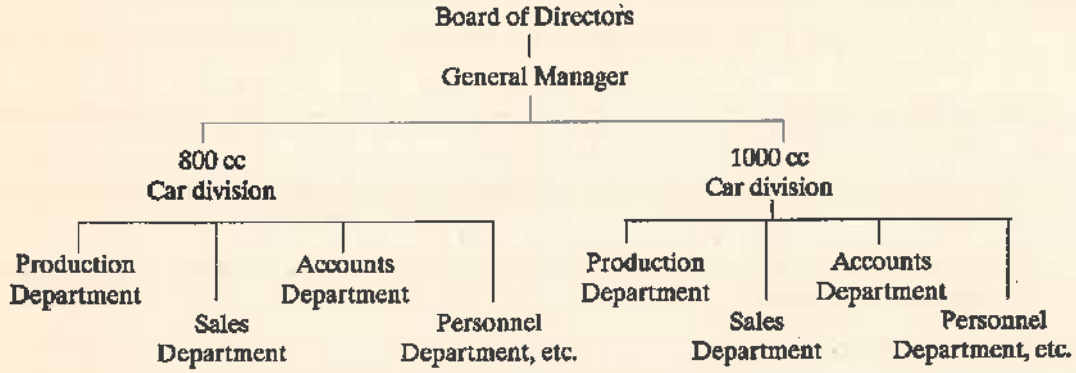


Fig. 3.12. Departmentalization by product.

Advantages of departmentalization by product

(*i*) Each product division could be considered as a viable profit centre for accountability purposes. It is easier to evaluate the performance of each product line. Unprofitable product lines may be dropped. Moreover, proper attention can be given to each product.

(*ii*) The problem of coordination as present in departmentalization by function is removed here.

(*iii*) Classification by product permits to make a maximum use of specialization in technical skill, managerial knowledge and capital equipments.

Defects of departmentalization by product

It increases management cost; duplicate service functions are required both at the top and operating levels of management. High cost of operation prevents the small and medium-sized concerns from adopting this basis of classification, particularly for creating major units.

(c) Departmentalisation by Customers or Markets

- *Sales* is the exclusive field of its application.
- To give individual attention to the diverse groups of buyers in the market, sales activities are often split into several *parts*.
- When the products are offered to an extensive market through numerous channels and outlets, it has the special merit of supplying goods according to the peculiar needs of customers.

(d) Departmentalisation by Territory

- Market area is broken up into sales territories and a responsible executive is put in charge of each territory.
- The *salesmen* of each territory report to their regional or *territorial manager* who in turn is in communication with the *sales manager*.

(e) Departmentalisation by Process

- The manufacturing activities may be sub-divided on the basis of their *process of production*. Similar machines such all lathes, all drilling machines, all shapers etc., are grouped into *separate* sections, each kept at one place and used for a distinct *operation* on the job.
- This arrangement works alright for job order work and is unsuitable for mass production.

In actual practice, no single method of grouping activities is applied throughout the organisation structure with all its levels. In reality, a single organization may employ one or all of the bases of departmentalisation at the same or various hierarchial levels.

3.18. MATCHING PEOPLE TO JOBS

Introduction

- The basic tasks of describing jobs and seeking the right people to do them can be considered as two different activities, perhaps requiring different skills, but the manager must appreciate that success of the organisation will only follow after a careful *matching operation*.
- On the one hand, the manager must be clear about the *job requirements,* on the other, he must be equally clear about the *sort of person* he is looking for.
- The sources of manpower supply and chosen method of attack in finding the person, will be of little value unless the *matching problem* is understood and allowed for.
- At times, even after offering high salaries, and involving expensive recruiting and selecting campaigns, managers find themselves asking why they were not able to get their man. The choosing opportunity is not that of the manager's alone, it is very much a two-way business, and it is quite likely that the manager (or job offer) be turned down by the person the manager wants. The reason for this lies in the matching aspect of the situation and failure to recognize

(*i*) Why people work and

(*ii*) Why people work for you.

Why people work—motivation

- Generally people work because they need to earn money. But money does not explain, why some people do the jobs they do when they could get more money by doing other jobs, why some people work to full capacity while others do the bare minimum with which they can get away.
- Research conducted in this subject has shown that, in the working situation, there are certain aspects of the *job* and the *environment* which, if below a certain standard, will lead to extreme dissatisfaction. These are called *hygiene or maintenance factors.* Other aspects, which if introduced or improved, would lead to extreme satisfaction and are called *motivators.* All these aspects may be grouped together and summarised as :

(*i*) *Salary*

This can be more widely interpreted as financial reward and the word is self-explanatory in the above context.

(*ii*) *Security*

Job insecurity is the main concern. Besides, arrangements for *sickness* and *accident* problems as well as *retirement* cannot be neglected and will, undoubtedly, be *demotivators* or *dissatisfiers.*

(*iii*) *Status*

- Status does not mean the possession of things visible as status symbol.
- Status is a sign of being important to the job and the business, of mattering, caring or belonging.
- This is a status consideration which makes a person feel good, wanting to do more and do better because he has been noticed, wanting to grow to greater importance by doing more important work.

(*iv*) *Satisfaction*

- Satisfaction in having achieved something, having done something worth doing and important to the organization.
- Satisfaction leads to development or growth in a situation receptive to growth, where the contribution of those motivated by the opportunity, to make it, will lead to a more profitable business.

Why people work for you

The relationship between *job descriptions* and *matching* people to the jobs is a close one. The answer to the question why people work for you is contained in this matching process. The *man's needs* must be satisfied by the job's requirements and this is the equation that must be used.

Man's needs

- A man will only stay in a job if it is satisfying his needs and continues to satisfy his developing needs as he moves up the hierarchy list. Some people will have their needs completely satisfied before reaching the top of the list; others will need to go the whole way.
- If people are going to work for a manager he must be aware of their hierarchy of needs and make it possible for these to be satisfied in the job provided; if they are not, his staff will look for satisfaction elsewhere.

– Different needs are

(*i*) *Physiological needs* : food, clothing, shelter.

(*ii*) *Safety needs* : Security, order.

(*iii*) *Belonging needs* : love, affection, identification.

(*iv*) *Esteem needs* : success, self-respect.

(*v*) *Self-fulfilment needs* : achievement, growth.

– The lack of attention to the satisfaction of human needs is at the root of the *turnover* problem.

The matching process

– Some final thoughts on matching are again related to the job description which identifies the following four component needs still of interest for matching.

(*i*) *Knowledge* starting with education both full- and part-time, knowledge gained in working elsewhere, from leisure activities, social and recreational.

(*ii*) *Skill.* While knowledge may be both general and specific to a job, skill is usually related to a job or category of job.

(*iii*) *Experience* implies the passing of time and familiarity by having done something repeatedly, or at least once before. Total experience will include that of life, perhaps enabling the formation of opinion or judgement, perhaps ability to make good decisions, which will be valuable assets to any manager if he knows which of his staff possesses them. There is an experience need.

(*iv*) *Personality* is shaped by background, family environment and way of life. It will be the foundation for developing interest and growth and will strongly influence the factors of the situation which motivate. There is a personality need.

– In matching the job, *performance requirements* and *personal qualities* of an individual must be seen.

Much information about an individual can be obtained through *Interview, Psychological test, Aptitude test, Trade test* etc.

– So it is now possible to be specific about the components of matching in the working situation:

(*i*) What does the job require by way of knowledge, skill, experience and personality ?

(*ii*) What does the person need and what is he capable of contributing, by way of knowledge, skill, experience and personality to his manager's situation ?

The manager who can relate these two sides of the matching equation will be getting nearer having the right people in the right jobs and keeping them there.

– **Generally :**

(*i*) Employees with high achievement needs thrive on work that is challenging, satisfying, stimulating and complex. They welcome autonomy, variety and frequent feedback from supervisors.

(*ii*) Employees with low achievement needs, prefer situations of stability, security and predictability. They respond better to considerate than to impersonal high-pressure supervision and look to the workplace and coworkers for social satisfaction.

3.19. AUTHORITY

Authority—concept

- Authority means *right* (to command) and *power* to act.
- Authority empowers the superior to make a subordinate to do the work. Everybody in the organisation, from top to bottom, possesses some authority to secure cooperation from his subordinates.
- Authority is the right to make decisions, direct the work of others and give orders. It is a right to direct, act and control.
- Authority is right to give orders and power to exact obedience.
- Authority denotes certain rights granted to a person(s) in an organisation to influence the behaviour of the subordinates in terms of doing right things so as to achieve goals of organisation. It may involve punishment for the erring subordinates and rewards for the outstanding ones.
- The extent and limit of authority of a position is not unlimited; it is specified in advance. The position holder is expected to use it as per rules, regulations, policies, practices and norms of the organisation.
- The *Authority* is the rightful legal power to request subordinates to do a certain thing or to refrain from doing that, and if he does not follow these instructions the manager is in a position, if need be, to take disciplinary action, even to discharge the subordinate. Without authority, only anarchy and chaos would result.
- Authority includes such rights or powers as those of spending specified amount of money, of using certain quantities of materials, of hiring and firing people.

Characteristics of Authority

1. Authority is given by the Institution (or organisation) and, is, therefore, legal or legitimate.
2. Authority is not endless or unlimited. Institution specifies the limits of authority of the position.
3. Authority should invariably be in writing, though in small organisations, it may be verbal.
4. Authority must be commensurate with responsibility. When a position in the organisation is entrusted with some responsibility, adequate authority should also be given to the position-holder so that he can successfully undertake the responsibility.
5. Authority must hold the legitimate command to punish the disobedients and to reward the obedients.
6. Authority may be centralised or decentralised.
7. Authority is given to the position and *not* to the position holder.

Kinds of Authority

There are three types of authority :

1. *Rational-Legal Authority*

- Any individual who happens to occupy a particular position in an organisation, enjoys the (legal) authority attached to that position.

- Legal authority is derived by a position holder from rules, regulations, policies, practices and norms laid down for the systematic functioning of the organisation.

2. *Traditional Authority*

- Unlike legal authority, traditional authority is derived from *tradition* and is not obtained by *competence.*

- As an example of traditional authority, the eldest son of a king will succeed to the throne because of age old tradition.

3. *Charismatic Authority*

- Charismatic authority depends upon the special or exceptional powers or qualities of individual leaders.

- Charismatic leaders are usually found in religion and politics.

- The authority is irrational because followers obey it because of their emotions. No rules or regulations are involved.

Charismatic authority often evolves into *traditional* authority as informal status and role systems become stabilized over time. It is exemplified by the phrase, "It has always been this way".

Just as *charismatic* authority often evolves into *traditional* authority, so *traditional* authority can evolve into *rational-legal* authority if the system is *legitimized* formally.

3.20. DELEGATION OF AUTHORITY

- An individual is only one man power. Single-handed, he can accomplish only so much in a day. The only way he can *achieve more* is through *delegation*—through dividing his load and sharing his responsibilities with others.

- Probably the most important of all the skills a manager must possess is delegation—the ability to get results through others.

- Delegation is *important* because it is both the *gauge* and the *means* of a manager's accomplishment. Once a man's job grows beyond his personal capacity, his success lies in his ability to multiply himself through other people (subordinates). How well he delegates determines how well he can manage.

- A manager who carries a full brief case home, is often overloaded-overworked because he does not know how to delegate.

- Delegation may be defined as the entrustment of responsibility and authority to another and the creation of accountability for performance.

- **The essential elements of delegation are :-**

1. Assignment of work (or *responsibility*) to another (person) for performance.

2. Grant of *authority* to be exercised.

3. Creation of an obligation or *accountability* on the part of the person accepting the delegation to perform in terms of the standards established.

The word *Accountability* indicates *liability* for the proper discharge of duties by the subordinate. It is the obligation to carry out responsibility and exercise authority in terms of performance standards established.

Responsibility is the work assigned to a position. Responsibility refers to the mental and physical activities which must be performed to carry out a task or duty.

- *Delegation of Authority* merely means the granting of authority to subordinates to accomplish a particular assignment while operating within prescribed limits and standards established.

Principles of Delegation of Authority

(1) *Parity between authority and responsibility*

There should be complete parity between authority and responsibility. If authority is more than responsibility, people will make misuse of their authority and if responsibility is more than authority, the results can never be achieved.

(2) *Responsibility in terms of results*

To be effective, delegation of authority should always be in terms of exact results of responsibility. In other words, responsibility should be specific on a specific person, because everybody's responsibility is nobody's responsibility.

(3) *Principle of Unity of Command*

To avoid confusion, conflicts and duplication of work–orders, instructions and guidelines should flow to a subordinate from a single particular executive only.

(4) *Delegation of responsibility*

Authority can be delegated.

But, *responsibility* and *accountability* cannot be delegated.

By delegating authority, an executive does not escape from responsibility, He is, in addition, responsible for the act of his subordinates also.

(5) *Overlapping of responsibilities*

While delegating authority, it must be ensured that duties and responsibilities of subordinates do not overlap.

(6) *Free flow of information*

In delegation of authority, there should be *free* two way communication (as regards exchange of ideas, instructions, guidelines, clarifications, suggestions etc.) between an executive and a subordinate.

(7) *Delegated authority*

Authority delegated to the subordinate should be adequate, enough and as per the status and position of the subordinate, in order to achieve optimum results.

Problem of Delegation of Authority

Though delegation appears to be a simple process, many problems or difficulties come in the way of effective delegation of authority. These difficulties may be classified under the following heads:

1. On the part of management/*executive*.
2. On the part of the *subordinate*.
3. On the part of the *organisation*.

1. On the part of management/executive

(*a*) *Feeling of perfection*

Some executives feel that they can do any job better than their subordinates and therefore they are reluctant to delegate authority.

(*b*) *Lack of ability to direct*

If the executive lacks the ability of giving proper directions and clear instructions to his subordinates, he will not delegate authority.

(*c*) *Lack of confidence in subordinate*

If an executive has little or no confidence in the subordinate's ability to perform assigned job, he will not delegate authority.

(*d*) *Fear of being exposed*

If the executive is inefficient, he will always be under fear that if he delegates authority, his subordinates may outshine him.

(*e*) *Absence of controls*

If the executive does not have adequate *controls* to assure himself that the authority is being used to accomplish the given assignments, he will hesitate to delegate authority.

(*f*) *Conservative attitude*

An executive may be handicapped by a temperamental aversion to take a chance. He is afraid that the subordinate may not spoil the work.

(*g*) *Desire of dominance*

The desire of dominance over the work of subordinates at each step hampers the process of delegation.

2. On the part of the subordinate

Sometimes the process of delegation suffers because a subordinate avoids to accept the responsibility due to the following reasons and there being no fault on the part of the executive.

(*a*) *Dependence on boss*

If a subordinate always depends upon his boss for tackling problems, he may avoid accepting authority.

(*b*) *Fear of criticism*

A subordinate may not accept authority and new challenges due to fear of committing mistakes and being criticised by the executive (boss).

(*c*) *Lack of self-confidence*

A subordinate lacking in self-confidence will always be under fear of failure and will generally try to shirk authority and responsibility.

(*d*) *Overburdened with work*

A subordinate who is already overburdened with work may hesitate to accept additional responsibility.

(*e*) *Lack of proper facilities*

Inadequacy of authority, information and working facilities for performing the duties, may compel a subordinate not to accept the responsibilities.

(*f*) *Lack of incentives*

A subordinate may hesitate in accepting authority if he does not get sufficient positive incentives in the form of recognition, higher pay, credit, better position etc.

3. On the part of Organisation

The process of delegation of authority may suffer due to some internal organisational *problems* such as:

(*a*) Defective organisation structure and nonclarity of authority-responsibility relationships.

(*b*) Defective and inadequate planning and policy formulation.

(*c*) Lack of unity of command.

(*d*) Lack of effective control mechanism in the organisation.

3.21. DELEGATION OF AUTHORITY v/s DECENTRALISATION

– Any manager may delegate authority to his subordinate. Delegation may thus be highly individualized relationship.

When *delegation* is used systematically and extensively throughout an organisation, the arrangement may be described as *decentralization.*

– In a decentralized organisation, authority and decision-making have been pushed downward throughout the organisation. Decentralization thus necessitates delegation, but delegation, on the other hand, might be used by a particular manager without being part of a decentralization program.

3.22. CO-EQUALITY OF AUTHORITY AND RESPONSIBILITY

– *Authority* implies *right* to command and *power* to act. Authority empowers the superior to make a subordinate to do work. Authority is the right to give orders to the subordinate.

– *Responsibility* is the assignment of duties (tasks) by the executive to the subordinate, which the subordinate is expected to perform. This now becomes the *responsibility* of the subordinate to complete the task given to him by the executive.

– In other words, responsibility may be defined as the *obligation* of a subordinate to whom a duty has been assigned, to perform the duty.

– Responsibility arises from the superior-subordinate relationship, from the fact that the superior has the authority to take specified service from the subordinate.

– In order to enable the subordinate to perform his responsibility well, the superior must clearly tell the former as to what is expected of him.

Coequality of authority and responsibility

– One of the basic principles of management is the *parity* of authority and responsibility. The

principle states that in delegating, managers must *match* the responsibility of subordinates with the grant of commensurate authority.

- First, the subordinate is given a responsibility of achieving certain defined objectives. Then he is given authority in *right* amount to achieve these objectives.

  The responsibility is therefore the *task to be done* and authority is the *tool* needed to perform that task.

- It should be noted that authority must be carefully tailored to match the responsibility involved. In other words, there must be a *balance* between responsibility and authority. Failure to comply with this, will result in malorganisation and frustration of the people charged with responsibilities.

- Consider the implications of an *unbalance* in authority and responsibility.

Suppose authority exceeds responsibility. The extra authority may be used arbitrarily, capriciously, or without adequate consideration of the effect on others. This condition also may be unsatisfactory because people may fear the potential acts of the holder of excessive authority even if such authority never is used. Thus, a benevolent-dictatorship form of government tends to be unstable.

It is also untenable to think of responsibility exceeding authority. If such were the case we would, in effect, be holding persons accountable for things they cannot change or control. The condition is unstable; the persons will eventually object and ask for additional authority, or they may seek to reduce their responsibility.

3.23. DELEGATION OF AUTHORITY, LEVEL AND SPAN OF CONTROL

- *Delegation* is the process by which an individual manager transfers part of his legitimate authority to a subordinate but without passing on the ultimate responsibility which has been entrusted to him by his own superior.

  The *reasons* for delegation are generally twofold :

(1) *Practical e.g.,* to relieve the burden on senior management, to speed up the decision-making process etc., and

(2) *Idealistic e.g.,* as a contribution to individual (subordinate) growth and overall morale.

- One of the major questions which has to be faced when considering the practical aspects of *delegation* is how many subordinates can be supervised effectively by any one manager. This is the issue of the so called *Span of Control i.e.,* the number of employees reporting directly to one person. The most likely range is between three and twenty. Smaller spans tend to be found among managerial, professional and technical groups.

- The whole question of spans of control is *linked* to top management's views about the number of *levels* they should have in their organization.

  If a flat organisation is preferred, then larger spans are an inevitable consequence.

  If a tall structure is preferred, then spans of control can be smaller.

- Following are a few more *factors* that influence the size of the spans in any single organization.

(1) *Level of ability of management.* If it can produce results even with large span.

(2) *Level of knowledge and experience of subordinates.* Well trained and experienced subordinates need less supervision.

(3) *Complexity of task.* The more complex and challenging tasks ask for narrow spans of control.

(4) The *Costliness* of possible mistakes by the subordinates.

(5) Degree of *hazard* or *danger* associated with the work.

These factors are self-explanatory.

3.24. GROUP DYNAMICS

Concept

- *Groups* are made up of individuals. Two or more individuals, just together, do not form a group, the *force of relationship* is a must to make them into a group. For example, twenty persons going in a bus do not form a group, they remain a mere aggregation. But, suppose, the bus goes out of order and all the persons have to push it to take it to a nearby mechanic, a group is automatically formed under the leadership of, say, the bus driver.
- The word *dynamics* is a Greek word meaning *force*.
- Hence *group dynamics* is *a social process* by which people *interact* face to face in small groups.
- Group dynamics focuses on team-work.
- The group generates its own leader, develops its goals clearly and furnishes suggestions to its members for the accomplishment of goals.

  The group has its own properties, quite different from those of individuals who make up the group. Individual behaviour of the members of the group need not necessarily represent the behaviour of the whole group and *vice versa*.
- Groups provide personal relationship in the work place as members talk to another about job or personal problems.
- Correct understanding of group dynamics permits the possibility that desirable consequences from groups can be deliberately enhanced.

Characteristics of groups

(1) Groups do exist.

(2) Groups are inevitable and ubiquitous.

(3) Groups mobilize powerful forces that produce effects of utmost importance to individuals.

(4) Groups may produce good or bad consequences in the organisation.

Reasons for formation of groups

(1) The need for *companionship*.

(2) *Identification.* Workers get more identified in small groups and so small groups tend to enjoy high morale.

(3) *Understanding from friends.* The daily work routine creates frustration and tension. Under these conditions, it is always satisfying if one gets a sympathetic ear preferably from a friend or colleague who has similar experiences.

(4) *Job satisfaction.* Working in group leads to higher motivation of the individuals. Many jobs which appear superficially dull and routine look interesting when working as group.

(5) *Protection of members.* Groups help protect their members from outside persons, pressures or dangers. Need for help in solving work problems.

Group structure

- Every group develops a *structure.* The structure determines the *relationship* of members to one another. It also develops a system of *communication,* and a system of *rewards* and *punishments.*
- Group evolves its own *goals* reflecting the interests of its members rather than having a commitment to the organizational goals.
- Groups also develop *standards of behaviour* to govern the behaviour of its members. Group standards protect the group members from real or imaginary outside dangers.

Types of groups

In every organization there may be *two* types of groups on the *basis* of *structuring.*

1. *Formal groups*
2. *Informal groups*

1. A *formal group* is a legitimate subunit of the organization which is duly established. A formal group is created by the management to carry out some of the specific work to achieve some goals of the organisation.

   Committees, project teams, task forces etc., are all examples of a formal group.

2. *Informal groups* are created due to socio-psychological forces operating at the work place.

   They arise spontaneously on the basis of friendship and like-thinking which may or may not be work related.

   Such groups are the creation of natural desire of human being to interact.

Advantages of groups

(*i*) A group creates a pleasant and satisfying environment for its members.

(*ii*) All needs and desires of its members are easily satisfied.

(*iii*) Work-performance becomes easier and better due to mutual cooperation.

(*iv*) Groups provide psychological support to its members.

(*v*) Need for close supervision is also reduced.

(*vi*) Groups lead to organisation development.

(*vii*) *Group cohesiveness* (degree of attachment of the members to their group) reduces turnover and absenteeism.

(*viii*) Individuals feel secured in a group.

Disadvantages of groups

(*i*) Groups often set production norms below the physical capabilities of their members.

(*ii*) Groups resist innovation and change in work methods.

(*iii*) Groups often oppose the management policies and procedures.

(*iv*) Groups often spread rumours affecting the smooth working of the organisation.

(*v*) Since the groups try to meet the social needs of their members, there is a natural tendency to produce *role conflict.*

(*vii*) Jurisdictional disputes among groups create problems for management.

3.25. ORGANISATIONAL CHANGE (DYNAMICS OF CHANGE)

Introduction

- Change refers to any alteration that occurs in total work environment.
- Change is an important characteristic of most organisations. An organisation must develop adaptability to change otherwise it will either be left behind or be swept away by the forces of change.
- Change is inevitable in a progressive culture.
- Modern organizations are highly dynamic, versatile and adaptive to the multiplicity of changes.
- *Organisational change* refers to the alteration of structural relationships and roles of people in the organization. It is largely structural in nature.
- An enterprise can be changed in several ways. Its *technology* can be changed, its *structure,* its *people* and other *elements* can be changed.
- Organisational change calls for a change in the individual behaviour of the employees.
- Organizations *survive, grow* or *decay* depending upon the changing behaviour of the employees.
- Most changes disturb the equilibrium of situation and environment in which the individuals or groups exist.
- If a change is detrimental to the interests of individuals or groups, they will *resist* the change.

Causes of Organisation Change

(A) External pressures

- *Change in Technology and Equipments*

  Advancements in technology is the major cause (i.e., external pressure) of change. Each technological alternative results in new forms of organization to meet and match the needs.

- *Market situation*

  Changes in market situation include rapidly changing goals, needs and desires of consumers, suppliers, unions etc. If an organization has to survive, it has to cope with changes in market situations.

- *Social and political changes*

  Organisational units literally have no control over social and political changes in the country. Relations between government and business or drive for social equality are some factors which may compel for organisational change.

(B) Internal pressures (pressures for change from within the organisation)

- *Changes in the Managerial Personnel*

  One of the most frequent reasons for major changes in the organisation is the change of executives at the top. No two managers have the same style, skills or managerial philosophies.

– *Deficiencies in the existing organisation*

Many deficiencies are noticed in the organisations with the passage of time. A change is necessary to remove such deficiencies as lack of uniformity in the policies, obstacles in communication, any ambiguity etc.

– Certaion *other factors* such as listed below also demand a change in the organisation.

Employee's desire to share in decision-making

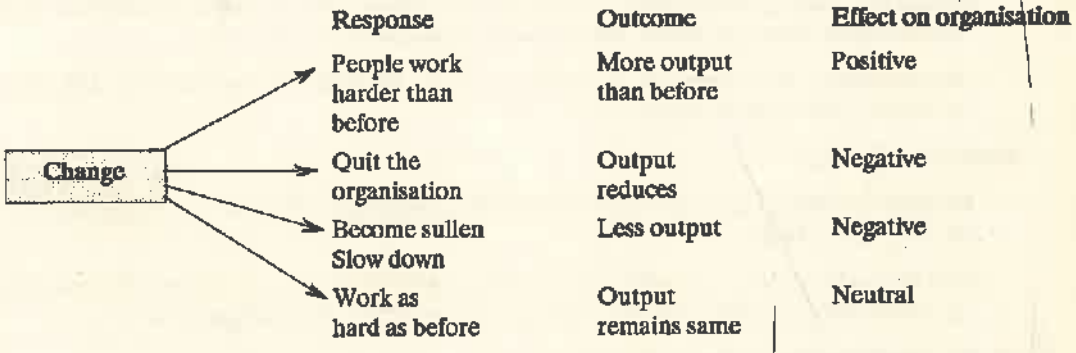
Employee's desire for higher wage rate

Improvement in working conditions, etc.

Response to change

– Every change is responded by the people working in the organisation.

– These responses may be positive or negative depending upon the fact as how they affect people.



– Before introducing a change, the manager should study and understand employee's attitudes so as to create a positive response. Three sets of factors—psychological, personal and social—govern the attitude of people.

The Change Process

– Unless the behavioural patterns of the employees change, the change will have a little impact on the effectiveness of the organisation

– A commonly accepted model for bringing change in people was suggested by Kurt Lewin in terms of three phase process :-



(1) *Unfreezing*

The essence of unfreezing phase is that the individual is made to realize that his beliefs, feelings and behaviour are no longer appropriate or relevant to the current situation in the organisation. Once convinced, people may change their behaviour. Reward for those willing to change and punishment for others may help in this matter.

(2) *Changing*

Once convinced and ready to change, an individual, under this phase, learns to behave in new ways. He is first provided with the model in which he is to *identify* himself. Gradually he will accept that model and behave in the manner suggested by the model. In another process (known as *internalisation*), the individual is placed in a situation where new behaviour is demanded of him if he is to operate successfully.

(3) *Refreezing*

During this phase, a person has to practice and experiment with the new method of behaviour and see that it effectively blends with his other behavioural attitudes.

Reinforcement, for creating a permanent set in the individual, is provided through either *continuous* or *intermittent* schedules.

Resistance to change

– Resistance to change is perhaps one of the baffling problems a manager encounters because it can take many shapes.

People may resign, they may show tardiness, loss of motivation to work, increased absenteeism, request for transfer, wild-cat strikes, shoddy work, reduction in productivity etc.

– Resistance to change may be classified as

Individual
Organisational

– *Individual resistance* may be there because of the following reasons :

1. *Economic reasons*

   (*a*) Obsolescence of skills

   (*b*) Fear of economic loss

(*a*) When a person feels that with the introduction of newer processes, his skills will just become *obsolete*, he will resist the change. For example, a twenty years experienced accountant is quite likely to resist the introduction of a computer for preparing the wage bills because he feels that might affect his pay and position.

(*b*) People resist change if it opens the possibility of lowering their *income* directly or indirectly.

2. *Personal reasons*

   (*a*) Ego defesiveness

   (*b*) Status quo

   (*c*) Fear of unknown

(*a*) A sales manager may turn down the suggestions of a salesman simply because the manager perceives that his *ego* may be deflated by accepting the suggestion.

(*b*) Most of the people feel comfortable with *status quo* and strongly resist change as it may involve uncertainty and risk.

(*c*) Change presents *unknown* and unknown poses a constant threat and sores people. For fear of unknown, a manager may refuse promotion that requires his relocating in another state.

3. *Social Reasons*
   (*a*) Social displacement
   (*b*) Peer pressure

(*a*) Introduction of change (*e.g.* relocating) may result in breaking up of work groups and thus result in disturbance of the existing social relationships of people.

(*b*) Whenever change is unwilling to the peers, they force the individual subordinate employees who are bent of accepting the change, to resist it.

Organizational Resistance

Resistance may also be present at organizational level. Some organizations are so designed that they resist innovations.

Some of the *reasons* of organizational resistance are :-

(*a*) Threats to power and influence
(*b*) Organizational structure
(*c*) Resource constraints
(*d*) Sunk cost

(*a*) Some people (especially sitting at the top levels) resist change because they feel that a change might affect their position, power and influence in the organization.

(*b*) Some organization structures (*e.g.* bureaucratic structure) have inbuilt mechanism for resistance to change.

(*c*) Non-availability of financial, material and human resources may also act as a resistance to change.

(*d*) In some companies, heavy capital is blocked in the fixed or permanent assets. If such an organization wishes to introduce change, then difficulty arises because of these sunk costs.

Overcoming resistance to change

- Change creates tension and emotional turmoil in the minds of employees. Change thus results in resistance quite frequently, negative reactions doom the success of the change program especially when a manager is unable to handle it properly.
- Some of the techniques to handle the change properly and to deal with resistance to change are
  (*a*) Education and communication
  (*b*) Participation and involvement
  (*c*) Support
  (*d*) Incentives
  (*e*) Manipulation
  (*f*) Coercion

(*a*) One of the easiest techniques to overcome resistance to change is to *educate* the people who resist it. In many cases, people do not properly understand the change and hence become afraid of its consequences and resist change.

(*b*) If subordinates are allowed to participate and involve themselves in the change process (decision-making regarding the implementation of the change), their misunderstandings about the consequences of change are cleared, they generally feel satisfied and do not oppose change.

(*c*) Support may be facilitative and emotional. Managers sometimes deal with potential resistance by being *supportive*. This includes listening, providing emotional support, providing training in new skills etc.

(*d*) Offering incentive is another fruitful way to overcome resistance to change.

(*e*) Managers generally indulge in manipulation when all other tactics have failed to overcome resistance to change.

(*f*) At times, there is no way except to deal with resistance coercively. People are forced to accept change by threatening them with loss of their jobs, promotion possibilities and so forth.

3.26. ORGANIZATIONAL DEVELOPMENT

Concept

- *Organizational* (or *organization*) *Development* or simply O.D. is a *technique of planned change*.

  It seeks to change beliefs, attitudes, values and structures—in fact the entire culture of the organization—so that the organization may better adapt to technology and live with the pace of change.

- O.D. is a comprehensive strategy for *organization improvement*.

- O.D. is a long range effort to improve an organization's problem solving and renewel processes, particularly through a more effective and collaborative management culture.

- *R. Beckhard* defines O.D. as a *change strategy* which is
  - (*i*) Planned
  - (*ii*) Organization-wide
  - (*iii*) Managed from the top *to* increase organization effectiveness and health *through* planned interventions in the organization's processes, *using* behavioural science knowledge.

Objectives of O.D.

- (*a*) Improvement in the *performance* of the organisation.
- (*b*) Improvement in the *ability* of the organisation to adapt to its *environment*, and
- (*c*) Improvement in *inter-personal* and *inter-group* behaviour to secure team work.

Characteristics of O.D.

1. Organisational development is an educational strategy for bringing a planned change.
2. It is related to real problems of the organisation.
3. Laboratory training methods based on experienced behaviour are primarily used to bring *change*.
4. O.D. uses *change agent* (or consultant) to guide and affect the change. The role of change agent is to guide groups towards more effective group processes rather than telling them what to do. Change agents simply assist the group in problem solving processes and the groups solve the problems themselves.
5. There is a close working relationship between change agents and the people who are being changed.

6. O.D. seeks to build problem-solving capacity by improving group dynamics and problem confrontation.
7. O.D. reaches into all aspects of the organization culture in order to make it more humanly responsive.
8. O.D. is a *long term approach* (of 3 to 5 years period) and is meant to elevate the organization to a higher level of functioning by improving the performance and satisfaction of organization members.
9. O.D. is *broad-based* and describes a variety of change programmes. It is concerned not only with changes in organizational design but also with changes in organizational philosophies, skills of individuals and groups.
10. O.D. is a *dynamic process*. It recognises that the goals of the organization change and hence the methods of attaining them should also change.
11. O.D. utilizes *systems thinking*. It is based on open , adaptive systems concept. The organization is treated as an interrelated whole and no part of the organization can be changed without affecting other parts.
12. O.D. is *research based*. Change agents conduct surveys, collect data, evaluate and then decisions are taken.
13. O.D. uses *group processes* rather than individual process. It makes efforts to improve group performance.
14. O.D. is *situational* and *contingency* oriented.
15. *Organization Development* and *Management Development* are complementary rather then conflicting.

Difference between Organizational Development and Management Development*

Organizational Development	*Management Development*
1 It is a strategy which is planned and implemented from the top with a view to bring about planned *change* in the organization for the purpose of increasing organizational effectiveness.	1. Management development is the *device* to increase the skill and ability of managers of an organization.
2. The ultimate goal of O.D. may be the creation of a new team, changing the attitudes of organization members and developing new values.	2. The goal of management development programme is to help managers to discharge their responsibilities effectively.
3. O.D. has problem solving approach.	3. Management development's approach is education and training.
4. O.D. is a long range strategy for organizational innovation and renewal.	4. It has short range programmes.
5. Trained specialists are required.	5. There is no special requirement of specialist service.

Steps in Organisational Development

Lawrence and *Lorsch* have provided the following steps in organisational development :-

1. Problem identification

* Refer Chapter 15 also.

2. Planning strategy for change
3. Implementing the change
4. Evaluation.

1. *Problem identification – Diagnosis*

   O.D. program starts with the identification of the problem in the organisation. Correct diagnosis of the problem will provide its causes and determine the future action needed.

2. *Planning strategy for change*

   O.D. consultant attempts to transform diagnosis of the problem into a proper action plan involving the overall goals for change, determination of basic approach for attaining these goals and the sequence of detailed scheme for implementing the approach.

3. *Implementing the change*

   O.D. consultants play an important role in implementing change.

4. *Evaluation*

   O.D. is a long-term process. So there is a great need for careful monitoring to get process feedback whether the O.D. programme is going on well after its implementation or not. This will help in making suitable modifications, if necessary.

   For *evaluation* of O.D. programme, the use of critic sessions, appraisal of change efforts and comparison of pre- and post-training behavioural patterns are quite effective.

3.27. ORGANIZATIONAL CONFLICT

Concept

- *Organizational Conflict* is a disagreement between two or more organization members or groups arising from the fact that they must share scarce resources or work activities and/or from the fact that they have different statuses, goals, values or perceptions. Organization members or sub-units in disagreement, attempt to have their own cause or point of view prevail over that of others.
- Conflicts may be at individual level, group level and at organisational level.
- Conflicts affect the work efficiency of the individual and of the group; as a result productivity is reduced.

Stages of Conflict

- Conflict can be more readily understood if it is considered as dynamic process. *Process* here indicates a series of *events*. Each conflict is made up of a sequence of inter-locking *conflict episodes.*
- Five stages of a conflict episode may be identified as
  1. Latent Conflict
  2. Perceived Conflict
  3. Felt Conflict
  4. Manifest Conflict
  5. Conflict aftermath

1. *Latent conflict*

- Latent conflict provides the necessary antecedent conditions for conflict in organisation. Here participants only anticipate conflict.

– *Four* basic types of latent conflicts are :-

Competition for scarce resources
Drive for autonomy
Divergence of subunit goals, and
Role conflict.

2. *Perceived conflict*

Perceived conflict is due to the parties' misunderstanding of each other's true position. Such a conflict can be resolved by improving communication between the parties.

3. *Felt conflict*

A person *X* may be aware that he is in serious disagreement with *Y* over some policy. If this makes *X* tense and affects his relationship with *Y* then, the conflict is *felt* by the two. Conflict arises only after the differences become *personalized* or internalized (*felt*).

4. *Manifest conflict*

This is the stage for open conflict. It takes the form of open aggression, sabotage, apathy, withdrawal etc.

5. *Conflict aftermath*

The aftermath of a conflict may be either *positive* or *negative* for the organization depending on how the conflict is resolved.

If conflict is resolved to the satisfaction of all the parties involved, the basis for a more co-operative relationship may be laid.

On the other hand, if the conflict is merely suppressed (but not resolved), the latent condition of conflict may be aggravated and explode in a more serious and violent form at a later stage.

Classes of Conflict

– Conflicts may be classified as follows :-

1. Individual conflict,
2. Group level conflict, and
3. Organisational conflict.

1. *Individual conflict*

– *Intra Individual* conflict is internal to the person and is probably the most difficult type to analyse Non-satisfaction of needs frustrates an individual and it leads to behaviour that negatively affects job performance.

– When two individuals are in confrontation with each other, it may be said an *inter-individual conflict*. For example, two individuals competing for the same promotion may develop inter-individual conflict.

2. *Group level conflict*

– Conflicts at the group (formal and informal) level may be classified as :-

– *Intragroup conflict* arises when differences over an issue crop up between the members of the group. Such a conflict may divide the group into two further groups.

- *Intergroup conflict.* Every group is in at least partial conflict with every other group it interacts with. They differ in goals, work activities, power, prestige, resource allocation, reward systems etc.

3. *Organizational Conflict*

- The *interorganisational conflicts* are assumed between two organisations or between a business organisation and the government.
- The *Intraorganisational conflicts* comprise of all intraindividual, interIndividual, intragroup and intergroup conflicts because they are the parts of the same organization. Such conflicts may turn into hierarchical conflicts, line and staff conflicts, management *versus* shop floor conflicts, union *versus* union conflicts etc.

Sources of Conflict

- Sources of conflict are found in some degree of *actual* or *perceived* divergence of *interests.*
- Conflict is rooted in a sharp incompatibility of interests.
- Any victory for one party means dissatisfaction or defeat for the other, thereby leading to a conflict.
- People disagree over *facts, goals, methods* and *values* because they have different interests and perceptions.
- *Facts.* Sometimes the disagreement occurs because individuals have different definitions of a problem, are aware of different pieces of relevant information etc.
- *Goals.* Sometimes the disagreement may be about what should and what should not be accomplished.
- *Methods.* Sometimes the disagreement may be about the procedures and strategies to follow to achieve the desired goal.
- *Values.* Sometimes the disagreement is over *ethics,* the way power should be exercised or assumptions about justice, fairness and so on.
- Conflicts may arise due to *economic, social* and *psychological reasons.*

Psychological factors no doubt contribute predominantly. For instance, feeling of *insecurity* is a potent cause of tension and conflict.

- Conflicts may also arise due to lack of consideration, lack of appreciation, misunderstanding or bad handling of situation and problems.

Resolution of Conflicts

Efforts for *conflict management* may be divided into two groups :-

(1) *Preventive measures* include :

(*a*) Development of effective *leadership,*

(*b*) *Participative* decision-making,

(*c*) Two-way *communication* system,

(*d*) Improvement in interpersonal *relationship*, and

(*e*) Revision for facilities and opportunities to develop *informal groups.*

(2) *Curative measures*

The following steps must be taken in resolving a conflict which has already arisen :

(*a*) Dig full *details* of the conflict and note the *stage* of conflict (whether preliminary or advanced). More efforts are required to resolve a conflict of advanced stage.

(*b*) *Issues* involved in the conflict should be analysed and understood. Conflict may be due to facts, goals, methods or values.

(*c*) Then, the following *conflict handling modes* can be tried

(*i*) *Problem solving.* May be done by the management or *mutually* by the parties involved in conflict.

(*ii*) *Mediation through persuation.* Management may attempt to sweep out the differences and smoothen the affair.

(*iii*) *Bargaining*

(*iv*) *Politics*

(*v*) Letting the *parties* in conflict to *settle their scores* if they adopt a rigid attitude and do not see to the reason or appeal. This is the last resort if all other conflict handling modes fail.

3.28. MANAGERIAL LEADERSHIP

- Effective managing requires leadership.
- It is seldom possible to segregate the behavioural functions of *managership* and *leadership*. It is because, every act of influence on a matter of organizational relevance is in some degree an act of leadership.
- A *manager* organises, directs and controls various activities of the enterprise directed towards specific ends.
- A *leader,* on the other hand, inspires confidence and trust in his subordinates, gets maximum cooperation from them and guides their activities in organised effort.
- Specifically, *managerial leadership* is behaviour that elicits voluntary follower behaviour beyond that associated with required performance on a job. Leadership is "------ the influential increment over and above mechanical compliance with the routine directives of the organization".
- A manager's leadership behaviour is what makes the difference between effective and ineffective organizations.
- *Managerial leadership* combines the skills of a manager and the qualities of a leader.
- The concept of managerial leadership is important because the term itself suggests the necessity of bringing together the managerial and leadership roles for the more effective task performance, organizational effectiveness and human satisfactions.
- The managerial leader, then, is generally evaluated on both *formal task* accomplishment and *informal* basis of personal and group goal accomplishment.

Style of Managerial Leadership

- While personally favoring the *democratic style,* some experts acknowledge that managers need to take certain practical consideration into account before deciding how to manage. It is suggested that a *manager* should consider three sets of *forces* before choosing a *leadership style* :
  1. Forces in the manager
  2. Forces in the subordinates, and
  3. Forces in the situations.

This approach sees the most effective managers as flexible, able to select leadership behaviours as needed in a given time and place.

- How a manager will primarily be influenced by his background, knowledge, values and experience (*forces in the manager*). For example, a manager who believes that the needs of the individual must come second to the needs of the organization may take a very directive role in his subordinates' activities.
- *Characteristics (forces) of subordinates* also must be considered before managers can choose an appropriate leadership style. A manager can allow greater participation and freedom when subordinates :
  1. Crave independence and freedom of action.
  2. Want to have decision-making responsibility.
  3. Identify with the organization's goals.
  4. Are knowledgeable and experienced enough to deal with the problem efficiently.
  5. Have experience with previous managers that leads them to expect participative management.

  Where these conditions are lacking, managers may have to lean toward the *authoritarian style*.
- Finally, a manager's choice of leadership style must reckon with such *situational forces* as
  1. The organization's preferred style,
  2. The specific work group,
  3. The nature of the group's work tasks,
  4. The pressures of time, and even
  5. Environmental factors which may affect organization members' attitude toward authority.

  Explaining the above :

1. Most managers, for example, will move toward the leadership style favoured by the organization's hierarchy.
2. A group that works well may respond more to a free and open atmosphere than to close supervision.
3. If the task requires specialized skill and knowledge possessed only by manager, direct instructions and close supervision may become necessary.
4. In situations where quick decisions are essential, even democratic managers may avert to an authoritative leadership style.

- In brief, there may be *two styles of Managerial leadership*

1. *Boss-centered leadership*–	Use of maximum authority by the manager. Too little freedom for subordinates.
2. *Subordinate-centered leadership*–	Minimum use of authority by the manager. Bigger area of freedom for subordinates to act, take decisions and to function within limits defined by Manager.

3.29. COMMUNICATION SYSTEMS

Introduction

- Communication may be thought of as any system by which people obtain information that affects the way in which they perform their jobs.

– In one sense, an organization can be no more efficient than the system by which it informs its members of what is expected of them, so that their efforts will reinforce each other and create a momentum toward the attainment of the organization's goals. Any failure of communication is at best wasteful and at worst demoralizing.

N.B. Communication has been discussed in detail in Chapters 15 & 20.

3.30. THE DYNAMICS OF ORGANISATION

– No formal organization chart (or manual) can give an entirely accurate picture of an organization as it actually exists. No sooner is the structure established, the people who must work within it, begin modifying it. The changes that occur in consequence of this, constitute the *dynamics of organisation.*

– One of the *results* of the dynamics is the existence of the *informal organisation* or rather several informal organizations, ranging from those affecting department heads to those that arise within departments or even within sections of departments.

4

Plant Location, Layout and Line Balancing

4.1. CONCEPT AND FACTORS GOVERNING PLANT LOCATION

A plant is a place, where men, materials, money, equipment, machinery, etc. are brought together for manufacturing products.

The problem of plant location arises when starting a new concern or during the expansion of the existing plant. Plant location means deciding a suitable location, area, place, etc., where the plant or factory will start functioning. Plant location involves two major activities. First, to select a proper geographic region and second, selecting a specific site within the region. Plant location plays a major role in the design of a production system as it determines the cost of

(*a*) getting suitable raw material ;

(*b*) processing raw material to finished goods ; and

(*c*) finished products distribution to customers.

Hardly any location can be ideal or perfect. One has to strike a balance between various *factors affecting plant location,* which are discussed below :

(1) Nearness to Raw Material. It will reduce the cost of transporting raw material from the vendor's end to the plant. Especially those plants, which consume raw material in bulk, or raw material is heavy, is cheap but loses a good amount of its weight during processing (trees and saw mills), must be located close to the source of raw material.

(2) Transport Facilities. A lot of money is spent both in transporting the raw material and the finished goods. Depending upon the size of raw material and finished goods, a suitable method of transportation like roads, rail, water or air is selected and accordingly the plant location is decided. One point must be kept in mind that cost of transportation should remain fairly small in proportion to the total cost.

(3) Nearness to Markets. It reduces the cost of transportation as well as the chances of the finished products getting damaged and spoiled in the way (especially perishable products). Moreover a plant being near to the market can catch a big share of the market and can render quick service to the customers.

(4) Availability of Labour. Stable labour force, of right kind, of adequate size (number), and at reasonable rates with its proper attitude towards work are a few factors which govern plant location to a major extent. The purpose of the management is to face less boycotts, strikes or lockouts and to achieve lower labour cost per unit of production.

(5) Availability of Fuel and Power. Because of the wide spread use of electric power, in most cases fuel (coal, oil, etc.) has not remained a deciding factor for plant location. Even then steel industries are located near source of fuel (coal) to cut down the fuel transportation costs.

It is of course essential that electric power should remain available continuously, in proper quantity and at reasonable rates.

(6) Availability of Water. Water is used for processing, as in paper and chemical industries, and is also required for drinking and sanitary purposes. Depending upon the nature of plant, water should be available in adequate quantity and should be of proper quality (clean and pure). A chemical industry should not be set up at a location which is famous for water shortage.

(7) Climatic Conditions. With the developments in the field of heating, ventilating and air-conditioning, climate of the region does not present much problem. Of course, control of climate needs money.

(8) Financial and Other Aids. Certain states give aids as loans, feed money, machinery, built up sheds, etc. to attract industrialists.

(9) Land. Topography, area, the shape of the site, cost, drainage and other facilities, the probability of floods, earthquakes (from the past history) etc. influence the selection of plant location.

(10) Community Attitude. Success of an industry depends very much on the attitude of the local people and whether they want work or not.

(11) Presence of related industries.

(12) Existence of hospitals, marketing centres, schools, banks, post offices, clubs, etc.

(13) Local bye-laws, taxes, building ordnances, etc.

(14) Housing facilities.

(15) Security.

(16) Facilities for expansion.

4.2. LOCATIONAL ECONOMICS

An ideal plant location is one which results in lowest production cost and least distribution cost per unit. These costs are influenced by a number of factors as discussed under section 4.1. The various costs which decide the locational economy are those of

(*a*) Land.
(*b*) Building/Rent.
(*c*) Equipment and machinery.
(*d*) Labour.
(*e*) Water, power and fuel.
(*f*) Freight
  (*i*) In-coming.
  (*ii*) Out-going.
(*g*) Raw material.
(*h*) Taxes, etc.

Besides these costs, community attitude, community facilities and housing facilities are also worth considering.

The economic aspects of locations are considered or an economic survey or economic analysis is carried out to decide as to which of the possible two or more preliminary selected locations, is the overall best location.

The following examples will clarify the procedure.

Example 4.1. Various costs and other considerations have been listed below as regards to locations 1 and 2. It is required to determine the overall best location.

Factors	*Location-1*	*Location-2*
Cost of	(Rs.)	(Rs.)
(*a*) Land	100,000	90,000
(*b*) Building	1,200,000	1,300,000
(*c*) Water	5,000	6,000
(*d*) Power	15,000	17,000
(*e*) Labour	140,000	120,000
(*f*) Freight		
(*i*) In-coming	120,000	110,000
(*ii*) Out-going	160,000	150,000
(*g*) Fuel	40,000	35,000

(*h*) Raw material and other supplies	140,000	130,000
(*i*) Taxes	4,000	2,000
Total Cost	1,924,000	1,960,000
(*j*) Community facilities	Good	Excellent
(*k*) Community attitude	Alright	Encouraging
(*l*) Housing facilities	Very good	Good
(*m*) Cost of living	High	Normal
(*n*) Community size[1]	Small	Medium

Apparently by considering the total costs involved, the location-1 seems to be better. But according to factors from (*j*) to (*n*)—location-2 possesses excellent community facilities, encouraging community attitude and normal cost of living (though housing facilities are not very good and the community size is not small). Considering these good points and moreover there being not much difference in the total costs of the two locations , the location-2 seems to be a better choice.

Example 4.2. From the following data select the most advantageous location for setting a plant for making transistor radios.

	Site-X	*Site-Y*	*Site-Z*
	Rs.	Rs.	Rs.
(*i*) Total initial investment	2,00,000	2,00,000	2,00,000
(*ii*) Total expected sales for the period	2,50,000	3,00,000	2,50.000
(*iii*) Distribution expenses	40,000	40,000	75,000
(*iv*) Raw material expenses	70,000	80,000	90,000
(*v*) Power & water supply expenses	40,000	30,000	20,000
(*vi*) Wages and salaries	20,000	25,000	20,000
(*vii*) Other expenses	25,000	40,000	30,000
(*viii*) Community attitude	Indifferent	Want Business	Indifferent
(*ix*) Employee housing facilities	Poor	Excellent	Good

Solution.

	Site-X	*Site-Y*	*Site-Z*
	Rs.	Rs.	Rs.
Total expenses (Add *iii, iv, v vi* and *vii*)	195,000	215,000	235,000

$$\text{Rate of Return (ROR), \%} = \frac{\text{Total sales} - \text{Total expenses}}{\text{Total investment}} \times 100$$

$$\text{R.O.R. for site } X = \frac{250{,}000 - 195{,}000}{200{,}000} \times 100 = 27.5\%$$

$$\text{R.O.R. for site } Y = \frac{300{,}000 - 215{,}000}{200{,}000} \times 100 = 42.5\%$$

$$\text{R.O.R for site } Z = \frac{250{,}000 - 235{,}000}{200{,}000} \times 100 = 7.5\%$$

1. Small community size, *i.e.* rural areas involve less taxes, less cost of land and buildings, lower labour charges and better labour relations. There are of course a number of disadvantages also.

Site-Y is the most advantageous because—

1. It associates the highest rate of return, i.e., 42.5%.
2. Community wants business.
3. Housing facilities are excellent.

4.3. RURAL V/S URBAN PLANT SITES

4.3.1. Selecting the Plant Site in a City (Urban site)

Advantages

1. A city is very well connected by rail, road and air.
2. It provides a good market also.
3. Right labour force is available.
4. Power and water is easily available.
5. It has good hospitals, marketing centers, schools, banks, recreation clubs, etc.
6. The factory can be set up in an existing available building.
7. Workers' and foremen's training classes and many other educational facilities can be found in cities.
8. Services of experts and specialists are easily available.
9. Many other small industries existing nearby can work as ancillaries.
10. Security is there.

Disadvantages

1. Land available for the building is limited in area.
2. Cost of land and building construction is high.
3. Expansion of the industry is seldom possible.
4. Local taxes etc., are high.
5. Labour salaries are high.
6. Union problems are more ; employee-employer relations are not so good.

4.3.2. Selecting the Plant site in a Small Town (More or less a Rural Area)

Advantages

1. Plenty of land is available for building construction and expansion purposes.
2. Land is cheap.
3. Unskilled labour is available which can be trained to suit the requirements of the concern
4. Employee-employer relations are good ; no union problem.
5. Undesirable manufacturing neighbour's are not likely to be present.
6. Municipal and other regulations and taxes etc., are seldom burdensome.
7. Goverment gives inducements as it wants to develop the underdeveloped areas.

Disadvantages

1. Skilled labour is not available.
2. Rail, road and air links may not be there at all or may not be adequate.
3. Power is not available.

4. Rural areas are far from selling markets.
5. Hospitals, educational and amusement centres are not available.
6. Ancillary services cannot be obtained.
7. Expert and specialist advice is not available.
8. High grade executives may not like to live in rural areas.

An alternative between the Urban and Rural areas is the *Suburban site* which being a compromise between the two is probably the most suitable. It possesses the good points of both Urban and Rural locations.

4.4. PLANT LAYOUT

Introduction

Plant layout means the disposition of the various facilities (equipments, material, manpower, etc.) and services of the plant within the area of the site selected previously. Plant layout begins with the design of the factory building and goes up to the location and movement of a work table. All the facilities like equipments, raw materials, machinery, tools, fixtures, workers, etc. are given a proper place. In deciding the place for equipment, the supervisors and workers who have to operate them should be consulted.

Objectives of Good Plant Layout

In a good plant layout :

(1) Material handling and transportation is minimized and efficiently controlled.

(2) Bottlenecks and points of congestions are eliminated (by line balancing) so that the raw material and semi-finished goods move fast from one work station to another.

(3) Work stations are designed suitably and properly.

(4) Suitable spaces are allocated to production centres and service centres.

(5) The movements made by the workers are minimized.

(6) Waiting time of the semi-finished products is minimized.

(7) Working conditions are safer, better (well ventilated rooms, etc.) and improved.

(8) There is increased flexibility for changes in product design and for future expansion.

(9) There is the utilization of cubic space (*i.e.,* length, width and height).

(10) There are improved work methods and reduced production cycle times.

(11) Plant maintenance is simpler.

(12) There is increased productivity and better product quality with reduced capital cost.

(13) A good layout permits materials to move through the plant at the desired speed with the lowest cost.

Principles of Plant Layout

For the guidance of Plant Layout engineers, many principles of *Plant Layout* have been developed during past years. Besides these ready-made principles, considerable art and skill is required in designing a good plant layout. The research work is being continued in order to develop a scientific approach for solving plant layout problems. Some of the outcomes are, the development of heuristic approach, mathematical models and computer aided computational techniques for balancing assembly lines.

A few sound principles of plant layout have been briefed as under. They are the principles of :

(*a*) *Integration.* It means the integration of production centres facilities like workers, machinery, raw material, etc., in a logical and balanced manner.

(*b*) *Minimum movements and material handling.* The number of movements of workers and materials should be minimized. It is better to transport materials in optimum bulk rather than in small amounts.

(*c*) *Smooth and continuous flow.* Bottlenecks, congestion points and back tracking should be removed by proper line balancing techniques.

(*d*) *Cubic space utilization.* Besides using the floor space of a room, if the ceiling height is also utilized, more materials can be accommodated in the same room. Boxes or bags containing raw material or goods can be stacked one above the other to store more items in the same room. Overhead material handling equipments save a lot of valuable floor space.

(*e*) *Safe and improved environments.* Working places-safe, well ventilated and free from dust, noise, fumes, odours, and other hazardous conditions decidedly increase the operating efficiency of the workers and improve their morale. All this leads to satisfaction amongst the workers and thus better employer-employee relations.

(*f*) *Flexibility.* In automotive and other industries where models of products change after some time, it is better to permit all possible flexibility in the layout. The machinery is arranged in such a way that the changes of the production process can be achieved at the least cost or disturbance.

4.5. PROCESS LAYOUT

It is also known as functional layout and is characterised by keeping similar machines or similar operations at one location (place). In other words, all lathes will be at one place, all milling machines at another and so on, that is machines have been arranged according to their functions. This type of layout is generally employed for industries engaged in job order production and non-repetitive kind of maintenance or manufacturing activities. Figure 4.1 shows a process layout.

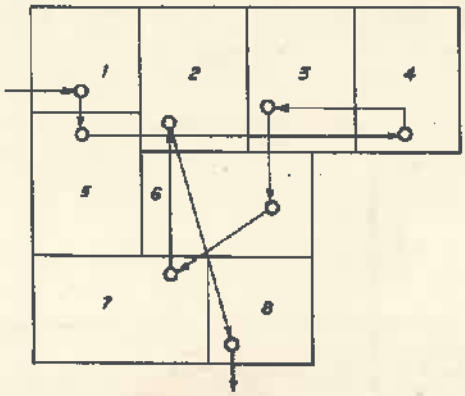


Fig. 4.1. Process layout showing product movements.

1. Store room , 2. Inspection Department, 3. Broaching Section, 4. Milling Section. 5. Lathe Section, 6. Shaper Section, 7. Drill Section, 8. Stock Room.

Advantages

(1) Wide flexibility exists as regards allotment of work to equipment and workers.

(2) Better utilization of the available equipment.

(3) Comparatively less number of machines are needed, thus involving reduced capital investment.

(4) Better product quality, because the supervisors and workers attend to one type of machines and operations.

(5) Varieties of jobs coming as different job orders make the work more interesting for the workers.

(6) Workers in one section are not affected by the nature of the operations carried out in another section. For example, a lathe operator is not affected by the rays of the welding as the two sections are quite separate.

Disadvantages of Process Layout (When compared with Product Layout)

(1) For the same amount of production, process layout needs more space.

(2) Automatic material handling is extremely difficult.

(3) More material-in-process remains in queue for further operations.

(4) Completion of same product takes more time.

(5) Work-in-process inventory is large.

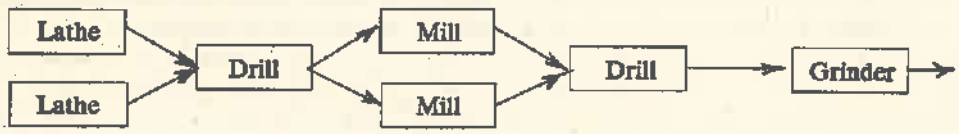
(6) Production control becomes difficult.

(7) Raw material has to travel larger distances for being processed to finished goods. This increases material handling and the associated costs.

(8) It needs more inspections and efficient co-ordination.

4.6. PRODUCT LAYOUT

It is also known as line (type) layout. It implies that various operations on raw material are performed in a sequence and the machines are placed along the product flow line, *i.e.*, machines are arranged in the sequence in which the raw material will be operated upon. This type of layout is preferred for continuous production, *i.e.*, involving a continuous flow of in-process material towards the finished product stage. Figure 4.2 shows a product type of layout.



A Simple product layout.

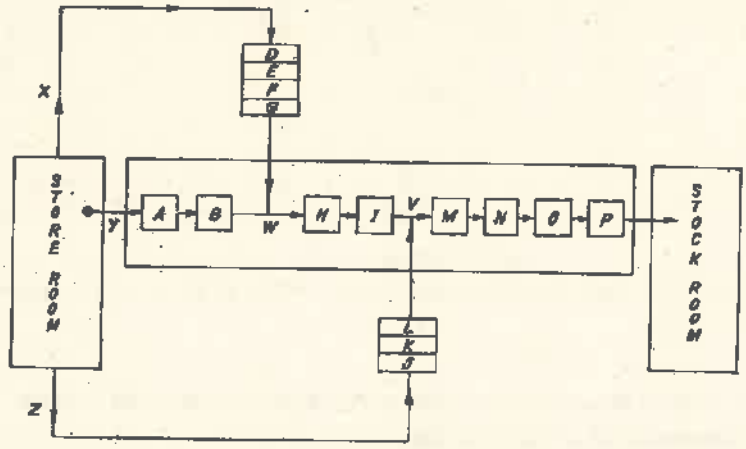


Fig. 4.2 Product layout.

Raw material from the store is fed to three lines *X, Y* and *Z*. Material in *X* line gets processed on machines *D, E, F* and *G* and meets material of *Y* line after it has been processed on the main assembly line machines *A* & *B*. Products of *X* and *Y* lines are assembled at *W* and get processed on machines *H* and *I* till another part comes from *Z* line and assembles with the main product at *V*. After that the total assembly gets worked on machines *M, N, O* and *P* and goes to the stock room. (The inspection phase has not been shown in the layout).

Advantages

(1) Less space requirements for the same volume of production.

(2) Automatic material handling, lesser material handling movements, times and costs.

(3) Less in-process inventory.

(4) Product completes in lesser time.

(5) Better co-ordination and simple production planning and control.

(6) Smooth and continuous work flow.

(7) Less skilled workers may serve the purpose.

Disadvantages as Compared with Process Layout

(1) Since the specified product determines the layout, a change in product involves major changes in layout and thus the layout flexibility is considerably reduced.

(2) The pace or rate of working depends upon the output rate of the slowest machine. This involves excessive idle time for other machines if the production line is not adequately balanced.

(3) Machines being scattered along the line, more machines of each type have to be purchased for keeping a few as stand by, because if one machine in the line fails, it may lead to shut down of the complete production line. This is how product layout involves higher capital investments.

(4) Though it involves less supervision as compared to process layout, sometimes it (inspection) becomes difficult when one inspector has to look after many (say all welding) machines in two or more production lines.

(5) It is difficult to increase production beyond the capacities of the production lines.

4.7. COMBINATION LAYOUT

A combination of process and product layouts combines the advantages of the both types of layouts. Moreover, these days pure product or process layouts are rare. Most of the manufacturing sections are arranged in process layout with manufacturing lines occurring here and there (scattered) wherever the conditions permit. A combination layout is possible where an item is being made in different types and sizes. In such cases machinery is arranged in a process layout but the process grouping (a group of number of similar machines) is then arranged in a sequence to manufacture various types and sizes of products. The point to note is that, no matter the product varies in size and type, the sequence of operations remain same or similar. Figure 4.3 shows a combination type of layout for manufacturing different sized gears.

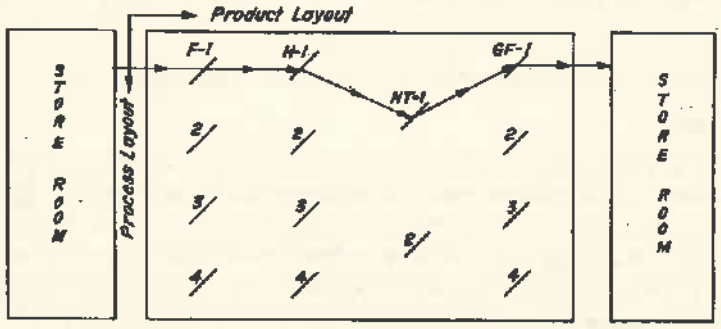


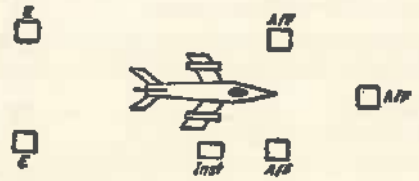
Fig. 4.3. A combination layout for making different types and sizes of gears.

F = Blank forging hammers.
H = Hobbing machines for cutting gear teeth.
HT = Heat treatment furnaces.
GF = Gear finishing machines.

A combination layout is also useful when a number of items are produced in same sequence but none of the items are to be produced in bulk and thus no item justifies for an individual and independent production line. For example, files, hacksaws, circular metal saws, wood saws, etc. can be manufactured on a combination type of layout.

4.8. FIXED POSITION LAYOUT

- Layout by fixed position of the product is inherent in ship building, aircraft manufacture (Fig. 4.4) and big pressure vessels fabrication.
- In other types of layouts discussed earlier, the product moves past stationary production equipment, whereas in this case the reverse applies; men and equipment are moved to the material, which remains at one place and the product is completed at that place where the material lies.



E - Engines
AfF - Air-frame
Inst - Instruments

Fig. 4.4. Layout by fixed position of products.

Advantages

(*i*) It is possible to assign one or more skilled workers to a project from start to finish in order to ensure continuity of work.

(*ii*) It involves least movement of materials.

(*iii*) There is maximum flexibility for all sorts of changes in product and process.

(*iv*) A number of quite different projects can be taken with the same layout.

Disadvantages

(*i*) It usually involves a low content of work-in-progress.

(*ii*) There appears to be low utilization of labour and equipment.

(*iii*) It involves high equipment handling costs.

Application

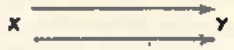
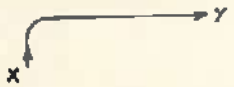
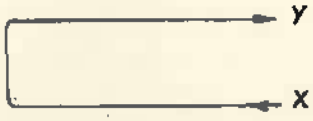
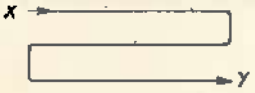
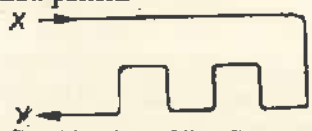
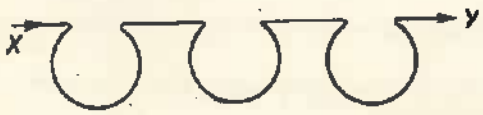
Layout by fixed position of product is limited to large items made singly or in very small lots.

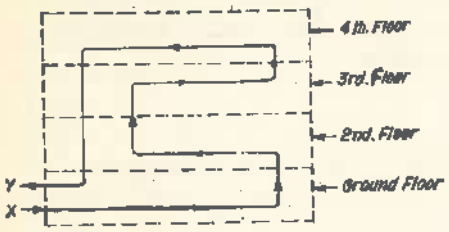
4.9. FLOW PATTERN

One of the most important phases of plant layout is to achieve an optimum effective flow of materials (raw materials, and in-process materials) through the plant. Naturally the principle of minimum movements (*i.e.*, number of movements and distance travelled in one move) forms the basis for optimum effective flow. The principle of minimum movements reduces material handling costs, in-process inventory and space for processing. The supervision and control becomes simpler. While designing a new plant layout, generally the flow patterns are decided earlier and then a system of facilities (machinery, material and building, etc.,) is designed and built around the flow pattern.

As far as possible a flow pattern should be simple in order to have easy supervision and control.

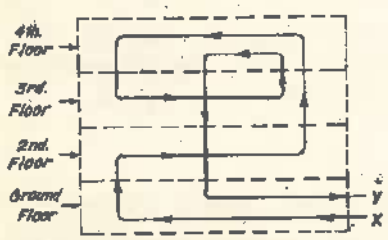
Various flow patterns along with their characteristics and place of application or use are given below.

Flow Pattern	Characteristics and Place of Use
 (*a*) Line flow	– Simplest, material enters at one end (*X*) and leaves at other end (*Y*). It is preferred in buildings having long lengths and smaller widths.
 (*b*) *L* type flow	– Resembles line flow and is used where buildings are more wide but less long as compared to line flow type buildings.
 (*c*) Circular flow	– Preferred for rotary handling systems. Different work stations are located along the circular path. Raw material enters at *X* and finished goods come out from *Y*.
 (*d*) *U* type flow	– Supervision is simpler as compared to (*a*) and (*b*) above. Raw material entrance and finished goods exit is on the same side. (*c*) and (*d*) are preferred in square-shaped buildings.
 (*e*) *S* or inverted *S*	– Preferred for production lines longer than (*d*) and in square shaped buildings. The system is compact, space has been better utilized and supervision is efficient.
 (*f*) Combination of *U* and line flow pattern	
 (*g*) Combination of line flow and *S* type of pattern	
 (*h*) Combination of line flow and circular type	As compared to line flow, this system needs smaller building lengths.



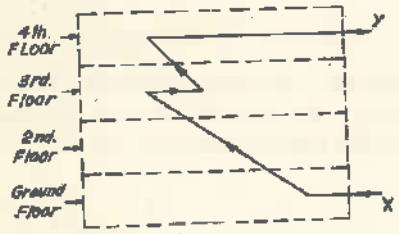
(*i*) Processing upwards

– The material may be processed while moving upwards or downwards in multi-storey buildings. In processing downward, gravity helps to bring the material down but first of all the whole material has to be taken to the top storey. An industry manufacturing plane glass may go for an upward type of flow.



(*j*) Retraction type of flow in multi-storey buildings.

– It involves more material handling cost as compared to (*i*) but finds better space and equipment utilization.



(*k*) Inclined flow

– Such system may be adopted depending upon the process characteristics.

Fig. 4.5. Flow patterns.

The various material handling equipments required for different flow patterns in multi-storey buildings may be elevators, conveyors, chutes, pipes, buckets, etc.

4.10. WORK STATION DESIGN

The work station design affects the production rates, efficiency and the accuracy with which an operation can be performed. A work station not only needs space for the worker and the machine, there are plenty of other items which also need accommodation. Space requirements and a few more factors governing a good work station design, are described below :

(*a*) ***Space Requirements :***

1. Space for the worker to stand, sit (as per requirements) or turn comfortably to operate the machine.
2. Space for the machine, taking into considerations the overhang, projection or the overtravel (OT) of the machine parts, like table of a milling machine or a planer.
3. Space for the work if it is ojecting out from the machine like a long bar fed to a turret lathe.
4. Space for bins storing in ming material and processed goods.
5. Space for necessary too nd supplies required by the worker.
6. Space for additional at ents, accessories, or jigs and fixtures.

7. Space to load large work on and off the machines.

(*b*) ***Besides space requirements as given above other factors are :***

1. Considerations of the space required, for the movements of material handling equipments.

2. Easy access to safety stops in case of emergency.

3. Easy access to machine for inspection, lubrication, maintenance and repairs.

4. Convenience of making foundations and machine installation.

5. Aisle space between one machine and the next.

6. Appropriate ventilating, lighting and safety arrangements. Figure 4.6 shows a work station layout, numbers 1, 2, 4, etc. refer to those of space requirements.

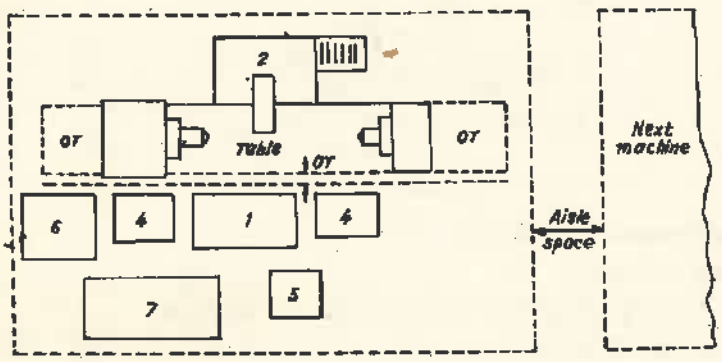


Fig. 4.6. A work station layout for a cylindrical grinding machine.

4.11. METHODS OF PLANT AND FACTORY LAYOUTS

A layout furnishes details of the building to accommodate various facilities (like workers, material, machinery, etc.). In addition, it integrates various aspects of the design of a production system. The information required for plant laying out includes, dimensions of work places, sequence of operations, flow pattern of materials, storage space for raw material, in-process inventory and finished goods, offices, aisles, toilets, etc. There is no single universal technique leading to best layout; the different techniques independently or in conjunction with other techniques may be employed at different stages invloved in plant or factory layout. The words plant and factory can be taken more or less as synonyms.

During different development stages of a layout the following methods may be used.

(1) **Process Flow Charts**[1] .They show, how different component parts assemble, in sequence of operations to form sub-assemblies which in turn lead to assemblies (finished products).

(2) **Material Movement Patterns**[2]. The flow pattern of materials-in-process is traced and layout is built around it.

(3) **Layout Analogues.** They cover two-dimensional cutouts or templates and three-dimensional models.

(*a*) **Templates.** They are used to develop plant layout. They are two-dimensional or block templates made up of cardboard, coloured paper or celluloid. They are made to scale (a typical scale being 1/50) and are placed on the scaled outline plan of the building. Templates or cutouts show the plan of the various facilities and the building. They show the actual floor space utilization. The templates can be placed and attached with a tape either on a board or on a cross-hatched surface or on a graph paper and thus being

1. Discussed under work study.
2. Refer section 4.9.

known as Graphic Technique. These templates have flexibility in use and can be moved on the graph paper from place to place in order to evaluate various feasible positions for different machines. It is better to photograph a layout before shifting the templates to try another layout of facilities. Templates save a lot of time and labour which otherwise would be spent in making drawings for each alternative plant layout arrangement. They visually present various characteristics, advantages and limitations of a layout. Coloured templates have still better vision effect. Figure 4.7 shows a block template and a two dimensional template. A two-dimensional template gives machine outline and its details whereas a block template shows the boundary of the maximum projected area of the machine. Templates, though simple and inexpensive, do not give real situation effect which is obtained through the use of three-dimensional models or block models.

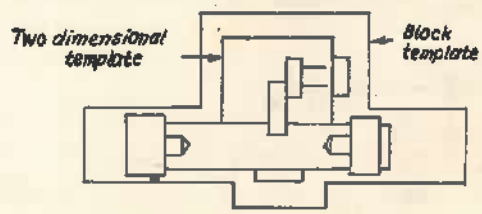


Fig. 4.7. Two-dimensional and block template.

Advantages of Two-Dimensional Templates

(1) They are the least costly.

(2) They can be readily interpreted and followed by technical hands.

(3) Duplicate copies can be made.

Disadvantages

(1) Non-technical persons find it difficult to grasp the clear picture.

(2) Overhead facilities cannot be visualized.

(b) **Three-Dimensional Models.** They are scale models of a facility and, more near to the real situation as, besides length and width they show the height of a facility also. Models are especially suitable for persons who are not familiar with plant layout practice. Models are made up of wood or diecast plastic. They show minor details and can be mounted on a thick plastic sheet acting as the floor plan. Models are used mainly to develop floor plans and elevations. Models can be made for production machines, workers, material handling equipments or any other facility. Models are much more effective and fast as compared to drawings or templates especially when multistorey plant layout is to be designed. Multistorey models can be made of Lucite (a clear plastic). Models though expensive have resulted in substantial saving in laying out of chemical factories and refineries.

Advantages of Three-Dimensional Models

(1) Layout is easier for the lay men to understand.

(2) Layout can easily be explained to management.

(3) Models can be shifted easily and quickly to study operational arrangements.

(4) Overhead structures can be easily checked.

(5) They convey more or less a real situation.

Disadvantages

(1) They require more storage area.

(2) They are expensive.

(3) It is difficult to take them to shop floor for reference purpose.

Other methods of plant layout are as follows :

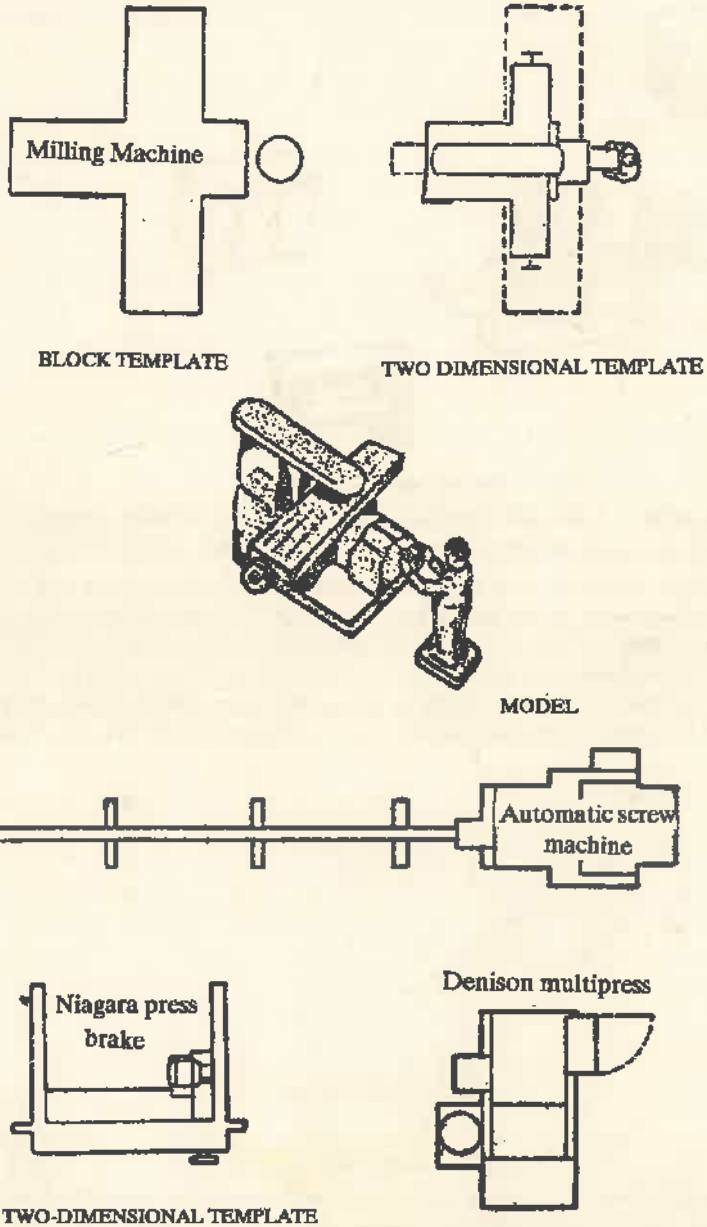


Fig. 4.8.

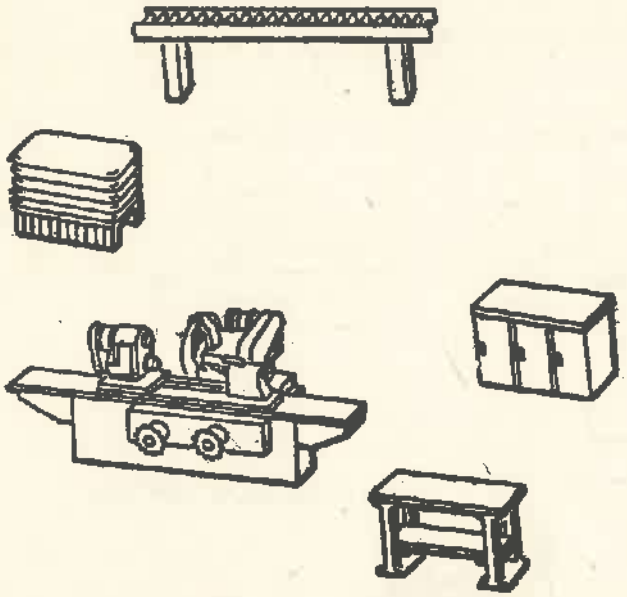


Fig. 4.9. Three-dimensional models.

(4) **The Correlation Chart.** It involves drawing a grid with rows presenting alternative solutions (*See* Fig. 4.10). Plant items can be ground floor, first floor or other floors of a multi-storey building.

After the grid has been drawn the next step involves applying the constraints and objectives of layout. For example, the constraints to the layout may be that, (1) X cannot be done on ground floor (G.F.), (2) Y cannot be performed on first storey (1S). Similarly there can be objectives, (3) W should be done on second storey, and so on there are other objectives (4), (5), etc. Constraints and objectives are then applied to the squares. When a constraint stops an item going into a square, then in that square the number of that constraint is marked. After that the objectives or preferences are applied. For example W is restricted to

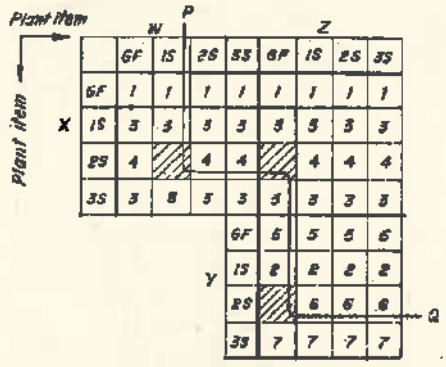


Fig. 4.10. Correlation chart.

second storey (2 S) hence it cannot be done on other floors therefore 3 (the identification number of objective) is marked on all other squares except (2 S). Similarly other objectives can be marked on the grid. A feasible solution of the layout problem is given by the path (PQ) traced along the grid rows fom the first (plant) item to the last item by joining open squares (hatched) only. The possible solution is

$$W_{1S} - X_{2S} - Z_{GF} - Y_{2S}$$

Correlation chart is an easy technique and gives visual presentation. However, drawing up consumes much time.

(5) Travel Chart. A travel chart as the name suggests is a chart or record of the amount of travel by the material in-process while going from machine to machine or from one department to another. The amount of travel depends upon the frequency of movements between sections or departments. A travel chart helps improving the existing plant layout.

The following example will explain a travel chart :

Existing plant layout showing the locations of various departments (*A* to *F*) is given in Fig. 4.11.

A	*B*	*C*
D	*E*	*F*

Fig. 4.11. *Ist Step* : (Existing layout).

2nd step : Movements *A* to *B* are 20 ; *B* to *A*, *10* ; *B* to *C*, 15 ; *A* to *F*, 25 ; *C* to *D*, 30 ; *D* to *C*, 50 ; *D* to *F*, 40 ; *E* to *F*, 10 and *F* to *E*, 15.

3rd step : A square grid is drawn and the various movements are marked.

FROM / TO	A	B	C	D	E	F
A		10				
B	20					
C		15		50		
D			30			
E						15
F	25			40	10	

Fig. 4.12 *3rd step.*

FROM / TO	A	B	C	D	E	F
A						
B	30					
C		15				
D			80			
E						
F	25			40	25	

Fig. 4.13. *4th step.*

4th step : Fig 4.12 is simplified by combining movements like *A* to *B* (20) and *B to A* (10) which involve same distance and therefore total movements $B \rightleftarrows A = 20 + 10 = 30$.

The simplified travel chart (*See* Fig. 4.13) shows the movements as follows :

$A \rightleftarrows B = 30$

$B \rightleftarrows C = 15$

$C \rightleftarrows D = 80$

$A \rightleftarrows F = 25$

$D \rightleftarrows F = 40$

$E \rightleftarrows F = 25$

According to these figures maximum number of movements are between departments *C* and *D*, hence in the plant layout these two departments should be side by side. The next lesser number of movements are between *D* and *F*, hence *D* and *F* should also lie closer to each other and so on. As a result the existing plant layout can be modified as follows :

C	D	A
E	F	B

Fig 4.14. Modified Layout.

Departments *C* and *D* (80), *D* and *F* (40), *A* and *B* (30), *A* and *F* (25), *E* and *F* (25) are closer to each other whereas *B* and *C* which have minimum number of movements (*i.e.*, 15) between them are away from each other.

A travel chart is advantageous because it brings out the relative importance of having different pairs of departments close to each other but it gives an optimum linear arrangement which may not be always required.

(6) Load Path Matrix Method. The method aims at reducing the transportation of in-process inventory from section to section. Like travel chart it also helps deciding the position of one department in relation to the other. The ultimate purpose is to modify the existing layout or the preliminary plant layout made by other techniques. The departments having mass flow of material or goods are placed close to each other. The following example will illustrate the method.

*Kgs of material moved per day.

FROM / TO	A	B	C	D	E	F
A		10				
B			15			
C	20*			20		
D	40				25	5
E			25			
F					15	

Fig. 4.15 From–to matrix constructed from the actual given data. (*Step 1*).

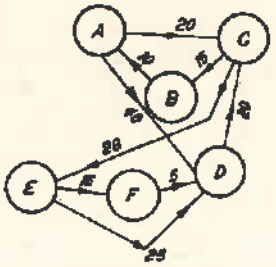


Fig. 4.16. (*Step 2*).

From the matrix (step 1) a diagram (*See* Fig. 4.16) is made showing the locations of different departments and the amount of material flowing among various departments (like *A, B, C,* etc.). Line joining *AC* shows that 20 kg. of material moves per day from department *A* to department *C* and so on. It can be seen that 40 kgs. of material while going from *A* to *D* passes *B*. If *D* department is brought in place of *B* then 40 kgs (*i.e.*, maximum) of material will move comparatively less distance. Similarly, material movements from *C* to *E* and *E* to *D* can be considered. The aim is to reconstruct this sequence diagram so that bigger loads travel small distances.

Step 3. Trial and error method can be used in order to modify the sequence diagram of step 2 and a comparatively better sequence diagram is drawn in Fig. 4.17. This has been obtained by placing those departments close to each other which involve movements of larger amounts of materials.

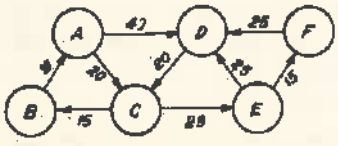


Fig. 4.17. Modified sequence diagram.

4.12. STORAGE SPACE REQUIREMENTS

Adequate storage space allocation to different materials and supplies is of great importance because otherwise, a small increase in their quantities may give rise to congestion and the whole storage system may be out of gear.

– The following items and the amount of stock holding determine the storage space requirements :

(*a*) Incoming new materials,

(*b*) Checking and sorting the raw material,

(*c*) Inspection of raw material.

(*d*) Temporarily storing the new material before it is placed at the proper location.

(*e*) In-process inventory,

(*f*) Tools and other supplies, and

(*g*) Finished products.

– The space to be provided for above factors depends upon :

(1) Size and weight of raw material, in-process goods and finished goods,

(2) Their quantities, and

(3) Frequency of use.

Liquid materials are stored in drums, cans, barrels and bottles, Gases are kept in cylinders whereas solid materials can be placed in boxes, barrels, bags, pallets, containers, etc. Castings or forgings can be stored in pallets and stocked in rows. Toxic materials are generally stored in well ventilated areas. The storage space should be such that the materials can be quickly and easily taken out for delivery or stocked as soon as they are received in the factory. Suitable equipments can be used for handling the material. Bins, drums, barrels, racks, shelves, tanks, tote boxes, pallets, etc. may be usefully employed for storage purposes.

Storage space should be adequate, considering the material requirements and the load bearing capacity of the soil if heavy materials are to be stored. Aisles are passages for the movements of men and materials. Depending upon the type and size of the material to be stored, the amount and frequency of men movements and other traffic involved, and the size of material handling equipment, the aisles and the sub-aisles are designed. Generally aisles can be 1.5-3 metres wide and sub-aisles between racks may be 75 cm wide. The aisles should not have many turns or blind corners which may cause accidents.

A window as a part of the enclosed store space can be used for issuing salable and portable products, which can be passed on to the workers through the same so that operators can be kept outside the store room. It is very necessary for an effective store room control.

Figure 4.18 shows the plan view of a store room indicating various spaces required.

(1) Incoming material receiving gate,

(2) Place for dumping raw material,

(3) Place for sorting and checking of raw materials,

(4) Place for raw material inspection,

(5) Place for temporarily storing the materials before putting them on racks, etc.

(6) Proper place for storing each type of material,

(7) Main aisles,

(8) Side aisles

(9) Service window,

(10) Boxes containing materials to be issued, and

(11) Counters for keeping materials, to be issued, which have been brought from (6) and will be placed in (10).

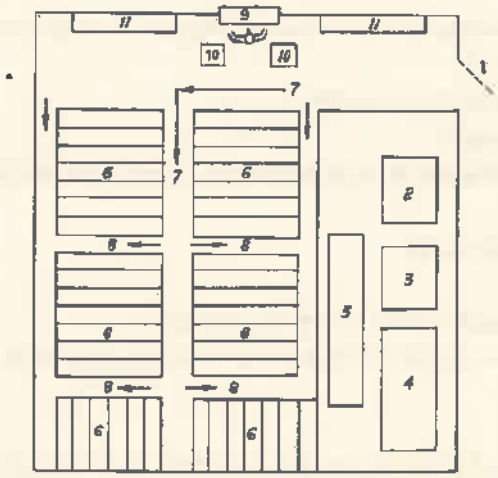


Fig. 4.18. Store room.

4.13. PLANT LAYOUT PROCEDURE

– The ideal procedure for a plant layout, is to build the layout around the productive process and then design the building around the layout.

This may not be possible always, because the plant building may already be existing or the shape of plant site may not permit the construction of a building to house the productive process, etc.

Ultimately, one has to strike a balance between the two approaches. However, various procedural steps involved in plant layout have been listed and described below :

(*a*) Accumulate basic data,

(*b*) Analyse and coordinate basic data,

(*c*) Decide the equipment and machinery required,

(*d*) Select the material handling system,

(*e*) Sketch plan of the plot for making factory building ,

(*f*) Determine a general flow pattern,

(*g*) Design the individual work station,

(*h*) Assemble the individual layout into the total layout,

(*i*) Calculate storage space required,

(*j*) Make flow diagrams for work stations and allocate them to areas on plot plan,

(*k*) Plan and locate service areas,

(*l*) Make master layout,

(*m*) Check final layout,

(*n*) Get official approval of the final layout, and

(*o*) Install the approved layout.

(*a*) **Accumulate basic data,** such as

- Volume and rate of production.
- Product specification and bill of materials.
- Process sheets indicating tools, equipments, the method and the product which will be manufactured.
- Flow process charts (refer Section 9.8).
- Standard time to complete each operation, etc.

(*b*) **Analyse and coordinate basic data** in order to find,

- the workforce size and type.
- Number of work stations required.
- Type of equipment required.
- Storage and other space requirements.

Assembly chart and operation process chart help coordinating basic data.

(*c*) **Decide equipment and machinery required**

Number of equipments required to meet a particular production target can be calculated by knowing :

(*i*) Number of articles to be produced.

(*ii*) Capacity of each equipment.

(*iii*) Time in which the order is to be completed, etc.

(*d*) **Select the material handling system** for moving raw material, semi-finished goods and final products. The type of material handling equipment to be selected depends upon :

- Material/product to be moved.
- Container in which it will be moved.
- Length of movement.
- Frequency of movement.
- Speed of movement, etc.

(*e*) **Sketch plan of the plot** to mark building outline, roads, storage and service areas, etc.

- The plan orientation should utilise maximum, the natural heat, light and other weather conditions.

(*f*) **Determine a general flow pattern**

- Machinery may be laid as per production process requirements and plant building be erected around the same.
- The flow pattern (refer Section 4.9) of materials should be such that the distance involved is least between the store and the shipping department through the production centres. There should be minimum back tracking and bottlenecks.
- Flow patterns may be analysed using operation process charts or travel charts (refer Section 4.11) in case of multiple flow patterns.
- Based upon the process or product requirements, one may adopt :

(*i*) A process layout,

(*ii*) A product layout, or

(*iii*) A combination layout, (refer Section 4.5)

– Plant layout should be flexible so that it can accommodate changes in product or product diversification.

(*g*) **Design individual work stations.** Each work station should be laid for achieving optimum

– performance of operations ;

– materials and space utilisation ; and

– safety and comfort of employees, etc. (refer Section 4.10)

(*h*) **Assemble the individual work station layout** into the total layout in accordance with the general flow pattern and the building facilities.

(*i*) **Calculate the storage space required**

– Stores accommodate raw materials, in process goods and finished products.

– Storage size increases with the plant size.

(N.B. For details refer Section 4.12).

– Storage space can be calculated by knowing :

(*i*) Volume of each store item.

(*ii*) Number of items to be kept in stores.

(*iii*) The time (date-wise) each item may be kept in the stores.

(*j*) **Make flow diagrams for work stations** and allocate them to areas on plot plan.

(*k*) **Plan and locate service areas,** such as

– Offices.

– Toilet and wash rooms.

– Tool rooms.

– Rest and lunch rooms.

– Cafeterias.

– Dispensary.

– Power generation areas.

– Parking areas, etc.

(*l*) **Make master** layout by using templates and models. (refer Section 4.11).

(*m*) **Check final layout** and associate in this act, all the persons concerned, *e.g.*, those from plant, production, personnel, safety and other departments.

– Final plant layout is checked as regard the following aspects :

(*i*) Safe and economical material handling.

(*ii*) Adequate production and production control.

(*iii*) Plant building and its surroundings.

(*iv*) Product design.

(*v*) Service areas.

(*vi*) Employee safety and comfort, etc.

(*n*) **Get official approval of the final layout**

– After the final plant layout has been checked, it is got officially approved and signed by the team which checked the final layout.

– A final layout accompanies :

(*i*) Product drawings,

(*ii*) Bill of material (parts lists),

(*iii*) Assembly and operation process charts,

(*iv*) Manpower requirements,

(*v*) Equipment requirements, and

(*vi*) Estimated expenditures and revenues, etc.

(*o*) Install the approved layout

– Make detailed plans for installing production, service and other centres.

– Install equipment, machinery, work benches, offices, etc.

4.14. FACTORY BUILDING

Introduction

– After the plant location has been selected and plant layout decided upon, the next step is to construct plant or factory building to house and protect employees, equipments, tools, machinery, materials, etc.

– The factory building is the primary tool required to carry on production and into which all other production tools, processes and mechanisms must fit.

– *A good factory building*

(*i*) helps performing different operations most effectively ;

(*ii*) reduces material handling costs ;

(*iii*) minimizes production cycle time ;

(*iv*) reduces bottlenecks, stoppages and interruptions

(*v*) increases plant flexibility and efficiency ;

(*vi*) lowers down the maintenance costs ;

(*vii*) increases equipment and employees' safety ; and

(*viii*) has good appearance and provides healthy and pleasant working conditions.

4.15. CONSIDERATIONS IN BUILDING DESIGN

– The following factors should be considered while planning a factory building :

(*a*) Nature of manufacturing process,

(*b*) Flexibility ,

(*c*) Expandability or future expansion,

(*d*) Service facilities,

(*e*) Employee facilities,

(*f*) Lighting,

(*g*) Heating,

(*h*) Ventilating,

(*i*) Air-conditioning, and

(*j*) Other considerations.

(*a*) Nature of Manufacturing Process

– Buildings required to house *continuous* or *intermittent* production processes differ quite a lot in their design. Seldom the same building is suitable for both these types of productions.

– Building design varies with the type of product to be manufactured and the equipment utilised.

Buildings manufacturing rubber tyres, clothes, machine tools, glass bottles, presses or steel plates possess designs which differ as regards floor loading, height of the ceiling, bay size, ventilation and humidity requirements, etc.

(*b*) Flexibility

– Suppose a factory owner is interested to leave his original product and decides to manufacture another product which he feels is probably more profitable. He cannot construct another building and thinks of using the same old factory building for making the new product. This is not strange; many old cotton mills and sugar factories are now being used for light engineering works.

At this stage the question arises, whether the old factory building is **flexible** enough to be used for manufacturing the new product?

– Thus, **flexibility** in the factory building avoids it from becoming obsolete and imparts to it (*i.e.*, to the building) the same operating efficiency even when there is a change in product, process or technology.

– The **flexibility** of a factory building *can be increased* by :

(*i*) providing a large floor area unobstructed by pillars, columns, etc., so that processes and layouts can be changed easily ;

(*ii*) keeping adequate roof truss strength and ceiling height so that newer material handling equipments can be installed and inside building temperatures may be controlled ;

(*iii*) erecting no permanent obstruction such as walls and partitions on the production floor ;

(*iv*) providing individual motor drives for the machines ;

(*v*) providing overhead electrical grid so that electrical supply (at various voltage levels) can be tapped near the equipment ;

(*vi*) making heavy duty floors to accommodate even heavier machines;

(*vii*) making machine installations such that the machines can be moved easily when layout changes are required.

(*c*) Expandability or Future Expansion

– Keeping provision for future expansion has become very necessary because of the enormous expansion of industry in recent years.

– Due consideration is being given to future expansions while designing a new building ; but before that a plant site size large enough for current needs and for future expansion requirements should be purchased.

– While designing the factory building, it is thought of carefully that in future, whether the building will expand length or breadth-wise or more number of floors will be constructed.

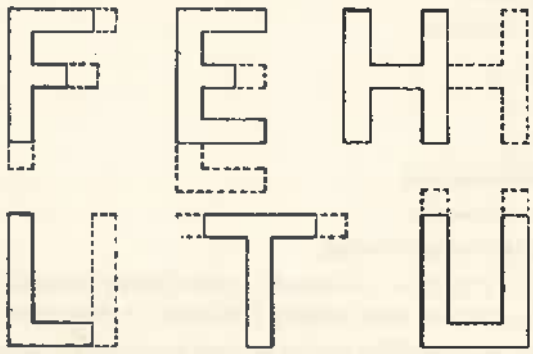


Fig. 4.19. Expansions to factory buildings.

- If it is decided to expand length- and breadth-wise, false and non-load bearing end walls are constructed to make expansion easier.
- If more floors are to be added in the building above the ground floor, adequate foundations, supports, etc., should be provided in the original structure to carry the weight of added floors.
- Where processes are housed in separate buildings, certain plan shapes have become popular due to their ease of extension (expansion) and they are in the form of the letters *F, E, H, L, U, T,* etc; (refer Fig. 4.19) original building is in full lines and extensions are shown dotted.

(d) Service Facilities

Service facilities such as fire fighting equipments, sewage-treating systems, emergency and stand-by power equipments, compressed-air equipments, heating, lighting, ventilating and air-conditioning equipments, etc., should be housed separately and suitably.

(e) Employee Facilities

Good employee facilities are incentives to the employees of an organisation and they build up the morale of the employees. Adequate provision should be kept as regards washroom and toilet facilities, dispensaries, cafeterias, recreation rooms, parking areas etc.

(f) Lighting

- One of the most important environmental factors is **Lighting** which increases productivity, reduces accidents and adds to employee satisfaction.
- **Advantages of Good Lighting**

(*i*) Increased output, therefore decreased costs,

(*ii*) Reduced accidents,

(*iii*) Improved product quality,

(*iv*) Better visibility, therefore less strain on the eyes,

(*v*) Less spoilage and consequent rework,

(*vi*) Better floor space utilisation and improved house-keeping,

(*vii*) Plant neatness and cleanliness can be better maintained.

(*viii*) Easier and better supervision of materials in process and finished products, and

(*ix*) Improved morale among employees resulting in reduced labour turnover.

- **Characteristics of Good Lighting**

1. Light should be of sufficient intensity for the particular operation being performed.

2. Light should be equally bright throughout the shop floor.

3. Light should be diffused and not glaring.

4. There should be adequate but not sharp contrast between each part of an object and from the surrounding background.

5. Light should not permit marked shadows.

6. Dazzling light should be avoided.

- **Nature of Light**

1. *Natural light* is actually the best for working, but it varies with the time of day, time of the year and weather (cloudy) conditions. It also varies with the size and positions of windows and moreover it is just not possible to regulate the intensity of natural lighting. This necessitates the use of *artificial lighting.*

2. *Artificial lighting* is designed in such a way that it should supplement natural lighting. Artificial lighting, during day time, serves only those areas which do not have enough light to work.

– *Artificial Light Sources*

(*i*) Tungsten filament lamps,

(*ii*) Fluorescent tubes, and

(*iii*) Mercury vapour lamps.

Tungsten filament lamps are inexpensive, easy to install and are available in different wattage ranges. But they have low rate of efficiency, need shielding to eliminate glare and therefore are used only for local lighting. They have been partly replaced by fluorescent lamps and tubes.

Fluorescent lamps and tubes have best efficiency rate and are in very common use in factories. Their current consumption is less, they have a low brightness rating, longer life and are available in a number of colours.

However, sometimes they cause stroboscopic effect when looking at rotating parts and create maintenance problems because they are being used in large number even in an average installation.

Mercury vapour lamps have a high brightness, are easy to maintain and have long operating life. Its greenish blue light gives an unnatural look. Mercury vapour lamps are used in large machine shops, hangers, and in high bays for general industrial lighting.

Reflectors may be employed for getting direct, diffused or indirect light.

– **Levels of Illumination**

The unit used to measure the intensity of illumination is the *lumen*, I lumen/ft^2 being equal to a foot candle.

Recommended standards of illumination for different types of work are given below :

	Type of Work and Factory areas	*Illumination (foot candles)*
1.	Passage ways	5
2.	Stair ways	10
3.	Rough work	15
4.	Normal work or auto-machine work	30
5.	Ordinary bench work	50
6.	Fine work	70
7.	Fine assembly work	100
8.	Minute and fine precision work	200-1000

(*g*) Heating

– In a factory, heating is required for following purposes :

(*i*) *Processing.* Heating is required for melting metals and alloys, making forging, etc.

(*ii*) *Work-place heating.* Work-place is heated for improving the efficiency of the workers in the winter season. The temperature maintained is within the comfort zone of about 60-65°F.

(*iii*) *Cooking* and preparation of factory meals.

– *Heat sources for*

(*i*) *Processing :* Electric, coke or oil fired furnaces, boilers etc.

(*ii*) *Work place heating :* Electric heaters, coal stoves etc.

(*iii*) *Cooking :* Gas or electric stoves.

– Fuel is generally burnt centrally and heat is transmitted to different work places, etc., with the help of pipes containing hot water, steam or hot air.

– Heating systems can be automatically controlled.

(*h*) Ventilating

- Ventilating is basically replacing stale air (of the factory building) by fresh air. If the stale air is not removed, it will smell bad and the concentration of carbon-dioxide, humidity and temperature will rise.
- Inadequate ventilation results in discomfort and fatigue.
- Modern plants provide ample ventilation by increasing the number of air changes per hour.
- *Methods to provide ventilation*

(*i*) *Natural ventilation* through windows and roof or wall ventilators.

(*ii*) *Mechanical ventilation,* employing exhaust fans to extract stale air from the factory building. Fresh air enters from doors and windows.

(*iii*) Mechanical ventilation employing fans which draw fresh air into the factory building; the stale air escapes naturally.

(*i*) Air-conditioning

- Air-conditioning is the control of air temperature, humidity, cleanliness and distribution of air.
- *Temperature control* involves heating the air in winter and cooling it in summer. Heat may be generated from a central heating plant using hot water or steam as a heating medium.

  Cooling may be caused by piping the coolant from a centralized compressor plant to local areas where air is run through the coils. Self-contained air-conditioners may be installed directly in the rooms to be cooled.
- *Humidity* of the air is adjusted by adding moisture to it in winter and by removing moisture from the moist summer air.
- *Air is cleaned of foreign* materials such as dust, etc., by
  - (*i*) Forcing air through a spray of water,
  - (*ii*) Passing air through filters, and
  - (*iii*) Electrostatic precipitation.
- *Air motion* is achieved by proper positioning of incoming air ducts and exhaust outlets.
- Odors and Bacteria in air are removed by passing air over chemicals.

Air-conditioning of buildings is done for the following *purposes :*

1. To avoid the precision measurement errors due to expansion of instrument parts.
2. To increase workability as in tobacco and textile industries.
3. To promote quality of workmanship.
4. To minimize deterioration as in meats, fruits, vegetables, certain oils and chemicals.
5. To increase employee efficiency, to reduce fatigue, to maintain morale and to create good public relations.
6. To increase output and improve product quality.
7. To reduce corrosion and deterioration of certain materials in process.
8. To protect workers against harmful dust (silica dust), smoke and poisonous gases.
9. To promote plant cleanliness and better psychological atmosphere.

(*j*) Other consideration, such as

1. *Good appearance,* can be achieved by making use of appealing colours, more glass and metal sections. The style of architecture and building materials are responsible for the good appearance of a factory building.

2. *Strong, durable, economical and safe construction.* Make use of steel structures for roofing and supports. Use prefabricated doors, windows etc. Precast concrete construction may be advantageous.

3. *Security measures* include providing fencing wires, laying broken pieces of glass on the boundary walls, keeping explosive and inflammable materials outside the factory building in separate enclosures, etc.

4. *Noise control, i.e.,* minimizing undesirable noises to reduce mental fatigue of the workers (resulting in) accidents and industrial deafness.

- Noise affects
  Job performance,
  Health of employees, and
  Employees morale.
- Sources of noise in industry

Source	*Distance (metres)*	*Intensity (decibels)*
Hydraulic press	1	130
Large pneumatic riveter	1.25	128
Pneumatic chipper	1.5	124
Multiple sand-blast unit	1.25	118
Automatic punch press	1	112
Cut-off saw	0.60	108
Automatic lathe	1	98

- Noise can be reduced by
  (*i*) Proper maintenance and lubrication of machines.
  (*ii*) Isolating noise sources from other machinery.
  (*iii*) Mounting machines on spring rubber or felt, etc.
  (*iv*) Redesigning the plant for better acoustical properties.

4.16. TYPES OF FACTORY BUILDINGS

- Factory buildings may be classed as follows (refer Fig. 4.20).

1. Single storey buildings with different roof structures such as flat, bow string, etc.

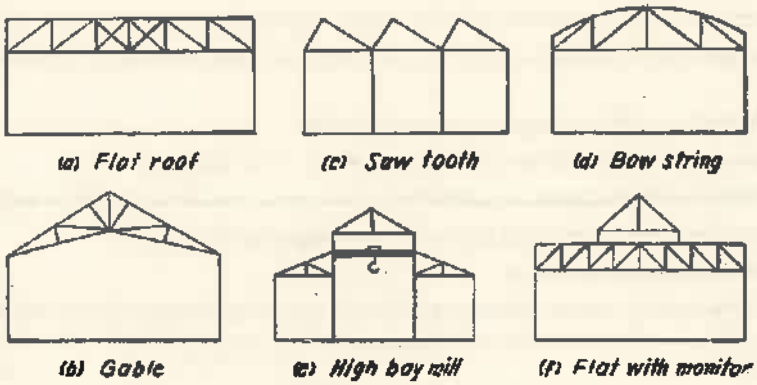


Fig. 4.20. Roof structures of factory buildings.

2. High bay and monitor types.
3. Multistorey buildings
4. Buildings of special types.

1. Single Storey Buildings

Advantages

(*a*) Easy to expand.
(*b*) Greater flexibility in layout.
(*c*) Natural light and ventilation can be supplied through the roof.
(*d*) Foundations required to be made are light.
(*e*) A single storey building requires less time to erect.
(*f*) Since floor to floor movements are not involved, material handling costs are lower.
(*g*) One floor level makes supervision and control easier.
(*h*) Less mechanical vibrations are involved.
(*i*) Heavy machinery can be installed.
(*j*) It is easy to isolate abnoxious or hazardous areas.
(*k*) No space is lost due to elevators and stairs.
(*l*) Building costs are less compared with a multi-storey factory of the same gross area.
(*m*) Permits high ceilings.
(*n*) Needs fewer columns.
(*o*) The risk of serious fire damage is less.
(*p*) Involves less operating cost.
(*q*) Maintenance of building and equipments is easy.

Disadvantages

(*a*) Single storey buildings do not make most effective use of land.
(*b*) They need more land.
(*c*) Layout is not very compact.
(*d*) Gravity cannot be employed for material handling purposes.
(*e*) Valuable production floor space is occupied by offices and stores.

Use. Single storey buildings are used where :

(*i*) Land is relatively cheap.
(*ii*) Heavy machinery is required for processing.
(*iii*) Growth of factory is expected.

2. High Bay and Monitor Type Buildings

- They are basically single storey buildings.
- For a given floor space, they provide maximum overhead space.
- Large overhead space can be utilised for operating cranes.
- Natural ventilation and natural illumination are the main advantages for these types of buildings.
- Foundry and steel mill buildings are generally of monitor or high bay type.

3. Multi-storey Buildings

Advantages

(*a*) They possess distinct material handling advantages where goods can be moved by gravity.

(*b*) They provide for maximum operating floor space per square metre of land.

(*c*) They involve a lower site cost for a given production area.

(*d*) They need less land and make more efficient use of land.

(*e*) They make a more compact layout.

(*f*) They involve lower heating costs.

(*g*) Top stories may be utilised for light stores and offices thereby increasing the size of production floor on the ground level.

Disadvantages

(*a*) Material handling is expensive for bulky materials.

(*b*) More time is taken by persons and materials in transit from one floor to another.

(*c*) Stairways, elevators, etc. reduce the effective area and thus increase the cost per square metre of usable space.

(*d*) The more the number of stories, the higher is the cost of foundations and the more is the space occupied by supporting columns.

(*e*) Natural illumination in the centre of a multistorey building is poor.

(*f*) Changes in width and length of upper floors (for expansion purposes) is not possible.

Uses. Multistorey buildings are used :

(*i*) Where cost of land is relatively high.

(*ii*) In process industries such as refineries, chemicals, fertilizers, floor mills etc.

4. Buildings of Special Types

- Special type buildings may be a combination of the three types discussed above.
- A special type building may be designed to accommodate a particular process.
- Such buildings are inflexible.
- They become obsolete, once the process changes.

4.17. TYPES OF BUILDING CONSTRUCTION

- An industrial building may have one of the following constructions.

(*a*) *Wood frame construction*

- Such a building generally is not more than two storeys in height.
- Floors take lighter loads only.
- It is highly flammable construction, therefore it is used where fire hazards are rare and are not a serious drawback.
- Such a building depreciates fast and thus has relatively shorter life.
- High insurance rates are associated with such construction.

(*b*) *Brick construction*

- Side walls and interior fire walls (*i.e.*, the walls which separate sections of the building to prevent fire spread) are made up of bricks.
- Floor beams and roof supports resting on the walls are pilastered.

- It lasts longer than wood construction and facilitates making changes, if any.

(*c*) *Slow burning mill construction*

- It is plank-on-timber building with load bearing brick siding.
- Owing to heavy wood members being used, the construction is fire-resistant because the members, *i.e.*, pillars, etc., are slow to burn and even after getting partially charred, support the building (*i.e.*, floors etc).
- Such a building can take moderate floor loads but involves high maintenance costs, high noise and vibration transmission and light and ventilation restricted by the load bearing walls.
- However, electrical, plumbing and other plant utilities can be altered with ease.

(*d*) *Steel frame construction*

- It makes use of steel girders, columns and trusses.
- Space between the columns is filled by bricks, etc.
- Such a construction involves a low insurance rate and facilitates making changes in the building.

(*e*) *Reinforced concrete construction*

- This is fire-proof construction.
- All structural members are made up of reinforced concrete, masonry or steel encased in concrete.
- It is a very good type of construction for multi-storey buildings.
- Such construction provides heavy floor loading characteristics and involves low maintenance costs.

  Of course the initial cost of construction is high.
- Changes in buildings are costly and difficult to make.

(*f*) *Precast Concrete Construction*

- It is very speedy and economical.
- Sections are precast either at vendor's end or on the ground itself, cured (*i.e.*, set) and then tilted vertically up by cranes to form the wall, roof and floor, etc.

Building Materials

For floors :

1. Concrete : It is cheap and serviceable; is very commonly used.
2. Wood blocks laid on concrete.
3. Vinyl-asbestos tiles laid on concrete.
4. Grease resistant asphalt tile.

For Walls :

1. Cement
2. Brick
3. Tiles
4. Concrete
5. Wood
6. Insulated metal panels
7. Asbestos cement panels.

A combination of brick and cement is very popular.

For Roofs :

1. Steel trusses, (refer Fig. 4.20).
2. Iron, brick and cement construction (flat roofs).
3. Wood construction etc.

4.18. HEURISTIC AND OTHER METHODS OF LINE BALANCING

Heuristic Approach. Heuristics mean 'serving to find out', *i.e.,* to find out (discover) things for oneself. Heuristic describes a particular approach to problem solving, decision-making and control. Heuristics are oftenly simple 'Thumb rules' which are employed to solve complex problems. They aim to provide ways to solve problems which, at the beginning of an investigation, elude rigorous logical analysis. Heuristic models utilize common sense, logic and above all, past experience to tackle the new problems, Heuristics methods, though, have little, if any, theoretical foundations yet they provide most likely (and if not the optimum) solutions which are good enough from a practical point of view.

Heuristic methods break down a complex problem into smaller and easily manageable sub-problems. Then, from the past experience of tackling different but similarly structured problems, the most promising solution for each sub-problem (of new situation) is determined. Heuristic approach has advantages of consistency, speed and ability to cope with more data and larger systems.

Line Balancing. Line balancing means balancing the line, for example balancing the production line or an assembly line. Suppose there are three machines (work stations) *A, B* and *C*, which can process 5, 10 and 15 pieces per unit time respectively and the pieces flow from *A* to *B* to *C* (precedence constraint). Since *A* has minimum capacity, i.e. of processing only 5 pieces per unit time naturally, work station (or machine) *B* will remain idle for 50% of its time and machine *C* for 66.66% of its time. It shows that the line is unbalanced. One way to partially balance the line is to have 3 machines of type *A*, 2 of type *B* with every machine of type *C*. Another approach to balance the line will be to give some other task to machines *B* and *C* so that they do not remain idle. The main objective of line balancing is to distribute tasks evenly over the work stations so that idle time of men and machines is minimized.

Line balancing aims at grouping the facilities (or tasks) and workers in an efficient pattern in order to obtain an optimum or most promising balance of the capacities and flow of the production on assembly processes. Tasks are grouped so that their total time is preferably equal to or a little lesser than the time available at each work station--this reduces the idle time.

For solving line balancing problems a number of methods are available, for example *Heuristic, linear programming model, dynamic programming and comsoal* (a computer method for sequencing operations for assembly lines).

For *intermittent flow system* normally heuristic methods are preferred. They are simple and involve less time and money. They provide most likely solution. Heuristic methods are also preferred where problem is so complex that better solutions are almost impossible to obtain. For *continuous flow* involving high volume production one may go for linear or dynamic programming methods which though are more costly and time consuming (even on the fastest computers) but yield optimum solutions.

Heuristic Method of Line Balancing. The heuristic method involves drawing a precedence diagram in a particular way which indicates the *flexibility* available for transferring tasks laterally from one column to another to arrive at the most promising balance. Heuristic approach produced very good results when Wester and Kilbridge applied it to T.V. assembly line problems (with 133 steps) .

The heuristic approach involves following procedural steps :

(1) Identity the work (job).

(2) Break down the work into elemental tasks or steps. For *example* drilling a hole is a step or elemental task.

(3) List the various steps as under (An example) :

Steps or elemental tasks	*Immediate Predecessor*	*Duration of the task (minute)*
1	–	3
2	–	4
3	1	2
4	2	5
5	3	4
6	5	8
7	4	2
8	6	4
9	8	6
		(Total time=38 minutes)

(4) Sketch the precedence diagram and mark the task duration.

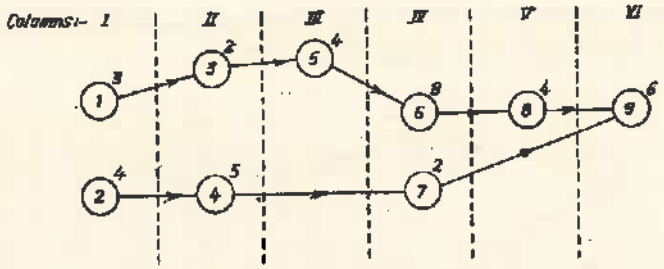


Fig. 4.21. Precedence diagram.

(5) Assume (for this problem) that the maximum time available at any work station is 10 minutes. In other words, cycle time is given as 10 minutes. The total duration of all the tasks is 38 minutes which means the minimum number of stations required are 38/10 say 4. The maximum number of stations may be equal to as many as the number of tasks or steps, *i.e.*, nine. It will be tried to achieve the balance with 4 stations.

(6) There are two basic concepts of assigning tasks to stations.

(a) *Permutability of tasks.* It means that any number of tasks or steps of a column can be combined to make up their total time closer to cycle time, provided their total time does not exceed the cycle time, (*i.e.*, time available at a work station). Tasks of even different columns can be combined, provided the precedence constraint is maintained. Analysis is carried out column by column and one can move to next column only after the tasks in the previous column have been assigned to a station.

(b) *Lateral transferability of the tasks.* For making total time of tasks equal to cycle time, tasks or steps may be shifted laterally provided the precedence relationships are maintained.

Using the above two concepts and with a purpose to minimize idle time at a station, Fig. 4.21 is modified as Fig. 4.22 in which, tasks 1, 2 and 3 have been grouped and assigned station *A*, task 4 has been transferred laterally from column II to column III and has been grouped with task 5, thus occupying station *B* (S-B). Similarly tasks 6 and 7, 8 and 9 have been grouped and placed at stations *C* and *D* respectively. Thus all the nine steps have been distributed to four stations.

Each of the three stations *A*, *B* and *D* are idle for 1 minutes (10-9) whereas station *C* has no idle time (10-10).

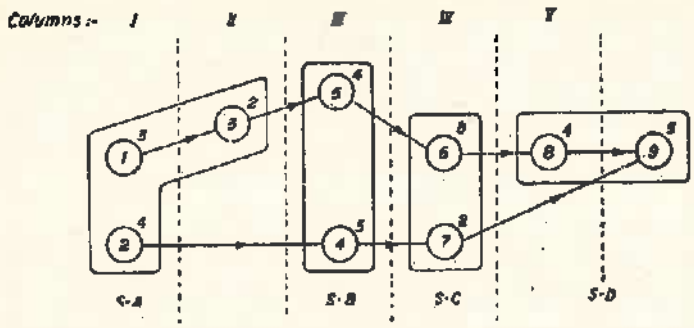


Fig. 4.22. Most likely solution (of line balancing problem, cycle time is 10 minutes).

Linear Programming Method of Line Balancing. Assume that a job is broken down into 6 elemental tasks and the total duration of all such tasks is 28 minutes. The cycle time, *i.e.*, the length of time that the workpiece is available at each work station is 10 minutes. Thus the minimum number of stations required are 28/10 say 3 and the maximum number of work stations may be 6, *i.e.*, equal to the number of tasks involved

The problem now reduces, to find out the exact number of work stations needed and which tasks will be assigned to which station. Figure 4.23 shows the precedence diagram.

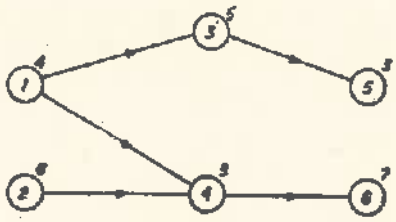


Fig. 4.23. Precedence diagram.

Three types of constraints equations namely cycle time constraint, step or task constraint and precedence constraints, will be formulated to solve the problem.

Assume

i represents the *i*th task or step where *i* can be 1, 2, 3, 4..... *N*, *N* is the maximum number of steps or tasks (6 in this case).

j means the *j*th work station where *j* can be 1, 2, 3,..... WS_{max}, WS_{max} being the maximum number of work stations.

t_i is the time required to finish the *i*th task.

and the decision variable X_{ij} is equal to 1 if the task *i* is assigned to station *j* and is equal to zero if the task *i* is assigned to a work station other than *j*.

Cycle time constraints. Cycle time constraints restrict the number of tasks which can be assigned to a work station. In no case the total duration of tasks assigned to a station should go beyond the cycle time (*c*). Mathemtically,

$$\sum_{i=1}^{N} t_i X_{ij} \leq c, \text{ for } j = 1, 2, \ldots\ldots WS_{max}$$

When applied to the above example it leads to following :

$$4X_{11}+6X_{21}+5X_{31}+3X_{41}+3X_{51}+7X_{61}\leq 10$$
$$4X_{12}+6X_{22}+\ldots\ldots\ldots\ldots\ldots\ldots+7X_{62}\leq 10$$
$$4X_{13}+6X_{23}+\ldots\ldots\ldots\ldots\ldots\ldots+7X_{63}\leq 10$$
$$\vdots \qquad\qquad\qquad\qquad\qquad\qquad \vdots$$
$$4X_{16}+6X_{26}+\ldots\ldots\ldots\ldots\ldots\ldots+7X_{66}\leq 10$$

Task constraints. Task or step constraints make certain that a task is assigned to one one station only.

$$\sum_{j=1}^{WS_{max}} X_{ij}=1, i \text{ can be } 1, 2, 3, 4\ldots\ldots\ldots N.$$

When applied to the present example, it becomes

$$X_{11}+X_{12}+X_{13}+X_{14}+X_{15}+X_{16}=1\ldots\ldots(i)$$
$$X_{21}+X_{22}+X_{23}+\ldots\ldots\ldots\ldots\ldots+X_{26}=1$$
$$\vdots \quad \vdots \quad \vdots \qquad\qquad \vdots$$
$$X_{61}+X_{62}+X_{63}+\ldots\ldots\ldots\ldots\ldots+X_{66}=1$$

The first (i) of the above equations shows that task 1 is assigned to only one of the possible six stations and a similar sense is conveyed by other equations.

Precedence constraints. Referring to precedence diagram (*See* Fig. 4.23), step or task 3 follows task 1, thus $X_{31}\leq X_{11}$ ...(a). If task 1 is assigned to work station 1, then decision variable $X_{11}=1$ (explained earlier) and if task 3 is not given to work station 1 then $X_{31}=0$. Since $0\leq 1$, (a) above is permitted.

Other precedence relationships can be written as

$$X_{32}\leq = X_{11}+X_{12}$$

It indicates that task 3 can be given to station 2 only after (its predecessor, *i.e.*) task 1 has been assigned to either station 1 or station 2. Similarly,

$$X_{33}\leq X_{11}+X_{12}+X_{13}$$
$$\vdots \quad \vdots \quad \vdots \quad \vdots$$
$$X_{56}\leq X_{31}+X_{32}+X_{33}+X_{34}+X_{35}+X_{36}$$
$$\vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots$$
$$X_{66}\leq X_{41}+X_{42}+X_{43}+X_{44}+X_{45}+X_{46}$$

Objective function . The aim of the objective function is to push the last tasks or steps into earlier work stations in order to reduce the number of work stations from 6 to 3 (previously calculated). This can be achieved by specifying the objective function as follows [equation (ii)] where the assignment of final tasks (*i.e.*, 5 and 6) to last few stations has been made much more costly than their assignment to earlier station. Tasks 5 and 6 are pushed into comparatively earlier work stations and last three work stations (*i.e.*, 4, 5 and 6) have been considered for the purpose.

Minimize, $Z = 1(X_{54}+X_{64}) + 10(X_{55}+X_{65}) + 100(X_{56}+X_{66})$ ____ (ii)

X_{54} means, task 5 has been kept at work station 4.

X_{55} means, task 5 has been kept at work station 5.

X_{56} means, task 5 has been kept at work station 6.

It can be inferred from equation (*ii*) that (arbitrarily) the cost of keeping task 5 at work station 6 is 10 times the cost of keeping the same at work station 5 and 100 times of the cost of keeping the same (*i.e.*, task 5) at work station 4 and similar is the case for task 6.

The constraint equations given above are required to solve the problem for perfect balance and an integer programming formulation is used for the solution.

5

Product Design, Planning and Development

5.1. INTRODUCTION TO PRODUCT DESIGN

- It is essential to design a product before starting its manufacture.
- The idea for new or improved products comes from many sources, such as
  - (*a*) Customer's suggestions and complaints.
  - (*b*) R & D department.
  - (*c*) Other competitor products in the market.
- When a new idea has been conceived and then developed to the point at which it shows itself to be both technically and commercially viable, it is considered as how the product should be made.
- Making of a new or modified product will require the services of the following departments of a company.
  - (*i*) Marketing,
  - (*ii*) R & D,
  - (*iii*) Design,
  - (*iv*) Manufacture,
  - (*v*) Accounts, and
  - (*vi*) Personnel.

Marketing gives advice on market trends.

R & D develops new product.

Design department modifies and extends the range of an original idea. The design department consists of designers, engineers and draughtsmen.

Product design deals both with form and function. *Form design* takes care of product's shape and appearance whereas *functional design* deals with its working.

Persons working in design department generally invite representatives from the *manufacturing* and *sales* divisions to view the preliminary design and collect their ideas and comments for further design modification if any.

- Design personnels today make use of *Work Study* (refer Chapter 9) and *Value Engineering* (refer Chapter 12) to systematically question the provisional design.

5.2. EFFECT OF DESIGN ON COST

- Product design decidedly influences the product cost.
- A complicated product design will associate high cost and *vice versa*.
- Product cost is made up of
  - (*i*) Direct labour cost,
  - (*ii*) Direct material cost,
  - (*iii*) Direct expenses, and

(*iv*) Indirect expenses.

(refer Chapter No. 27).

- Product cost can be reduced if better mutual understanding exists between the design department and the manufacturing division. If they mutually decide to make use of the existing equipment with a little additional tooling etc., it may be possible to reduce cost of the product.
- Product may be redesigned to lower the product cost in order to compete the market; sometimes it may be at the cost of product quality.
- A designer should know the technology of industry so that he can select the best method and the materials whether they are in use in the concern or not.
- Product cost can be reduced by applying the concept of *Value Analysis* (refer Chapter No. 12).
- *Product cost can also be reduced by considering the following aspects at the design stage.*

1. *Materials :*

(*i*) A product should be designed of a material which is Cheaper,

Correct, and

Easily workable and machinable, etc.

(*ii*) A product should be designed with a minimum of material to reduce both machining costs and original material costs.

(*iii*) Alternate cheap materials should be considered. For example, an aluminium alloy may be used for making a casting instead of costly magnesium alloy.

(*iv*) Depending upon the functional requirement a product may be made out of metals or non-metals (*i.e.*, plastics, etc.)

2. A product should be designed out of as many standard (and inter-changeable) parts as possible in order to cut down the product cost.

3. A product should be designed with parts as fewer as possible. Lesser the number of component parts, lesser is the product cost.

4. A product should not be given tolerances unnecessary tight; this will increase rejection and in turn will add to the cost of the product.

5. Too high a surface finish, simply to add to sale appeal will entail high product cost.

6. To reduce product cost, some component parts of the product which cannot be economically and easily manufactured in the concern itself should be purchased from outside suppliers (Make or Buy decision).

7. If feasible, the product may be redesigned to make use of existing equipment and machinery. This will help reducing cost of the product.

8. The product design should be such that a minimum number of operations (machining, etc.) are required to convert raw material into the finished product. This will decrease product cost.

9. Design should be simple so that the product can be manufactured without much complications.

5.3. REQUIREMENTS (OR CONSIDERATIONS) OF A GOOD PRODUCT DESIGN

It is not possible to specify exactly what constitutes a good design, but the essential requirements are that it should bring :

(*a*) Customer satisfaction, and

(*b*) An adequate profit.

(*a*) In order to achieve *customer satisfaction,*

- The product should function correctly.
- It should possess desired degree of accuracy.
- It should have required standard of reliability.
- Product should be easy to operate *e.g.,* a number of controls may be operated from one position.
- Product design should be such that it is easy to achieve accessibility for servicing.
- Product design should obtain good space utilization.
- Product should be sufficiently rugged to withstand all but exceptionally rough handling.
- Product should have pleasant appearance. Colours play an important role in product design.
- Product should be of reasonable price to compete other products in the consumer market.

(*b*) Making *adequate profit* means that

- It should be easy to manufacture the product within the available resources.
- Manufacturing process should be decided on the basis of the product quantity to be manufactured. Small parts on mass scale may be produced by Die casting rather than the sand casting.
- The use of standard component parts wherever possible can lead to great saving.
- A well designed product will consist of minimum number of parts.
- Good product design will call for minimum number of operations.
- Good product design should not extend the through-put time.
- A well designed product should be easy to pack and distribute.

5.4. FACTORS AFFECTING PRODUCT DESIGN

The design of any product involves due attention to the following factors :

(*a*) Technical factors.
(*b*) Industrial design factors.
(*c*) Designing for production-economic factors.

(*a*) Technical Factors

1. *Operating conditions*

- Kind of workers which will be making use of the product.
- Conditions of noise, vibrations and heat, etc.

2. *Performance*

- Accuracy.
- Speed, feed, etc.
- Length of time.
- Type of materials used.

3. *Maintenance*

- How often maintenance and repair will be required.
- Whether planned or breakdown (maintenance) policy will be adopted.

4. *Company experience*

- Has the product been designed by the company before ?
- Has the company experience or expertise to design the product ?

(*b*) Industrial Design Factors

1. *Function*

- Will the product function at minimum cost ?

2. *Appearance*

- Does the product has a pleasing appearance ?
- Does it create esteem ?

3. *Ergonomics*

- Is the product suitable for human use ?
- Does the use of product cause excessive fatigue to the workers ?
- Does the product fulfils the principles of 'Fitting the job to the workers' ?

(c) **Designing for Production–Economic Factors**

1. *Materials*

- Material specifications : Is the cheapest material, consistent with technical design requirements, being used.
- Yield : Is the waste during production being minimized ?
- Content : Is the minimum amount of material being used in making each component part ?

2. *Methods*

- Equipment : For the production quantity required, can the most productive equipment be employed ?
- Layout : Does the product design make best use of factory layout ?
- Labour : Can the product be manufactured with the available (direct and indirect) labour ?
- Tolerance : Does the product design allow the maximum possible tolerance ?
- Tooling : Does the product design permit the use of existing or otherwise simple economical tooling ?
- Overheads involved.

3. *Standards*

- Is design simple ?
- Does it keep (number of) types and varieties of parts to a minimum ?
- Does the design make use of standard parts ?

4. *Finish*

- Finish may include painting, polishing, electroplating, etc.
- Is the right finish being used consistent with cost, endurance and appearance requirements ?

5.5. DESIGN BY IMITATION

- New designs come from innovation.
- New conceived ideas are developed and turned into new products. But, this procedure involves a lot of money and risk of failure or unsuccess in the consumer market.
- For this reason, the greatest flow of new designs is not from innovation but *by imitation.*
- Design by imitation saves a lot of R & D money and avoids the risk of being unsuccessful ; because only those designs are imitated which have proved their success in the market.
- Imitators start late but move faster than the innovators since they can easily get the new product and its design.
- For example, in 1950's, Sperry Rand had the first computer but IBM soon captured the market and is very well known today for its computers.

5.6. DESIGN SPECIFICATIONS AND DRAWINGS

A designer communicates his ideas to the manufacturing section through the medium of

drawings and specifications.

Preparation of drawings and specifications is the last step in product design.

5.6.1. Drawings

- Drawings show the exact size and shape of the product, its different parts and subassemblies.
- Rough sketches made during the process of product designing are drafted into exact engineering drawings.
- Drawings show, how the finished parts, subassemblies and the final product look like when completed.
- Drawings are generally made on standard-sized drawing sheets in order to facilitate their storage, filing and reproduction.
- A drawing should be kept as simple as possible and be clearly drawn.
- An ambiguity on a drawing can lead to mistakes.
- An engineering drawing should include the following *information.*
  - (*i*) Component part number (for identification) and part description,
  - (*ii*) Dimensions from a common datum face to facilitate setting and gauging,
  - (*iii*) Tolerances and limits,
  - (*iv*) Material details including specification, size and condition,
  - (*v*) Finish description,
  - (*vi*) Title block,
  - (*vii*) Scale and projection, and
  - (*viii*) Details of any inspection requirements.
- Before releasing drawings to the manufacturing section, they should be checked, approved by the persons concerned and given the date of issue.

5.6.2. Specifications (Bill of Material or Parts List)

- Product design features other than physical dimensions (already shown on the drawings) are described in writing in the from of *specifications.*
- The specification is regarded as the key manufacturing document.
- Industries producing single-unit articles such as forgings and castings can provide all the relevant information on the drawings, but those industries which make assemblies need a complete *parts list* to assist in buying, production control and assembly.
- Specifications provide a written statement of requirements. It states the function of the product. A typical specification is shown in Fig. 5.1.

Sheet of sheets		*Assembly description*		*Assembly part No. H 347*		
Item No.	*Part No.*	*Description of part*	*Material specification*	*Material size*	*Material condition*	*Quantity per assembly*
1.	H_1	Body	Al alloy		Permanent mold casting	1
2.	H_2	Cover	Al alloy		-do-	1

Fig. 5.1. Design specification.

- In addition, the specifications may include the following :
  - (*i*) Conditions of testing (*i.e.,* range of temperature, vibrations, humidity, etc.),
  - (*ii*) Efficiency of performance,
  - (*iii*) Site testing and commissioning procedure, and
  - (*iv*) Quality of material and finish, etc.

5.7. PRODUCT PLANNING

DEFINITION AND CONCEPT

- Product planning may be *defined* as—Evaluation of the range, mix, specification and pricing of existing and new products in relation to present and future market requirements and competition; planning of product range, mix, specification and pricing to satisfy company ojectives; and specifying the research, design and development support required.
- From the above definition it is clear that both existing and potential products must be included in the product planning activity, and it follows that the activity itself should deal with the proper balance between old and new products in the product-mix in so far as the future course of the business is concerned. The evaluation and planning activities referred to, and particularly the emphasis on satisfying the company's objectives, implies the existence of an over-all *corporate plan* which provides a framework within which these activities may take place.
- Within the overall corporate plan as set down by senior management, the product plan usually represents the activity which links the company with its market, and so is most directly concerned with the forward development of the company as a whole.

  This is not to say that product planning is the prerogative of top management, indeed it is a function which is most usually discharged by line management, but rather to argue that successful product planning can only occur within a clear frame work of goals and objectives laid down by the board of directors. Further, senior management must ensure direct lines of communication between itself and the product planning function.
- Product planning serves as an input to process design.

NEED FOR

The product planning stems from the identification of a need for a product. Need may evolve from several sources :

(*a*) **Needs determined from current deficiencies**

This area primarily relates to those needs which are stimulated as a result of some problem or deficiency occuring in a product *today.* The resolution is often achievable through the development, production and use of a new product or process.

(*b*) **Needs determined from anticipated deficiencies**

Through the prediction of societal, political, ecological, technological, and/or economic trends, anticipated needs can often be determined. For example, we suspect that economic constraints in the future will likely prohibit the use of certain systems currently in use. As a result, a replacement system that exhibits a lower overall life-cycle cost is needed to accomplish the designated function(s).

CONSTITUENTS

- The product planning function often includes :

1. Marketing and Marketing analysis.
2. The performance of feasibility studies, and
3. Advanced planning.

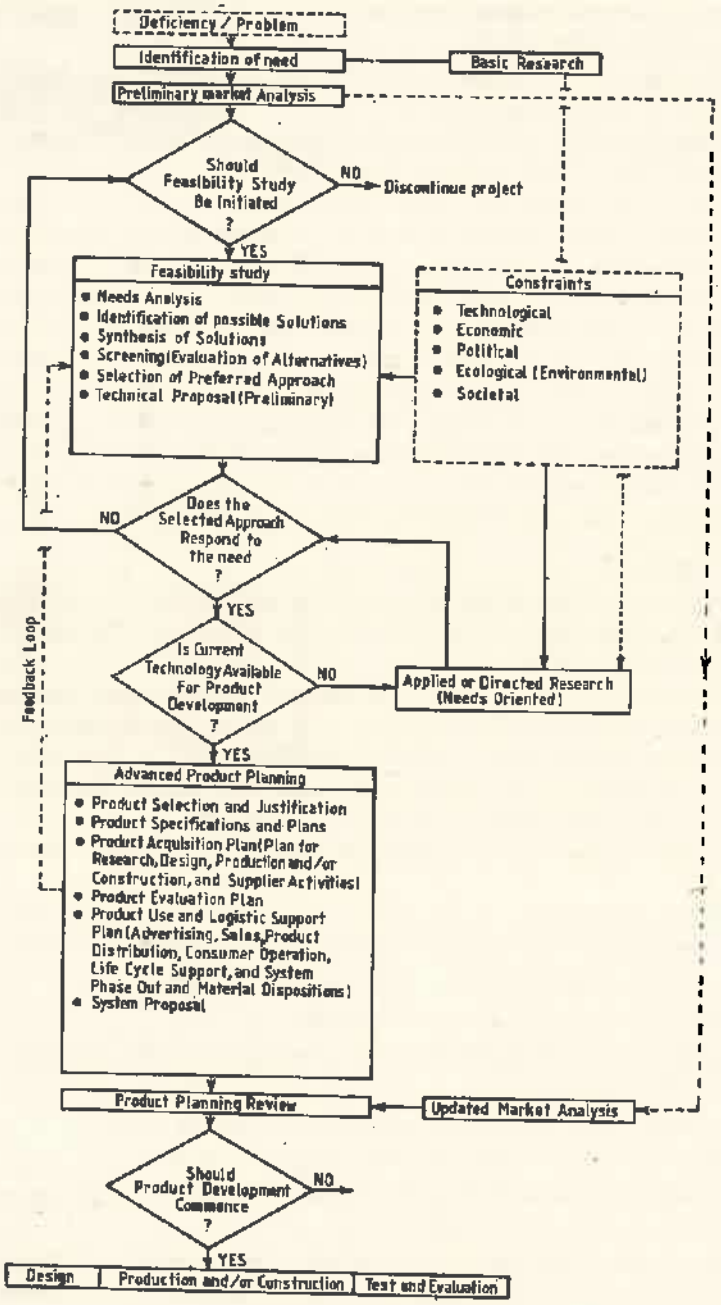


Fig. 5.2. Product planning process.

1. MARKETING AND MARKETING ANALYSIS

– The aspect of *marketing* can assume different proportions, depending upon the nature of product. If the product is relatively simple, the marketing function may not require direct en-

gineering involvement except in the preparation of technical material or specifications which support the product in its promotion.

- On the other hand, for more complex products the marketing effort involves a team approach, constituting the nontechnical sales and promotional orientation, with the engineer in a role of technical support to answer questions concerning product performance features, reliability and effectiveness characteristics, maintenance requirements and so on.
- Once the need for product planning is established, it is necessary to determine whether the technology currently exists to satisfy the need, and if not, when it will become available.

  In this instance, *technology* refers to the technical methodology and/or techniques required for achieving a practical purpose. This is basically accomplished through *technology review* (knowledge of what is currently available) and *technological forecasting* (knowledge of what is likely to be available in future *e.g.* future characteristics of useful machines, procedures or techniques).
- Given the availability of the proper technology, the producer of the prospective system will complete a preliminary *analysis of the market* potential and the market share. The objective is to view the system over its projected life cycle on the basis of economic considerations. Gross estimates of revenues from sales and costs are made with the intent of assessing whether or not the venture is worthwhile (*i.e.*, should one pursue the project further).

2. FEASIBILITY STUDY

- The purpose of the feasibility study is to extend the preliminary market analysis with the intent of arriving at a preferred system configuration that the producer is willing to propose in response to an identified need.
- The feasibility study includes (*i*) a *detailed need analysis* (*i.e*, definition of *system operation* and *maintenance support* requirements (*ii*) identification of alternative configurations, (*iii*) screening and evaluation of the available alternatives and (*iv*) selection of a preferred approach.
- The *output* of the feasibility study constitutes a *proposal* covering the *technical* characteristics of the preferred system configuration. This information, combined with *advanced planning data* is reviewed to determine whether the producer should proceed further with the system development.
- The feasibility study constitutes another significant step in the decision-making process, thus influencing future product activities, particularly in case of large-scale systems.
- **System Operational Concept** includes the following information :
  - (*a*) Identification of prime mission of the system.
  - (*b*) Definition of the operating characteristics of the system (*e.g.* size, weight, accuracy, output rate, capacity etc.).
  - (*c*) Identification of the quantity of equipment, personnel facilities etc.
  - (*d*) Anticipated time that the system will be in operational use.
  - (*e*) Anticipated usage of the system and its elements (*e.g.* hours of operation per day, on -off sequences, operational cycles per month).
  - (*f*) Given that the system will perform, how effective or efficient it is. Effectiveness factors considered may be dependability, logistic support effectiveness, mean time between maintenance (MTBM), failure rate (λ) , maintenance down time (MDT), facility utilization, personnel efficiency and so on.
  - (*g*) Definition of environment in which the system is expected to operate (*e.g.* temperature, humidity, arctic, tropics, mountainous or flat terrain, airborne, ground, ship board).

– **System Maintenance Concept**

(*a*) The maintenance concept responds to the question : How does the producer envision that the system will be *supported* through its life cycle ? It delineates levels of maintenance support, repair policies, effectiveness measures (*e.g.* maintenance manpower, time and cost restraints) and serves several purposes.

(*b*) It provides a baseline for the establishment of supportability requirements (*e.g.* reliability, maintainability and human factors characteristics) in system/equipment design.

(*c*) It provides the basis for the establishment of requirements for total logistic support. Given an assumed design configuration of the prime mission equipment, it is then necessary to consider how it should be supported. The maintenance concept supplemented by logistic support analysis, leads to the identification of maintenance tasks, task frequencies and times, maintenance personnel quantities and skill levels, training needs, test and support equipment, supply support (*e.g.* spare/repair parts), facilities and data. These support requirements are evaluated and integrated with the prime mission equipment and associated software to form the total system.

(*d*) The maintenance concept evolves from the deployment profile. Levels of maintenance include *organizational* maintenance, *intermediate* maintenance and *depot* maintenance.

Organizational maintenance is performed at the operational site by the company personnel using the equipment (*i.e.*, at consumer location). Maintenance at this level is normally limited to periodic checks of equipment performance, visual inspections, cleaning of equipment, some servicing, external adjustments and the removal and replacement of some components.

Intermediate maintenance is performed by mobile, semimobile, or fixed specialized organizations and installations, again at consumer location.

At this level, end items may be repaired by the removal and replacement of major modules, assemblies or piece parts.

Scheduled maintenance requiring equipment disassembly may also be accomplished.

Intermediate maintenance personnel are usually more skilled and better equipped than those at the organizational level and are responsible for performing more detailed maintenance.

Depot maintenance may be at producer's factory. It is the highest type of maintenance and supports the accomplishment of tasks above and beyond the capabilities available at the intermediate level.

The depot is a specialized repair facility supporting a number of systems/equipments, may be in producer's plant. Complex and bulky equipment, large quantities of spares, environmental control provisions, and so on, can be provided if required.

The depot level of maintenance includes the complete overhauling, rebuilding, and calibration of equipment as well as the performance of highly complex maintenance actions.

– *The results of feasibility study* are generally presented in the form of a technical proposal to management. The information prepared should include the following :

(*a*) A definition of the functional configuration (*e.g.* functional block diagram) and physical characteristics of the system.

(*b*) A description of the system operational and maintenance support requirements.

This proposal serves as the engineering technical baseline to support management decisions made throughout the product planning process.

3. ADVANCED PRODUCT PLANNING

(A) Product system evaluation, selection and justification

- The combined results of the preliminary market analysis and the feasibility study aid in justifying the product in terms of need and technical approach. However, the results of these efforts must be reviewed further from the business standpoint.
- The selected product must be evaluated in terms of *life-cycle cost.* Life-cycle cost includes all future costs associated with planning, R & D, investment (production and/or construction), operation and support and system phase-out. These costs are estimated and projected by year. Subsequently, a product *pricing scheme* must be established, with the objective of maximizing the return on investment.
- With the establishment of pricing data, an estimate of the market share, and a knowledge of the time of need, revenues can be projected by year and compared with the anticipated costs.
- When evaluating a project representing a particular product configuration, one should select evaluation criterion factors that cover all major considerations necessary to *justify the selection* decision. A typcial listing of such factors is given below :

	Evaluation Criterion Factors	*Weighting*
1.	Technology available	15
	Now	
	From 1 to 5 years	
	More than 5 years in future	
2.	System technical characteristics	
	Performance	15
	Effectiveness--operational availability	10
3.	Marketing information	
	Market potential	12
	Market share	8
4.	Financial data	
	Return on investment	20
	Estimated annual sales	10
	Investment recovery point	10
	Total	100

(B) Product specifications and plans

- With the initial product configuration fairly well established, advanced planning continues through the development of formal *specifications* and *planning* documentation.
- Specifications basically cover the technical design requirements for the product and planning documentation includes all management-related activity.
- The combination of specifications and plans along with the associated cost data constitute the proposal for all subsequent research, design, production, evaluation and test, product use and logistic support activity.

Once these specifications and plans have been reviewed and accepted, they will be considered as the basis for all future program engineering and management decisions.

(B–1) Specifications may be classified as

(*i*) *System specification :* States the technical, operational, and support requirements for a product. Further it allocates these requirements to functional areas and defines the various functional-area interfaces.

(*ii*) *Development specification :* States the technical requirements for any item below the top

system level where R & D (to include design) is required. Each development specification must include the performance, effectiveness and support characteristics that are required in evolving from preliminary design to detail design and production.

(*iii*) *Procurement specification :* States the technical requirements below the system level for any item that is currently in the inventory and procured off-the-shelf.

(*iv*) *Process specification :* Covers a service (*e.g.* heat-treating, plating, welding, packing etc.) that is performed on any product or material.

(*v*) *Material specification :* Covers the raw material, mixtures (*e.g.*, paints, chemicals etc.) and/or semifabricated material (*e.g.*, electrical cable, piping) that are used in the fabrication of a product.

The preparation of product specifications is an engineering function.

(B–2) **Planning documentation**

- The top-level program management plan forms the basis for all lower-level plans.
- Individual supporting plans will be prepared to cover the various phases of product life-cycle activity and will include organizational structure and responsibilities, program functions and tasks, schedules, processes and procedures, and cost projections.
- All plans should (if at all possible) be prepared by those responsible to execute the work involved, and must be consistent with available resources and based on a realistic schedule. In addition, there should be provisions for contingency plans for coping with the unexpected.

(*c*). **Product acquisition plan**

- Acquisition refers to the process of acquiring a product or system commencing with the identification of a need and extending through the delivery of the product for consumer use. It may involve research, design, production, and some test and evaluation activities.
- The material presented under product acquisition plan must cover

(*i*) *Definition of tasks :* Detailed tasks are identified to cover all acquisition functions.

(*ii*) *Scheduling of tasks :* Using a bar chart, PERT, Gantt chart, line of balance etc.

Line of balance (LOB) is a technique that complements Gantt chart in determining production status. While the Gantt chart technique primarily relates information on the effective and efficient utilization of resources (*e.g.*, machine loading, man loading), LOB is more product oriented. LOB is not directly concerned with the resources expended but is utilized in determining production progress in terms of per cent of task completion. Major bottlenecks in the production process are emphasized.

(*iii*) *Organisation of tasks :* The events and activities discussed above constitute tasks that are organised into work packages. The identified work packages are evaluated from the stand point of task type, complexity, and required completion schedule. In addition, estimated costs are established for each activity (as when using PERT) and are then related to work packages.

(*iv*) *Cost/schedule/performance/effectiveness measurement and control :* Initial target objectives are established for schedule, cost performance (*e.g.*, range, accuracy, capacity, size), and effectiveness factors (*e.g.*, availability, reliability, supportability). Such objectives may take the form of single discrete values, a range of values with both upper and lower limits, or a set of maximum and minimum criteria.

With these requirements initially established, it is now essential that a MIS (Management Information System) be developed to report data that enables the measurement and control of certain selected factors as the program progresses. This is necessary to provide the assurance that the ongoing system development process is producing the desired results.

(v) *Corrective action*

The data from the management information system should readily point out existing problem areas as well as potential areas where problems are likely to occur if program operations continue as originally planned. In order to deal with such contingencies, planning should be initiated to establish a corrective action procedure.

(D) Product evaluation plan

– Requirements for the product in terms of *performance* and *effectiveness* (*e.g.*, range, accuracy, capacity, power, availability, reliability, maintainability, support-ability) must be evaluated to ensure that these have been adequately accomplished. Requirements must reflect the need, and when established one must intuitively consider the methods by which these requirements will be verified.

– The preliminary product evaluation plan should include

1. Test and evaluation requirements.
2. Categories of test and evaluation.
3. Test preparation phase.
4. Test and evaluation procedure.
5. Data collection, analysis and corrective action methods.
6. System rework, modifications and retest procedures.
7. Test and evaluation reporting.

(E) Product use and Logistic support plan

Product use and distribution planning

– The product marketing and sales strategy for those items in the producer's inventory not yet sold.

– The deployment and distribution of the product to designated consumer locations after production.

– The recommended procedures for product operation.

Logistic support planning

– A detailed maintenance plan which describes proposed echelons or levels of maintenance and recommended functions to be performed at each echelon.

– A plan for the acquisition of test and support equipment and/or handling equipment.

– A supply support plan to cover the acquisition of spares and repair parts.

– A transportation and handling plan to cover the packing, the use of containers and the shipment of material.

– A technical data plan to include system maintenance procedures (*i.e.*, servicing, inspection, calibration and overhaul instructions).

– A personnel and training plan to cover system operator training, maintenance training and training equipment (*i.e.*, aids, devices, simulators etc.).

(F) Product (or system) proposal

– Product proposal will represent a recommended course of action based on the results of the technical feasibility study and the advanced product planning.

– *Proposals* may be *classified* as follows :

1. *Internal proposal*—a proposal generated within an industrial firm (in response to an identified need) and directed to the management of the firm for approval to accomplish a defined scope of work.

2. *External proposal* –a proposal generated within a firm (approved by its management) and directed to an outside agency *e.g.*, another firm or government organization.

Although both types of proposals have a great deal in common, the external proposal is usually broader in scope and is more significant in industry since the immediate objective is to win contracts, bring in funding, and make a profit.

- *Proposal strategy.* Strategy in this instance refers to the type and amount of effort that should be applied in generating the proposal and in establishing a bidding approach. Proposal preparation often requires the expenditure of a great deal of time and money. Thus it is important to thoroughly evaluate the probability of success along with associated risks. This is accompanied and supported by the results of the market analysis, the feasibility study, and the planning accomplished up to this point. The prime question is whether *to bid* or *not to bid.*
- *Proposal preparation.* Proposals are generally prepared by a team of specially selected individuals who represent marketing, engineering, research, production (*e.g.*, manufacturing, quality control), purchasing, finance, accounting, contracts and ancillary services (*e.g.*, technical editing, printing). The *team* will analyze the invitation for bid, assess the requirements, and the results will determine the depth of manpower coverage in each area.

During the proposal effort, each team member is responsible for defining the tasks in his area of responsibility, scheduling these tasks, and establishing the organizational approach proposed for task accomplishment. In addition, cost projections are prepared for each task and identified in terms of work packages and the work breakdown structure (WBS), which links objectives and tasks with resources and is an excellent management tool for program planning and budgeting.

- *Proposal Content.* The ultimate content of a solicited proposal will, of course, depend on the requirements included in the invitation for bid. The proposal in its final form should generally contain the following information :
  - (*a*) Proposal title and outline.
  - (*b*) Introduction – Bidder to define the problem at hand and summarize the proposed approach to problem resolution.
  - (*c*) Summary of proposed effort – What is being offered and what are the costs involved.
  - (*d*) Technical requirements – Covers a definition of the proposed system in terms of all technical requirements.
  - (*e*) Management plan – The bidder's management approach, relative to accomplishing the proposed effort, should be defined herein.
  - (*f*) Contractual and legal provisions – Contingencies that pertain to contract type, payment dates, warranties, liabilities, penalty etc.
  - (*g*) Supplemental information – any supporting data to help the bidder in winning a contract *e.g.* a statement of bidder's financial status, a description of successful work accomplishment, a description of available facilities and resources, etc.
- *Proposal review, evaluation and contract negotiation.* Upon receipt of a proposal from a bidding firm, the customer proceeds with the review and evaluation process.

  If a *single bidder* is involved, the customer may review the proposal and negotiate directly with the bidder resulting in a mutually agreeable statement of work and price.

  When *competitive bidding* occurs, the customer generally establishes an evaluation procedure directed toward selecting the best approach proposed.

  Evaluation criteria may include *technical characteristics* (*e.g.*, system effectiveness), *management plan* (*e.g.*, resources available), *total cost* and *supporting factors* such as prior experience or past performance.

Once that a preferred bidder is selected on a technical and management basis, the customer and bidding firm will proceed toward negotiating a contract. Negotiation may not only become an extensive undertaking relative to the contract type established, but may also involve some haggling in the areas of scope and work and the proposed price/cost figures.

5.8. PRODUCT CLASSIFICATION

Products may be classified as :

(1) **Convenience goods** such as cigarettes, candy bars, blades, magazines etc. All these items are found clustered around the checkout stand of food stores, and food, of course, is usually a convenience good. Convenience goods are placed so that they can remind consumers that they are available when needed.

(2) **Shopping goods** are more expensive items that people buy less frequently. A key factor in the purchasing of shopping goods is the customer's desire to make comparisons among an assortment of similar items, and as a result, retailers who handle shopping goods tend to cluster.

- Examples of shopping goods are ready-made garments, clothes (for shirts, pents, or suiting), automobile scooters and cars etc.
- The role of sales people at the retail level assumes critical proportions in marketing shopping goods. Their blandishments and skills are not needed to sell cigarettes at retail, but they are certainly necessary in the case of clothing and automobiles.

(3) **Speciality goods** are those for which buyers will take extra ordinary pains to obtain.

- The hobbyist, whose numbers are growing rapidly, is a typical speciality goods shopper. The mountain-climber who absolutely must have a certain down-filled sleeping bag provides another typical example.

(4) **Industrial goods**

- Industrial goods comprise of raw materials, semifinished goods which must be converted into more finished products, machinery, equipment, supplies, containers and packaging materials, etc.
- People involved in the sale and purchase of industrial goods behave remarkably unlike other consumers in some significant ways. Industrial goods purchases are intended to become part of the manufacture of a product which is later sold to consumers. To explain, an automobile manufacturer has no personal need for steel; he buys steel only because consumers will later buy the automobile it makes from steel. On the other hand convenience or shopping goods are bought for *personal* use, therefore in such goods, a consumer is likely to be subjective in his purchases.

5.9. PRODUCT DEVELOPMENT

5.9.1. Introduction

- **A Product** is an article obtained by the transformation of raw material and is marketed/sold by the manufacturer, *i.e.*, a product is a salable item.
- It may be a *consumer product* such as cigarettes, televisions or an *Industrial product, e.g.,* a lathe, an overhead bridge crane, etc.
- **Development** is carried out after *applied research* which follows *pure research.*
- Development concerns the most economically feasible method for applying the principles identified through Research.
- Development involves design/redesign and fabrication of new or modified product and then testing it to find its usefulness.
- Product Research and Development are concerned with all aspects of the product design and applications including its,

(*i*) Functional efficiency,

(*ii*) Quality,

(*iii*) Unexplored uses,

(*iv*) Investigation of materials and possible substitutes,

(*v*) Utilization of waste products, and

(*vi*) Standardization and customer satisfaction.

- Product development is *essential* in order to,
  - (*i*) Meet changing consumer needs.
  - (*ii*) Manufacture improved and low cost products.
  - (*iii*) Maintain (one's) sales position and profit margin.
- *Products can be developed by* :

(*i*) *Imitation, i.e.*, marketing another product similar to one in the market, *e.g.*, when one concern introduced a refrigerator with automatic defrosting unit, others imitated and marketed their own refrigerators having such a unit.

(*ii*) *Adaptation, i.e.*, developing an improved product for an already existing in the market, *e.g.*, the introduction of electronic and atomic clocks (against mechanically spring wound clocks).

(*iii*) *Invention, e.g.*, synthetic fibres, nylon, etc., for making garments and other items of use.

- Product development may involve a
  - (*i*) Small refinement, or
  - (*ii*) A major redesign.

  Frequently a completely new design results, *e.g.*, the development of more reliable rotary, fuel injection pumps for diesel engines in place of old reciprocating types of pumps.
- Product development generally involves considerable expenditure; but a concern has to meet it if it has to survive when competition is hard.

5.9.2. Product Development Procedure

The various steps involved in developing a product are discussed below;

(*a*) Get new ideas,

(*b*) Separate the good and feasible ideas,

(*c*) Evaluate ideas technically,

(*d*) Evaluate ideas from market's point of view,

(*e*) Take the final decision,

(*f*) Get into production, and

(*g*) Introduce product into the market.

(*a*) New ideas can be obtained :

- (*i*) By Imitation.
- (*ii*) By Adaptation.
- (*iii*) By Invention (*i.e.*, R and D).
- (*iv*) From dealers and customers
- (*v*) By advertising – asking people to send their ideas and announcing prizes for the best idea.

(*b*) Separate the good, meritorious and feasible ideas from amongst the many, received in step (*a*) above.

Screening of ideas may be done by a committee consisting of managers of R and D, Production, sales and other departments related with the product development.

(*c*) The selected ideas are evaluated technically as regards,

The method of manufacture,

Labour and equipment requirements,

Performance characteristics of the product,

Cost of manufacture, etc.

(*d*) Selected ideas are evaluated as regards their acceptability by the customers.

- The first evaluation is simply a cursory survey by salesmen.
- If the idea looks promising a nation wide market survey can be conducted.

(*e*) Based on the information collected on technical and market aspects of the new product, it is decided finally as whether to go ahead for production or to forget the idea.

(*f*) If it is decided to take up the idea,

- The product is designed,
- Equipments are ordered,
- Materials are procured.
- Workers are selected and trained,
- Control systems etc., are established, and it is decided whether to manufacture the product on mass scale or job-lot basis.

(*g*) While the product is under manufacture, preparations are done to introduce the product into the market and to impress the market with the developed product. The following aspects are explored :

(*i*) Size, location and characteristics of market,

(*ii*) Advertisement policies,

(*iii*) Appealing packaging,

(*iv*) Channels of distribution,

(*v*) Price, discount and guarantees,

(*vi*) Service after sale, etc.

The three principles, namely *standardization, simplification and specialization,* which are basic and integral part of product development are discussed below :

5.10. STANDARDIZATION

5.10.1 Introduction

- *Standards* are at the base of all mass production. They make possible thousands of different articles to be placed within the reach of everybody.
- When one purchases a new spark plug for a scooter or car, he knows that it will screw into the engine head all right. Why ? Because spark plug threads are *standardized.*
- *Standards* convey the sense that there are only certain specific sizes made and sold.
- Standards are carefully established specifications for products, materials, etc.
- *Standardization* means producing maximum variety of products from the minimum variety of (*i.e., standardized*) materials, parts, tools and processes.
- Standardization is one way which leads to economical products. Standardization usually means

that non-standard products will not be produced—except when a customer orders them to be made.

– Standardization is the process of establishing standards or units of measure by which extent, quality, quantity, value, performance, etc., may be compared and measured.

5.10.2. Standardization Procedure

Steps involved :

(*a*) With the help of market research, sales statistics, etc. decide what to sell in future.
(*b*) Then, define a standard range of products.
(*c*) From the range, ask the designer to develop minimum variety of components to match the range.

Introduce new materials, components, etc. if necessary.

An approach to standardization necessitates the classification of materials and component parts.

Classification

– 'Classification' is of great value in material and component standardization.
– Classification aims at, systematically, grouping items, together by their common features and subdividing them by their special features.
– A system of *classification and coding* is necessary for the design of new products within the range defined.

Such a system should readily :

(*i*) Identify and locate identical items.
(*ii*) Facilitate the use of standard items in new designs.
(*iii*) Identify substitutes in case of *stock outs.*
(*iv*) Help developing Group Technology.
(*v*) Aid to improve parts location in the store.

– *Classification procedure* involves the following steps :

(*i*) Define all items.
(*ii*) Classify each item according to its basic characteristics.
(*iii*) Identify each item by allocating to it some meaningful code number.

A code consists of letters and numbers. The aim is to classify from general to particular.

– Taking an example of *grinding wheels* for classification and coding purposes , various wheel features are denoted by letters and numbers. A code is marked on the grinding wheel.

According to Indian Standard Specifications, for example, a grinding wheel is specified as follows :

G	*C*	*54*	*G*	*6*	*V*	*BE*
Green (Prefix)	Silicon carbide abrasive	Medium grain size	Soft grade	Dense structure	Vitrified bond	Suffix (Trade secret) Depends upon the process and type of manufacture.

5.10.3. Advantages of Standardization

All sections of a company benefit to some degree from standardization.

1. *Design department*

– Fewer specifications, drawings and part lists have to be prepared and issued.

- Thus more time is available to develop new designs or to improve established designs.
- Better resources utilisation.
- Allocation of work to suit available talent.
- Lesser design mistakes and design alterations.
- Less qualified personnel can handle routine design work.

2. *Manufacturing department*

- Lower unit costs.
- Better quality products.
- Accurate delivery dates.
- Better methods and tooling.
- More effective training.
- Better services of production control, stock control, purchasing, etc.
- Fewer tool changes and process set-ups.
- Increased interchangeability of parts.
- Better utilisation of manpower and equipments.
- Longer production runs are possible with fewer changeovers ; wider use of automation and mechanisation.
- The operations can be analysed and broken down into short repetitive cycles which can be easily mastered.

3. *Marketing department*

- Marketing section gets better quality products of proven design at reasonable prices.

This leads to a greater sales volume.

- Increased margin of profit.
- Less pressure of after-sales-services.
- Better product deliveries.
- Easy availability of spare parts.

4. *Production planning section*

- Scope for improved methods, processes and layouts.
- Opportunities for more efficient tool design.
- Greatly reduced pre-production planning activities. Fewer issues of new planning cards.

5. *Production control department*

- Well proven design and methods improve planning and control.
- Chasing small batches (of products) consumes less time.
- Fewer delays arise from waiting for materials, instructions, tools, etc.
- Accurate delivery promises.

6. *Purchase and stock control section*

- Holding stock of standard items, (*i.e.*, less variety of materials and components) means less paper work and fewer requisitions and orders.
- Storage and part location can be improved.
- Because of large purchase quantities involved, favourable purchase contacts can be made.

– Newer techniques can be used for better control of stocks.

7. *Quality control department*

– Better inspection and quality control is possible.

– Operators become familiar with the work and produce jobs of consistent quality.

– Quality standards can be more clearly defined.

8. *Work-study section*

– Efficient break down of (limited) operations into short repetitive cycles and effective work measurement afford considerable opportunities for work-study.

9. *Supervision*

– All the above points help the supervisor to run his department efficiently and more effectively.

– Less time is wasted in resolving production snags such as wrong informations, faulty tooling, etc.

– Reduced rejections and scrap.

– More time is available to the supervisor to make useful records and preserve statistics.

10. *Costing*

– Costing can obtain better control by installing standard costing.

5.10.4. Disadvantages of Standardization

– Reduction in choice because of reduced variety and consequent loss of business or custom.

– Changes in public taste seriously affect a company producing only standardized product range.

– It becomes difficult to introduce new models because of less flexible (existing) production facilities and due to the high cost of specialised production equipment.

– Standardization tends to favour large famous companies, because small or new concerns can rarely get much business even by producing same items and by selling them at the same price as the big companies.

– Standards once set, resist change and thus standardization may become an obstacle to progress.

5.10.5. Applications of Standardization

Standardization can be applied to a major extent in the following fields :

1. *Finished products, e.g.,* cars and televisions.

2. *Subassemblies and components, e.g.,* automobile gearboxes and auto-electric bulbs.

3. *Material Standardization, e.g.,* both of direct materials (plain carbon and alloy steels, arc welding electrode core wires, etc.) and indirect materials (such as oils and greases).

4. *Production equipment standardization, e.g.,* that of machine tools, presses, welding equipments, etc.

5.10.6. International Standardization

– It becomes very necessary to follow international standards if a country has to capture the export market.

– The work of international standardization is carried out under the aegis of ISO (International Organisation for Standardization).

– Most industrialized countries are members of ISO.

– ISO was founded after World War II.

– ISO does not issue independent standards of its own but it makes recommendations which are included in the national Standards of the collaborating countries.

5.10.7. National Standardization

Every country has its own national standards. IS in India, BS in UK, DIN in Germany are a few examples of national or home standards.

5.11. SIMPLIFICATION

5.11.1. Introduction

- The concept of simplification is closely related to standardization.
- Simplification is the process of reducing the variety of products manufactured (known as variety reduction).
- Simplification is concerned with the reduction of product range, assemblies, parts, materials and design.
- A manufacturer may reduce the number of different types of radio sets from a dozen to three or four to simplify his range.
- Simplification makes a product, assembly or design, simpler, less complex or less difficult.
- Simplification removes the superfluous. It decreases variety of sizes ; for example a garment factory making tea-shirts in sizes 16, 16¼, 16½, 16¾, 17, 17¼ etc., can eliminate superfluous sizes such as 16¼, 16¾, 17¼, etc., and thus simplify its production line.
- A production line is generally simplified when it possesses unnecessary complexity and confusion.
- Often variety reduction will reveal that a subassembly or component needs simplification.
- *Variety reduction*

(*i*) Variety reduction consists in identifying the existing variety and then removing unnecessary items from the system.

(*ii*) Classification and codification (refer Section 5.10.2) help locating and identifying all items (*i.e.*, products, materials, components, etc.).

- The availability of suitable standards assists in simplification.

5.11.2. Considerations in Simplifying Items (*i.e.*, products, components, etc.)

(*i*) Can simplification be effectively achieved depending upon the nature of item ?

(*ii*) How the simplification will affect customer demand and volume of sale ?

(*iii*) Does market competition permit simplification or it encourages product diversification ?

5.11.3. Advantages

(1) Simplification involves fewer, parts, varieties and changes in products ; this reduces manufacturing operations and risk of obsolescence.

- Since simplification reduces variety, volume of remaining products may be increased.
- Simplification provides quick delivery and better after-sales service.
- Simplification reduces inventory and thus results in better inventory control.
- Generally speaking, simplification implies fewer parts and fewer the parts, the lower the production costs.
- Thus, simplification reduces price of a product.
- Simplification improves product quality.

5.12. SPECIALIZATION

5.12.1. Introduction

- Specialization is the natural outcome of the application of standardization and simplification.
- Specialization means concentrating efforts on a particular field of action or towards a specific attempt.
- A worker is said to be *specialized* in a work when he acquires skill and proficiency in it by concentrating solely on it (*i.e.*, on that particular work or job). A mechanic, brick-layer or an engineer is a specialist in his field.
- A factory producing spark plugs only is a specialist in its production.
- Specialization as applied to human activities on shop floor can be defined as 'Division of Labour'. This means that if a worker instead of completing the full product, performs one small operation on the product and attains proficiency in that one activity, he becomes a specialist in that.

5.12.2. Advantages

(1) Workers achieve a high state of skill and proficiency.

(2) They take smaller times to complete the activity in which they are specialized.

(3) Thus they raise their salaries and their standard of living.

5.12.3. Limitation

(1) Specialized labour and equipment are not flexible, *i.e.*, they cannot be used for other purposes.

(2) Specialization may result in monotony.

5.12.4. Applications

(1) Specialization is universal in application ; it is a rule rather than exception in today's industry.

(2) Specialization has been applied to

(*i*)	Products	(*ii*)	Processes
(*iii*)	Individuals	(*iv*)	Companies
(*v*)	Jobs	(*vi*)	Equipments, etc.

5.13. DIVERSIFICATION

Concept

- *Diversification* is just contrary to *simplification.*
- Diversification means (*i*) addition of new products or (*ii*) introduction of established products into new markets.
- This tends to increase complexity of the methods of manufacturing, because, sometimes consumers like to have variety in type, size, colour and quality of products being manufactured. This adds to the cost characteristic of the production which is of varied nature.
- The extent to which diversification programme can be carried out must be determined by market analysis of probable volume at varying levels of diversification compared with production cost of the volumes obtainable at those various levels.
- Industries generally expand. An automobile concern may think in terms of diversifying in its own product lines, an aircraft concern may like to expand in the field of propulsion or electronics, and so on.
- Diversification adds to the classes of consumers served, by developing new technical knowledge.

Reasons for diversification

Given below are the reasons why companies diversify :

(A) *Survival*

- To offset declining or vanishing markets.
- To offset obsolete facilities.
- To offset declining profit margins.
- To compensate for technological obsolescence.

(B) *Stability*

- To offset seasonal slumps.
- To offset cyclical fluctuations.
- To provide balance between high margin and low margin products.
- To maintain market share.
- To meet new products of competitors.
- To tie customers to the firm.
- To distribute risk by serving several small markets.
- To develop a strong competitive supply position by offering several close substitute products.

(C) *Productive utilisation of resources*

- To utilise waste or by-products.
- To make use of basic raw materials.
- To utilise excess productive capacity.
- To make use of innovations from internal technical research.
- To make full use of management resources.
- To capitalise on a firm's market contacts.

(D) *Adaptation to change in Customer needs*

- To meet the demands of diversified dealers.
- To meet the specific requests of important groups of customers.
- To improve performance of existing products through adding accessories.

(E) *Growth*

- To counter market saturation on present products.
- To reinvest earnings.
- To take advantage of unusually attractive opportunities.

(F) *Miscellaneous*

- To maintain reputation for industrial leadership.
- To realise maximum advantages from the tax structure.
- To comply with the desires (or whims) of owners or management.

Probably the easiest route to diversification is through *merger* or *acquisition*.

5.14. INTERCHANGEABILITY

5.14.1. Introduction

- The system of interchangeable manufacture is considered as the eighth great invention of the Industrial revolution.

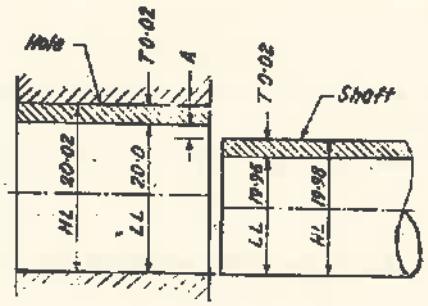
- The credit to first establish such a system of interchangeable manufacture in 1798 goes to an American, Eli Whitney, who carried out a contract for ten thousand muskets.
- Interchangeable manufacture played an extremely important role in the growth of mass production techniques and is very common today.
- The concepts of *specialization, standardization* and *simplification* are closely inter-related and lead to *interchangeability.*
- *Interchangeability* or *interchangeable manufacture* means that any standardized component will assemble correctly with any mating component, both being chosen at random.

  For an *interchangeable system* to work, the parts produced should be as near identical as possible, and for continuous production, a transfer line will achieve this best because it eliminates the human control of the machines.
- Interchangeability reduces cost because the task of assembly is simplified. Moreover standard replacement parts can be drawn from the stock with the certainty that they will fit without alteration.
- In order to achieve interchangeability :
  - (*i*) Appropriate component tolerances must be specified (from the standard) to suit the type of fit required.
  - (*ii*) Manufacturing process should be selected to make components within the specified tolerances.
  - (*iii*) A system of inspection and quality control should check that only components within the specified tolerances are accepted for use.

5.14.2. Elements of Interchangeable System

- In interchangeable system is also called a *limit system* or system of *limits and fits.*

  Fig. 5.3, gives the concept of limits, tolerance and allowance.
- The larger and smaller dimensions of the hole or shaft are called the **LIMITS,** there is a *high limit* (HL) and a *low limit* (LL).



HL : High limit
LL : Low limit
T : Tolerance
A : Allowance

Fig. 5.3. Limits and tolerances for hole and shaft.

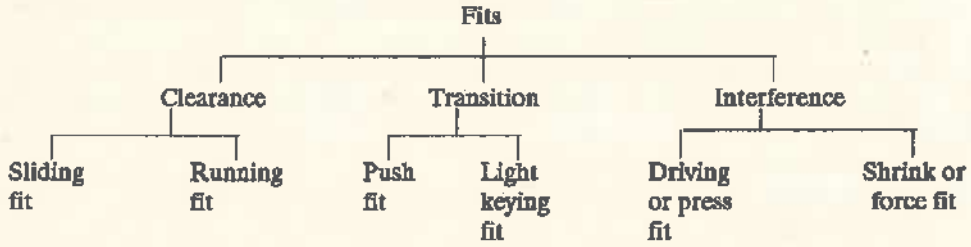
- The difference between the high and low limits (which is the margin allowed for variations in workmanship) is known as *TOLERANCE* (T).

The system is *unilateral* when tolerance is allowed on one side of the nominal diameter, *e.g.*, $20.00\ ^{+0.02}_{-0.00}$ and it is called *bilateral* when tolerance is allowed on both sides of the nominal diameter, *e.g.*, $20.00\ ^{+0.01}_{-0.01}$.

– FITS

1. A system of limits provides information from which the most usual kinds of engagement between two mating parts can be got.

2. Fits are classified as



1. *Clearance fit.* It is the type of fit in which largest possible shaft is smaller in size than the smallest possible hole and when mated a clearance always occurs between the hole and the shaft, (Fig. 5.4).

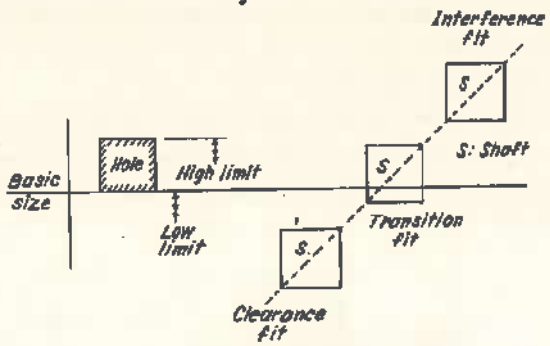


Fig. 5.4 Types of fits.

– *Sliding fit* can be seen in press working operations such as blanking, where a blanking punch and the die have a sliding fit.

– *Running fit* is a smooth, easy (but not loose) fit and such a fit exists between a bush bearing and the rotating shaft.

(2) *Interference fit*

– An interference fit results when the smallest possible shaft is greater in diameter than the largest possible hole.

– *Driving or press fit* gives a semi-permanent fit. It needs light hammering as in keying a pulley on a shaft.

– *Shrink or force fit* gives a permanent fit. It requires great pressures to assemble. Fixing a crank on a locomotive wheel is an example of this type of fit.

(3) *Transition fit*

– Transition fits exist between the zones of interference and clearance (Fig. 5.4).

- A transition fit results from a condition in which tolerances are disposed in such a way that either clearance or interference may occur depending upon the actual sizes of the mating components. For example, smallest shaft could be clearance fit with the smallest hole and the largest shaft could be an interference fit with the largest hole.
- Push fit and light keying fit result when assembling is done with the help of light hand pressure, *e.g.*, locating plugs, fitting dowels in a hole, etc.
- **ALLOWANCE**
- Allowance is the variation given for the purpose of providing different classes of fits.
- Allowances for different fits may be obtained either on the

(*i*) *Shaft basis, i.e.,* keeping shaft diameter constant and varying the hole diameter.

(*ii*) *Hole basis, i.e.,* keeping the hole diameter constant and varying shaft diameter to provide the fit required.

All modern limit systems are based upon the principle of *Hole basis system,* because under quantity production conditions, holes are made by using a fixed diameter cutter such as a drill or reamer. It is therefore more economic to specify a change in shaft diameter which is machined by using easily adjustable tools to provide the required type of fit.

Shaft basis system offers very little benefit in the production of shafts but it makes hole production very much complicated because for each class of fit a different sized reamer may not be available.

A shaft basis system, however, is not obsolete ; it is used when a number of accessories such as bearings, collars, etc., are to be fitted on the same shaft.

6

Process Planning and Group Technology

6.1. INTRODUCTION AND CONCEPT

- A process is defined as any group of actions instrumental to the achievement of the output of an operations system in accordance with a specified measure of effectiveness.
- When the product of the enterprise is designed, certain specifications are established; physical dimensions, tolerances, standards, and quality are set forth. Then it becomes a matter of deciding the specific details of how to achieve the desired output. This decision is the essence of **Process Planning.**
- Process planning is the systematic determination of the methods by which a product is to be manufactured, economically and competitively.

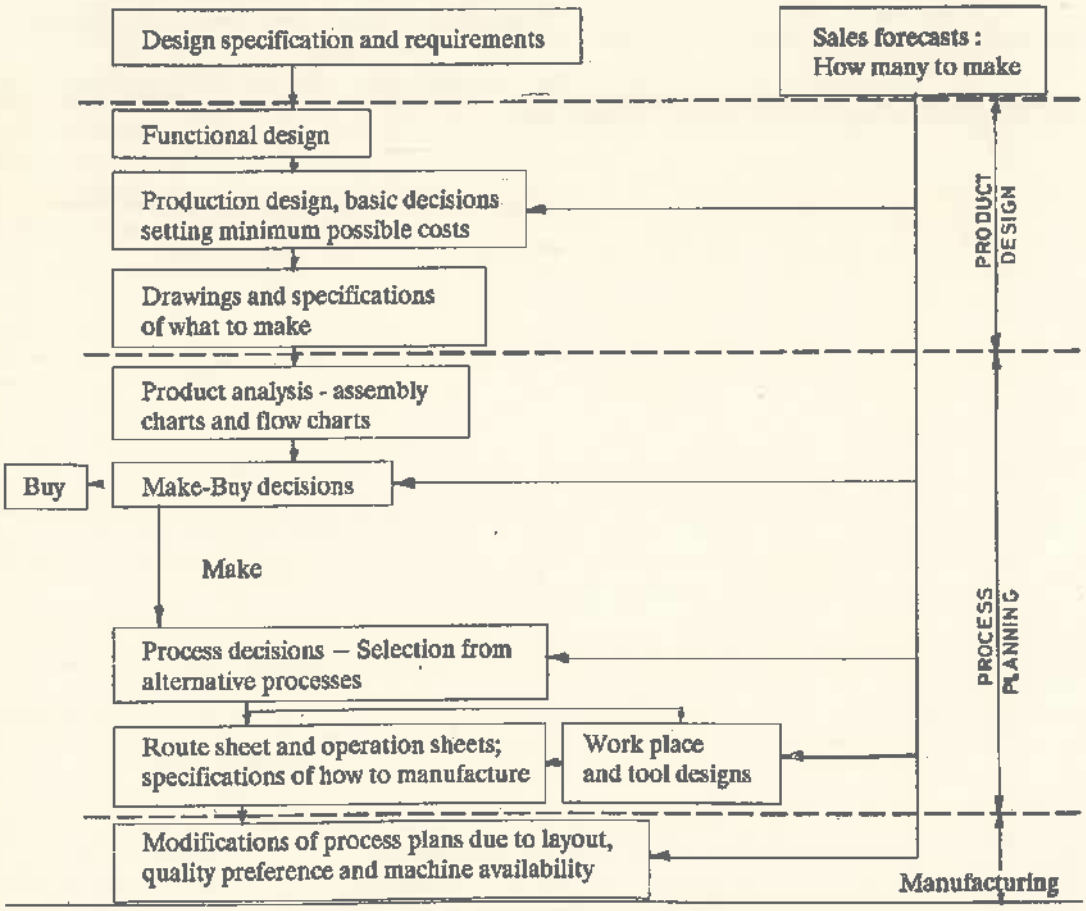


Fig. 6.1. Overall development of processing plans.

- **Process Planning** has been *defined* as *the subsystem responsible for the conversion of design data to work instruction*. A more *specific definition of process planning* is "that function within a manufacturing facility which establishes the processes and process parameters to be used (as well as those machines capable of performing these processes) in order to convert a piece-part from its initial form to a final form that is predetermined (usually by a design engineer) on a detailed engineering drawing."
- Process planning is an intermediate stage between designing the product and manufacturing it (Fig. 6.1).
- Where the product design ends, the process planning begins. However, the *basic* process planning must begin during the product design stages where selection of materials and initial forms, such as casting, forging, and die casting, take place. The accepted end point for production design is manifested by the drawing release, which summarizes the exact specifications of what is to be made. Process planning takes over from this point and develops the broad plan of manufacture for the part or product.
- Process planning takes as its *inputs* the *drawings* or other specifications which indicate *what* is to be made and also the forecasts, orders or contracts which indicate how many are to be made.

  The *drawings* are then *analyzed* to determine the overall scope of the project. If it is a complex assembled product, considerable effort may go into *exploding* the product into its components and subassemblies.

  Preliminary decisions about subassembly groupings to determine which parts to *make* and which to *buy*, as well as to determine the general level of *tooling* expenditure, may be made at this point.

  Then, for each part, a detailed *routing* is developed. Here technical knowledge of *processes, machines* and their capabilities is required, but of almost equal importance is a knowledge of *production economics*.
- *In brief,* the *engineering drawing* of the component is interpreted in terms of the *manufacturing process* to be used. This step is referred to as *process planning* and it is concerned with the preparation of a *route sheet*. The route sheet is a listing of the sequence of operations which must be performed on the component. It is called a route sheet because it also lists the machines through which the part must be routed in order to accomplish the sequence of operations, (refer fig 6.7).

6.2. PROCESS PLANNING ORGANISATION

Process planning is a staff activity. It may constitute a department or alternatively may be considered a subgroup which, along with other subgroups such as plant layout, tool design, etc. will make up a manufacturing staff or manufacturing services department. Either of these plans accords with accepted organizational principles.

6.3. INFORMATION REQUIRED TO DO PROCESS PLANNING

1. Quantity of work to be done along with product specifications.
2. Quality of work to be completed.
3. Availability of equipments, tools and personnels.
4. Sequence in which operations will be performed on the raw material.
5. Names of equipments on which the operations will be performed.
6. Standard time for each operation.
7. When the operations will be performed ?

6.4. PROCESS PLANNING PROCEDURE

The different steps involved in process planning are :

1. Preparation of working drawings
2. Deciding to make or buy
3. Selection of manufacturing process
4. Machine capacity and machine/equipment selection
5. Selection of material and bill of materials
6. Selection of jigs, fixtures and other attachments
7. Operation planning and tooling requirements
8. Preparation of documents such as operation and route sheets etc.

6.5. WORKING DRAWING

- A product is depicted by its drawing.
- A working drawing is a document complete in itself to manufacture a component or product. It shows component's geometrical shape, its dimensions with tolerances, if to be machined, surface finish required, any heat treatment, surface coating if required, bill of material and any other information considered necessary so that the component can be manufactured and inspected without any difficulty.
- An *assembly drawing* shows the complete product with all its parts in proper relationship. *Sub-assembly drawings* are concerned with particular group of parts that make up the product. *Detail drawings* show each part individually and indicate dimensions, material specifications and other information.

  Much of the planning in manufacturing companies is based on the specifications provided by mechanical drawings. The tooling department uses them to plan the tooling that will be required in manufacturing.
- The drawings should be in some standard form so that the part number, can be found quickly and that every separate item shown in a drawing should have its own number and name, corresponding to that given in the parts list.
- It is also important that full particulars of the material standard required should be included for all materials, and that these should be arranged in some standard form, so that there is no risk of missing important particulars and that time is not wasted in long examination of drawings.
- *Notes* on drawings such as "Tube to be hydraulically tested to 14 kg/cm^2" should not be tucked in round the edge of a complicated drawing, but should be shown in a standard panel on the drawing pro-forma.
- The process engineer should thoroughly review every drawing for the following :
  (1) Are dimensioning and datum surfaces compatible with accepted machining practices ?
  (2) Are sufficient stock allowances provided on castings, forgings, and stampings to allow for anticipated mismatch or distortion in heat treatment ?
  (3) Are sufficient clearance and access allowed for proper assembly of all components ?
  (4) Are tolerances on functional characteristics realistic and is statistical tolerancing used where possible.
  (5) Are adequate clamping and locating surfaces needed for manufacturing provided ?

6.6. MAKE OR BUY DECISION

- Recommendations should be made whether to make or buy the material, part or assembly. Information should be sufficiently detailed to take intelligent decisions.

Factors affecting Make or Buy decision

(a) **Quantitative Factors**

(1) *Opportunity costs :* May be defined as the monetary value sacrificed in rejecting an alternative. Facilities utilized in manufacturing a part or component are, in effect, sacrificed for any other use. The decision to make or buy often boils down to an attempt to optimize the utilisation of facilities.

(2) *Incremental costs :* Only those costs that vary with the decision to make or buy are generally considered relevant.

(3) *Idle facilities :* Availability of idle facilities bears directly on the make or buy decision, particularly with regard to determining the incremental costs involved. If sufficient facilities are available, only variable costs -- *i.e.* those costs that vary with volume-must be considered.

(b) **Qualitative factors**

(1) *Product quality :* Parts may be made in one's own factory in an attempt to control the overall quality of an end product even though it may be more economical to buy the parts from outside.

(2) *Patents :* Legal restrictions may prevent a company from making certain parts.

(3) *Skills and materials* : Required skills may be very technical or materials very rare and special, thereby precluding in-house manufacture of certain parts.

(4) *Long-term Considerations :* It may be more profitable in the short run, for example, during slow periods, to utilise idle facilities by manufacturing more parts in house. However, this may result in poor relations with suppliers, or even in non-availability of parts from outside sources during busy periods when in-house facilities could be used more profitably in other ways.

(c) **Other factors**

Factors of intangible nature that may influence the make or buy decision are :

(1) Number of outside suppliers.

(2) Reliability of outside sources.

(3) Seasonal demands

Example 6.1.

ABC Company manufactures and sells gas stoves. It makes some of the parts for the gas stoves and purchases others. The engineering department believes it might be possible to cut costs by manufacturing one of the parts currently being purchased for Rs. 8.50 each. The firm uses 100,000 of these parts every year, and the accounting department compiles the following list of costs based on engineering estimates.

Fixed cost will increase by Rs. 50,000.

Labour costs will rise by Rs. 125,000.

Factory overheads, currently running Rs. 500,000 per year may increase by 12%.

Raw materials used to make the part will cost Rs. 600,000.

Given the above estimates, should ABC Company make the part or continue to buy it.

Solution : Calculate total cost incurred if the part was manufactured :

Additional fixed costs	=	Rs. 50,000
Additional labour costs	=	Rs. 125,000
Raw materials cost	=	Rs. 600,000
Additional overhead costs	=	Rs. 60,000 ($\because 0.12 \times 500{,}000$)
Total cost to manufacture	=	Rs. 835,000
Cost to manufacture one part	=	Rs. 835,000/100,000
	=	Rs. 8.35

Therefore, the Company should make the part itself because manufacturing cost per part (Rs. 8.35) is less than the present cost to purchase (Rs. 8.50 by Re. 0.15 per part.)

6.7. PROCESS SELECTION

Process selection determines how the product (or service) will be produced. It involves

1. Major technological choice
2. Minor technological choice
3. Specific component choice
4. Process flow choice

1. Major technological choice

- Does technology exist to make the product ?
- Are there competing technologies among which we should choose ?
- Should the technology be developed in the country itself ?
- Should innovations be licensed from foreign countries ?

2. Minor technological choice

- Once the major technological choice is made, there may be a number of minor technological *process* alternatives available. The operations manager should be involved in evaluating alternatives for costs and for consistency with the desired product and capacity plans.
- Should the process be *continuous,* which is carried out for 24 hours a day in order to avoid expensive startups and shutdowns as used by steel and chemical industries.
- An *assembly line process* on the other hand, follows the same series of steps as mass production but need not run for 24 hours a day *e.g.*, automobile and ready-made garment industries.
- *Job shop processes* produce items in small lots, perhaps custom-made for a given customer/ market.
- Suppose, we make a job shop choice. The alternatives do not end here. For example, in a factory, the fabrication, joining together and finishing of two pieces of metal may represent only a minuscule part of creating a finished product. There may be numerous ways of casting and molding, several ways of cutting, forming, assembly and finishing.

  Deciding on the best combination of processes in terms of costs and the total operations process can be difficult.

3. Specific component choice

- What type of equipment (and degree of automation) should be used ?
- Should the equipment be *specific purpose* or *general purpose ?*
- To what degree should machines be used to replace human labor in performing and automatically controlling the work ?

  Computer-aided manufacturing (CAM) and industrial *robots* are being used increasingly in many manufacturing systems.

4. Process flow choice

- How should the product flow through the operations system ?
- The final process-selection step determines how materials and products will move through the system.
- Assembly drawings, assembly charts, route sheets and flow process charts are used to analyze process flow.
- Analysis may lead to resequencing, combining, or eliminating operatons in order to reduce materials handling and storage costs.

The four phases of process selection as discussed above are closely interrelated. In each phase, choices should be made to minimize the process operations costs.

Factors affecting process selection

- A process is necessary in order to shape, form, condition and join materials and components with the help of machines and labour in order to convert raw material into a finished product.
- One should select the most economical process (a breakeven chart similar to one discussed in Chapter 27 may be useful for the purpose) and sequence that satisfies the product specifications.
- *The selection of process depends upon* :

(*a*) *Current production commitments.* If enough work has already been allocated to more efficient equipments, the current work may have to be passed on to less efficient machines to complete the same in time.

(*b*) *Delivery date.* An early delivery date may :

(*i*) Force the use of less efficient machines,

(*ii*) Rule out the use of special tools and jigs as they will take time for design and fabrication.

(*c*) *Quantity to be produced* :

- Small quantity will not probably justify the high cost of preparation and efficient set-ups. Thus, quite possible they may have to be made on less efficient machines and *vice-versa.*

(*d*) *Quality standards* :

- Quality standards may limit the choice of making the product on a particular machine, etc.

6.8. MACHINE CAPACITY

- *Capacity* is a rate of output, a quantity of output in a given *time*, and it is the highest quantity of output that is possible during that time. Yet, capacity is at the same time a dynamic concept which is subject to being changed and managed. To some extent, it can be adjusted to meet fluctuating sales levels.
- *Machine capacity* may be defined as the time-available for work at a machine expressed in machine hours (minutes etc.). For example, a machine may have a maximum capacity of 168 machine hours per week (7 days of 24 hours each).
- If *overtime* is worked, these extra-hours per week should be added to the *normal machine capacity* to find the *planned machine capacity.*
- It is now necessary to subtract time for *maintenance* (machine down time), finding the time preferably by reference to the *maintenance plan* and to a statistical record of past machine break-downs.
- Next, time must be allowed for *idle machine time* (waiting for work, no operator etc.) and for *machine ancillary time* (setting up, cleaning etc.).
- Finally, to find the *time actually available* for *useful work,* the *machine running time* must be corrected up or down, if the average performance in the factory is more or less than the *standard performance* used in fixing the standard times for work operations.

The *final capacity* achieved after making all these corrections is known as the *Standard Machine running time* and is generally very much less than the maximum 168 hours per week.

- Fig. 6.2 illustrates these various levels of machine capacity. It will be realized that it would be possible to check load against capacity at a number of these levels, by making the adjustment to correct for lost time, to either the load or the capacity.

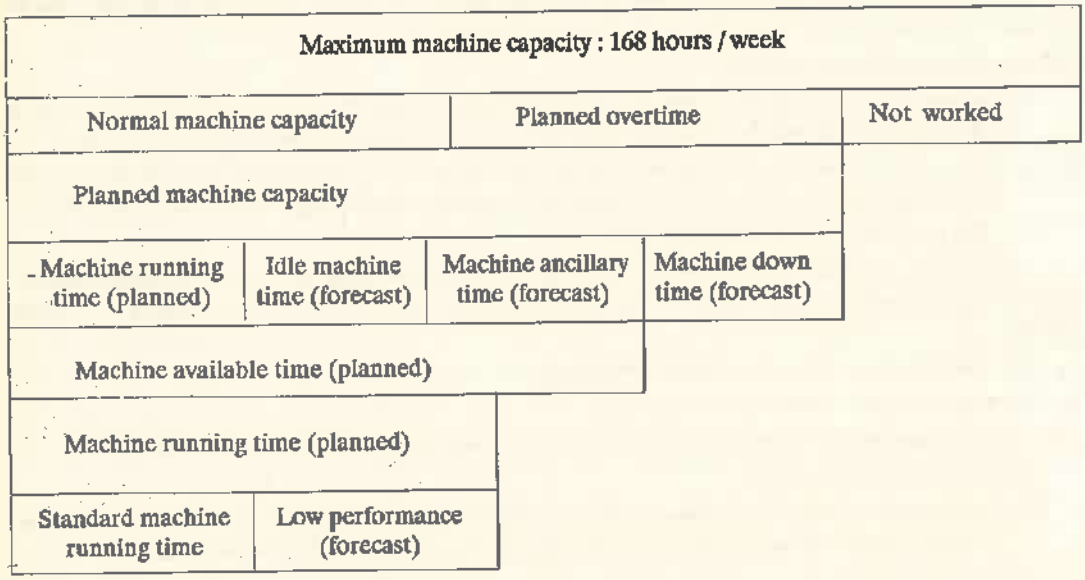


Fig. 6.2. Types of capacity.

Analysis of Machine Capacity

- The process of obtaining accurate information regarding the capacity of the available machines to produce the desired output is known as machine analysis.
- An objective of machine analysis is to obtain the answers to certain definite questions in regard to the use of manufacturing machines.
  - (1) How long will a certain machine take to perform its operation on a unit quantity of material ?
  - (2) How many units of material can be processed on this machine per day, week or month ?
  - (3) What is the maximum plant capacity per day for each process on each material ?
- The first of these three questions can be answered either
  - (*a*) from standard data,
  - (*b*) by actual experiment and trial or
  - (*c*) by reference to records of past performance.
- The second question can be answered when the machining time and set-up time are known and when an adequate allowance has been made for the inevitable idle time.
- The third question is answered by aggregating the number of units which can be processed by similar machines to give the total plant capacity in units of product.

From this information it is possible to determine the maximum capacity of each process and the plant as a whole. Machine load charts, showing the work ahead of each machine, can also be prepared.

- *Certain ratios related to this topic are* :

(*i*) Machine availability $= \frac{\text{Machine available time}}{\text{Total machine time}} \times 100$

(*ii*) Machine utilisation $= \frac{\text{Actual running time}}{\text{Machine available time}} \times 100$

(*iii*) Machine efficiency $= \frac{\text{Standard running time}}{\text{Actual running time}} \times 100$

(*iv*) Machine effective utilisation $= \frac{\text{Standard running time}}{\text{Machine available time}} \times 100$

6.9. PROCESS AND EQUIPMENT SELECTION PROCEDURE

The formal steps of the process and equipment selection procedure are :

1. Developing a general statement of the *manufacturing operations* to be performed.

2. Establishing a *provisional* process to provide each individual feature identified by the product designer. Several additional inputs are necessary before beginning the selection of the provisional process. Specifically one must (a) establish targets for facility and piece costs (b) specify raw material (c) determine hourly production volume preparatory to establishing machine capacity, (d) establish timing, (e) *select the provisional process.* As part of the selection of the provisional process, the manufacturing engineer will estimate the number of steps and consequent stations necessary to provide all the design features identified on the blueprint. This will require visualization of each individual sequence, an estimate of manpower required and a rough approximation of the necessary layout provisions to accommodate each step of the process.

No process should be selected with a confidence level below that acceptable to the particular management (0.92 is a suggested minimum).

(f) Based on the provisional process, the manufacturing engineer will develop judgemental costs of facilities and materials and, with the assistance of the industrial engineering function, will develop the preliminary piece cost of the components for the final assemblies.

3. Upon completing the provisional processing steps, the manufacturing engineer should *develop a list of process alternatives,* particularly for those areas where detailed analysis of the preliminary processing has shown high cost, questionable performance, or places where the confidence level of achieving the requirements of the individual operator is judged to be marginal. Of assistance in developing these opportunities are the historical data relative to similar operations.

4. A careful step-by-step comparison between each phase of the *provisional process* with each phase of the *alternative process* will allow the manufacturing engineer to select the compromised position, which optimizes all the elements of cost, quality, flexibility and inherent risk.

All engineering management and manufacturing considerations being equal, production processes will be chosen on the basis of the most favourable return on investment or other financial criteria.

5. *Upon completion of process selection, it is communicated* to the product engineering, industrial engineering, plant and maintenance engineering, industrial relations and finance departments. This will provide coordination and communication among all conerned which is essential for the successful adaptation of new technology to existing plant and staff.

6. *Performing detailed processing.* When the process has been *selected* and *communicated* to all affected departments, the final *detailed processing* upon which all actions depend is initiated.

As the detailed processing proceeds, the manufacturing engineer will make extensive use of the body of engineering knowledge that resides with the machine and equipment suppliers.

As in the establishment of the provisional process, the starting point in establishing the detailed processing is to assemble the latest information relative to product design, production rate, facility cost and part cost targets. Detailed processing follows the same format as did the provisional processing, except that each element of the process will be completely identified and documented through the use of process estimate sheets. Information is included on the source of the material for each process from

rough stock to finished piece. The subsequent operation should be identified on each process sheet so that there can be an orderly part flow through each of the manufacturing operations.

TYPICAL PROCESS SHEET

Plant..... Department.....

Program No.	Party Name							Issue	Party No.	
For Models	Material			WT/kg. RGH	FIN			dates	Release	Sheet of
Oper No.	Operation description	Tool-M/c-Equipt Description	M/cs reqd.	Net hrly. capacity	Est. Minutes	Facility & durable tool cost*			Special tool cost+			Expense cost
						T	B	F	I	T	D	BL IT
10	Drill (3) locator holes 10ϕ, 30 deep	Single spindle Drill press locating fixture reqd.	1	16	3.75							
Total												
Remarks												

	Process Engr.	PLt layout	Design	Material Engr.	Daily service	Reqd. per vehicle	Next Assy.	Oper No.
	Ind Engr.	QC Contr.	Plant Engr.	Prodn	Daily PLT planning volume	Reqmts. pc/hr	Supersedes	

*T - Total +T - Total
B - Basic D - Design
F - Freight BL - Build
I - Installation IT - Inst. Tryout

Fig. 6.3. Typical Process Sheet.

Process sheet description

To examine the required amount of processing documentation, a particular example -- a machining operation--will be used.

- The basic principle involved is that the instructions detailed in the manufacturing engineering document, that is, the *process sheet,* be sufficiently explicit that operational personnel can perform every function necessary to produce the finished component and that operations can establish staffing and piece cost from which to judge operation efficiency during and after physically launching the operation.
- The process sheet contains columns for recording the operation number, a description of operation, numbers and types of machines required, effective operational rates, labor distribution, and minute costs; provision is also made for recording facility and tool costs.

  The *process engineer* will fill out those portions of the process sheet that relate to establishing the process and selecting the machinery; the *plant engineer* will enter data relating to the installation cost of the machinery; and the *industrial engineer* will appropriately ascertain and register the direct labor minutes of each operation, and so on.
- The *sample entry* on the process sheet shows the manner in which the manufacturing engineer

describes each step in manufacturing process. The engineer numbers and names the operation, namely, drill. He indicates the features, namely, the holes, and establishes their limits, that is, their size and depth. With this information, it is possible to identify the machine (s) required to carry out this specific step. In the example, the machine can be a single-spindle or multi-spindle and can be part of additional automation, that is, a transfer line or a dial machine. All of this information is included on the process sheet.

Numbers of machines required to meet the production volume and the space required complete the description of this individual process sheet. If fixtures or tools are required, they should be individually listed and costed as durable tools or special tools in the space provided. Each subsequent operation is identified in the exact detail until the part is finished.

6.10. SELECTION OF MATERIAL, JIGS, ETC.

- It has become a subject requiring study, because selection of material has become complicated by the great increase not only in the kinds of materials but also in the various forms in which any one material may be available.
- Material should be of right quality and chemical composition as per the product specifications.
- Shape and size of material should restrict the scrap (*i.e.*, material removed for getting the product shape).

(a) Bill of Material

- The most common method of analyzing a product into component parts is through the use of *bills of material* or specification sheets.
- *Bill of material* is a means of determining purchasing and production order requirements. It should indicate if the part is to be manufactured or purchased.

The production-control department uses the bill of material to determine manufacturing and scheduling dates.

Process engineering uses it as a check list to complete their work.

Methods engineering uses it in the preparation of time allowances for assembling operations.

Accumulations are made by the stores department according to the bills of material. They in turn set up the shortage lists for use by expediters of the production-control department.

Releases by assembly units are made by the finished-stores department in accordance with the bills of material.

- The design of the bill of material varies slightly in minor details, depending upon the various uses made of it by individual companies. The information usually required on the *bill of material form* includes

(1) The product name
(2) Product code identification
(3) Sheet number
(4) Use
(5) Date of preparation
(6) Name/initials of preparer
(7) Name/initials of checker
(8) Item numbers
(9) Make/purchase designations
(10) Subassembly part numbers and names
(11) Quantity requirements, and
(12) Material used in each part.

- Bill of material is also known as *parts list.*

Item *Switch, Y 30* Sheet No. *1 of 2*
Drawing Z5 Assembly *5HP motor*
Date.....

Part No.	*Part Name*	*No/item*	*Material*	*Quantity per item*	*Cost per item*	*Remarks*
SJ-64	Drive Spring	2	Sprg steel	–	Rs 5/-	Purchase

Made by..... Checked by .....

Fig. 6.4. Bill of materials.

(b) **Selection of Jigs, Fixtures and Other Special Attachments.**

These supporting devices are necessary :

– to give higher production rate ;

– to reduce cost of production per piece.

(c) **Selection of Cutting Tools and Inspection Gauges.** They, respectively, are necessary to :

– Reduce production time ;

– Inspect accurately and at a faster rate.

(d) Make the *process layout* indicating every *operation* and the sequence in which each operation is to be carried out.

6.11. PROCESS ANALYSIS

Process Analysis means the study of the overall process in a factory (plant). It analyses each step of the manufacturing process and aims at improving the industrial operations. Process analysis aids in finding better methods of doing a job and this is achieved by eliminating unproductive and unnecessary elements of the process or through modified layout of facilities.

The process is analyzed with the help of Process Charts and Flow Diagrams.

Various steps involved in Process Analysis are :

(1) Select the process for analysis.

(2) Break down the process into operations and sub-operations.

(3) Construct a process chart and a flow diagram.

(4) Analyse the process chart and flow diagram by subjecting each and every step to questioning procedure as discussed in Chapter 9.

(5) Reconstruct the process chart and flow diagram for the modified (proposed) procedure.

(6) Test the proposed method for all the advantages claimed for the same.

(7) Explain the new method to the workers and put it into operation.

6.12. PROCESS CHART

A chart may be a diagram, a picture or a graph which gives an overall view of the situation, say a process. It helps visualising various possibilities of alteration or improvement.

A chart representing a process may be called a *Process Chart.* A process chart records graphically

or diagrammatically, in sequence, the operations connected with a process. The chart portrays the process with the help of a set of (process chart) symbols and aids in better understanding and examining the process with a purpose to improve the same.

6.13. PROCESS CHART SYMBOLS (Refer article 9.7)

6.14. OUTLINE (OPERATION) PROCESS CHART

Fig. 6.5 shows an Outline Process Chart.

TASK : *CHANGING REFILL OF A BALL POINT PEN*
Chart begins : *Unscrew cap*
Chart ends : *Screw the cap.*
Charted by .....
Date .....

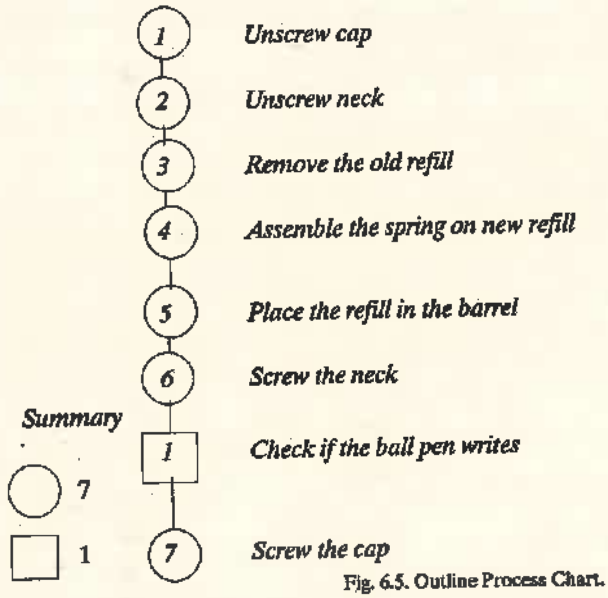


Fig. 6.5. Outline Process Chart.

– *An outline process chart,*

(a) surveys and records an overall picture of the process and states only main events or steps sequence-wise,

(b) it helps visualising and comprehending the full process so that necessary improvements may be made if required,

(c) it shows relationship between the different activities.

(d) it considers only (main) operations and inspections, and thus it makes use of only two symbols,

(e) each operation and inspection is numbered from the beginning to the end of the chart,

(f) description of operations and inspections are written on the right-hand side of the symbols (refer Fig. 6.5) and

(g) actually an outline process chart is the first step or the beginning of a detailed analysis.

6.15. FLOW PROCESS CHARTS (refer article 9.8)

6-16. OPERATION PLANNING AND TOOLING REQUIREMENTS

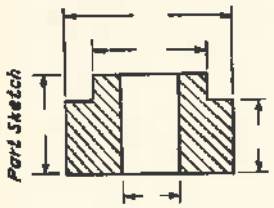
– Operation planning is that stage in planning which marks the completion of *routing* (refer article 7.19) at the process planning level. The operation planning is concerned with planning the

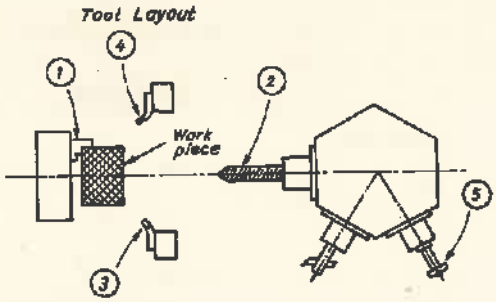
details of the method to be used to complete each operation at its chosen work centre and with *designing the necessary tooling.*

- Operations are divided into work elements. The record used to show the planned sequence of work elements is generally known as an *operation sheet* (Fig. 6.6.) It is in effect a record showing how an operation should be carried out.
- The purpose of the *operation sheet* is to record and communicate information that is essential for making each part. This is the sole determinant and criterion for the design of the *form* that will be used. It is intended to achieve a level of specification that can be costed, evaluated and altered in specific rather than in abstract terms.
- Operation sheets are prepared for each part, subassembly and assembly. They indicate the route of the parts through the various departments, the sequence of required operations, the machines, special tools and gages needed, the time required to do each operation, the details of speeds, feeds etc.

Operation sheets vary greatly from company to company. Simpler operation sheets list mainly the required operations and the machines to be used.

Part : Pump flange	Part No : T40/815
Operation : Bore, ream, face and chamfer	Operation No :
Material : B.S.S. 32/4, 10 cm diameter	No. of operations : 13
Machine : Ward No. 7	Machine No: 2057





Operation No.	Operation Description	Machine Tool	Cutting Tool	Cutting speed	Feed	Depth of cut	Setup time	Machining time per piece	Remarks
1.	Load in jaws								
2.	Drill 27 mm diameter		27 mm T.S. drill						
3.	Rough turn face and chamfer		Turn, face and chamfer tool Boring bar						
4.	Finish bore 31.75 mm								
5.	Ream 31.75 mm bore								

Operation Time ..... Set-up time .....

Prepared by : ..... Checked by : ..... Date .....

Fig. 6.6. An operation sheet.

- As the next step, the process planner designs the tooling and calculates tooling requirements. Once the tooling is designed, it must be recorded on some document, so that the correct tooling for any operation can be found when required ; it is also necessary to make reference on the operation layout to this record.
- The record may consist of a simple list of tools for use in the tool store or, if production is in sufficient volume, it will pay to prepare special *operation sheets* which can be used by both the tool stores and by the machine setters. An example of these *operation sheets* is shown in Fig. 6.6.
- The best way of numbering the tool kits for each operation is to use the part number, plus a suffix to show the operation concerned, or to use a classification system which will show the association between tooling kit and production operation in a similar manner. When this type of numbering system is used it is unnecessary to have a separate column on the operation layout for tooling ; the tool-kit numbers are known.
- When the operation sheet has been accepted and finalized, real implementation of plans can begin. Machines, tools, gauges, fixtures and jigs required for fabrication can be assembled and inventoried.

Part Name ..... Date .....
Part Number ..... Issued by .....

Operation	Dept	Description	Equipment
01	07	Shear coil to desired length	480 shear
02	05	Punch blanks	335 punch press
03	06	Press blanks into form	333 press
----	----	----------	----------
----	----	----------	----------

Fig 6.7. Route sheet.

- An *Operation and Route sheet* summarizes the operations required , the preferred sequence of operations, auxiliary tools required, estimated operation times etc. (Refer Fig. 6.8).

OPERATION & ROUTE SHEET

Component No. ---------- *Drawing* ----------
Name of Component ----------
---------- *Quantity* ----------
Material ----------
---------- *To be completed on* ----------

Routing		*Operation No.*	*Operation Description*	*Tools Reqd.*	*Fixtures & Other Accessories*	*Time*		
Section	*Machine*					*Setup*	*Operation*	*Total*
.....	.....	.....	.....	.....	.....	.....	.....	.....

Fig. 6.8. An operation and route sheet.

6.17. MANUAL PROCESS PLANNING

- This type of planning is known as *man-variant* process planning and is the commonest type of planning used for production today.
- Planning the operations to be used to produce a part requires knowledge of two groups of variables :

  (i) the part requirements (as indicated by an engineering drawing) and,

  (ii) the available machines and processes, and the capabilities of each process.
- Given these variables, the planner selects the combination of processes required to produce a finished part. In selecting this combination of processes, a number of *criteria* are employed.

  Production cost or *time* are usually the dominent criteria in process selection; however, *machine utilization* and *routing* often affect the plans chosen.

  In general, the process planner tries to select the best set of processes and machines to produce a whole family of parts rather than just a single part.

6.18. AUTOMATED PROCESS PLANNING

- *Man-variant* process planning (at times) becomes a boring and tedious job. It produces erroneous process plans. This, coupled with the labor intensity of man-variant planning, has led many industries to investigate the *automation of process planning.*
- A *completely automated process planning* system would eliminate all human effort between the preparation of an engineering drawing and a complete process plan for every manufacturing operation. Schematically, the system would correspond to Fig 6.9(a). The block labeled LOGIC

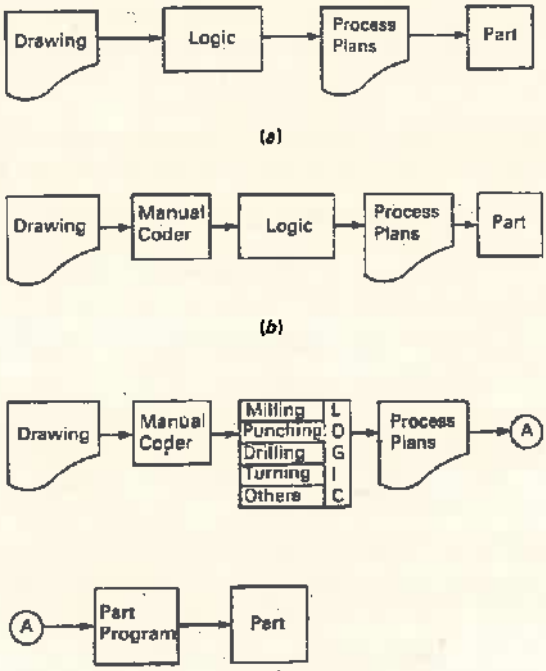


Fig. 6.9. Automated Process Planning Systems

would include the capability to scan and interpret the drawing, to convert this information into process requirements and to select machines, tools and operations to yield an economically acceptable product. Such a system would be truly automated. Self contained *logic* would check for contradictory requirements on the engineering drawing. These requirements would be checked for compatibility with available processes. Selection of the processes (such as turning, milling or stamping) would be based on product requirements, quantities ordered and process capabilities. Whenever contradictory or incompatable requirements were detected, a printed message would indicate the source of the problem and recommend remedial action.

- A less automated system is shown in Fig. 6.9 (*b*). This system needs human assistance to code the engineering drawing data. Thereafter, the system is fully automated.
- In Fig. 6.9 (c), a still less automated system is shown. For this arrangement, a man must select the process as well as interpret and code the drawing information.
- Many developments in *computer-aided process planning* have focused on eliminating the process planner from the entire planning function. Computer-aided process planning can reduce some of the decision making required during a planning process.

Advantages of computer-aided process planning

(*a*) It can reduce the process planning time.

(*b*) It can reduce the skill required of a planner.

(*c*) It can create more consistent plans.

(*d*) It can produce more accurate plans.

(*e*) It can increase productivity.

(*f*) It can reduce both process planning and manufacturing costs.

Benefits from computer-aided process planning have been documented by several industries. Such systems can reduce planning time from days to hours or from hours to minutes.

6.19. GENERATIVE PROCESS PLANNING

- Generative process planning may be defined as a system that synthesizes process information in order to create a process plan for a new component automatically. Process plans are created from information available in a manufacturing database with little or no human intervention. Upon receiving the design model, the system can generate the required operations sequence for the component. Knowledge of manufacturing must be captured and encoded into efficient software. By applying decision logic*, a process planner's decision-making process can be imitated. Other planning functions, such as machine selection, tool selection, process optimization, and so on, can also be automated using generative planning techniques.
- Decisions on process selection, process sequencing, and so on, are all made by the system. However, transforming component data and decision rules into a computer-readable format is still a major obstacle to be overcome before generative planning systems become operational.
- *The generative method* of process planning essentially consists of four steps :-

(1) Describe a part in detail.

(2) Describe a catalog of processes available to produce parts.

(3) Describe the machine tool(s) that can perform these processes.

(4) Create the software to inspect the part, process, and available machinery to determine whether all three are compatible.

* Decision logic consists of the unusual ability to check some conditional requirements of the component and select a process. Ideally, a generative process-planning system is a turnkey system with all the decision logic contained in the software.

- **Advantages** of generative process planning :
  - (*a*) It can generate consistent process plans rapidly.
  - (*b*) New components can be planned as easily as existing components.
  - (*c*) It can potentially be interfaced with an automated manufacturing facility to provide detailed and up-to-date control information.

6.20. GROUP TECHNOLOGY

Introduction

- Group technology was originated in Russia and was used during World War II.
- **Group technology** or **Cellular manufacturing** has become an increasingly popular concept in manufacturing that is designed to take advantage of *mass production layout and techniques, in* smaller *batch-production systems.*
- In a typical factory organised for **small batch production,** the machines are by tradition usually arranged according to their *function,* for example, in a metal cutting industry, there may be a turning section having lathes, a milling section having various types and sizes of milling machines and so on (Fig. 6.10). A component during manufacture may need to visit some or all of these sections. This results in heavy losses of time due to the resetting of machines, in particular, as *largely dissimilar parts* may be loaded successively, causing large queues of parts awaiting processing on each machine. *Further problems associated with small batch production are :*
  - (*i*) Large variety of components. The overall effect is that throughput times are both long and uncertain, causing considerable problems in scheduling and production control.
  - (*ii*) Long and uncertain throughput times are the source of the delivery problem.

A further direct result is excessively high levels of work-in-progress and of stocks of finished goods kept in an effort to insure against non-delivery. Such investments in inventory are very costly.

- Broadly, it is these problems of flow, controlling excessive work-in-progress, excessive manufacturing time, and excessive variety, with which group technology is concerned.
- Group Technology is the realization that many problems are similar, and that by grouping similar problems, a single solution can be found to a set of problems, thus saving time and effort.
- *Group technology,* in manufacturing, is the replacing of traditional jobbing shop manufacture by the analysis and grouping of *work into families* and the formation of *groups of machines* to manufacture these families on a *flow-line principle* with the *object* of minimizing setting times and throughput times.

6.21. FUNCTIONAL AND GROUP/CELL LAYOUTS

- Functional layout consists of functional grouping of machines that do similar work. For example, all turning machines may be grouped together at one place and all milling machines at another. Depending on their processing requirements, parts may be moved in different sequences from one machine to another. Besides factors mentioned above, there is considerable back-tracking and thus the distance moved by a component while being transformed from raw material to finished part is much more.
- *Functional or Process layout* dominates batch production facilities. This results in (*i*) a large number of setups for different parts (*ii*) as well as high material handling costs and (*iii*) high work-in-process inventory.
- Before understanding *Group-layout,* it should be clear that group technology is a technique for identifying and bringing together *related* or *similar* components in a production process in order to take advantage of their similarities by making use of, for example, the inherent economies of flow-production methods. The aim is to substantially (*i*) reduce work in progress and (*ii*) improve delivery performance by reducing the throughput time. This is achieved by organising what may appear to be a large number of very diverse components into *families* which require *similar* manufacturing *processes,* and providing the most suitable manufacturing facilities for groups of families.
- In a *group/cell layout system* Fig. 6.10 (*b*), the layout design is not according to the functional characteristics of machines, but rather by groups of different machines (called *cells*) that are necessary for the production of families of parts. Fig. 6.10 (*b*) shows four families of *parts.* The first

group of parts is of *ring-type* and requires operations such as turning, milling, drilling and *cylindrical* grinding. The second group parts are *cylindrical* and require operations on a turning (lathe) machine, milling machine, drilling machine and surface grinder and so on for other two families of *parts*.

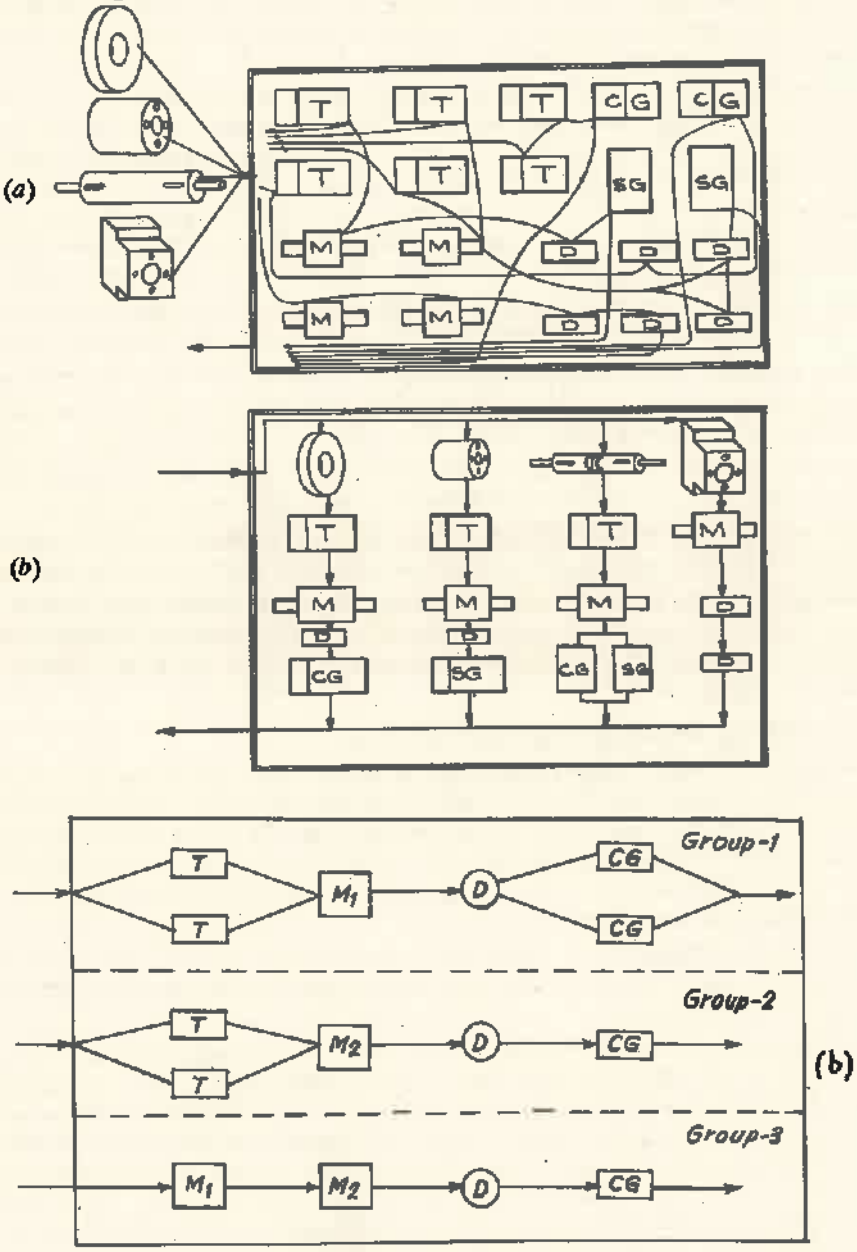


Figure 6.10. (*a*) Function and (*b*) group layouts

T. Turning
M. Milling
D. Drilling
S.G. Surface grinding
CG. Cylindrical grinding

In the practice of group technology, a group of machines for producing one part family (or more) may be formed such that it can perform all the operations required by the family of parts. The machines themselves are arranged in a semi-flowline to minimize transportation distances and waiting problems. The result is very similar to a modern N/C machining center.

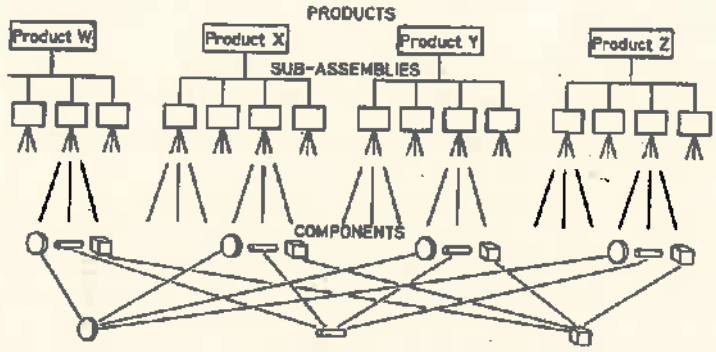


Fig. 6.11. Manufacturing Groups.

The relationship between final products, subassemblies, individual parts and the grouping of similar components for manufacture.

- The *relationship* between the products and the parts is shown in Fig. 6.11.

While final assembled products may bear little relation to each other, the sub-assemblies from which they are constructed will exhibit some like features; for example all gearboxes will have some similar characteristics. Such assemblies, when broken down into their individual constituent components/parts result in a wide range of seemingly diverse parts. It is by exploiting the similarities which are known to exist among such a population of components, that *group technology* attempts to reduce the time and cost of component manufacture.

- *Cells* will be created to manufacture defined types and size-ranges of components. This approach can be contrasted with that of the traditional functional factory layout, where specialization is concentrated on manufacturing processes, rather than on component types.
- Groups of machines, chosen for each family, are situated together in a *group layout* in such a way that components flow from one machine to next in sequence of operation. It is not necessary for every component to pass to each machine but the machines within the cell should ideally be capable of carrying out all the operations required in the family.

Advantages of group layout

- The first obvious saving from a group layout is the reduction of transportation and queuing time between operations but the similarity of components within a family allows resetting times to be minimized, by the design of quick-change group tools and fixtures.

  The overall effect is then to reduce the length of time a component is in the process of being made. This allows simpler and more effective methods of production control to be employed and can form the basis for a beneficial reorganisation of management structure within a company.
- At the same time this approach of considering components in related groups can lead to other benefits including the improved use of standard times and standard tools, the standardization of design and production practice, and the facility of easily retrieving data to aid variety reduction and standardisation, for design and production.

Appropriate and successful implementation of group technology leads to such *advantages* as (1) more effective design (2) less stock and fewer purchases (3) simplified production, planning and control

(4) optimum sequencing and loading (5) reduced tooling and set up times (6) reduced in-process inventories, (7) shorter throughput times and (8) more efficient utilization of expensive machines. Significant economic benefits will be achieved.

The crux of the problem of introducing group technology is the identification of the components (from the large variety and total number of components) of the families requiring similar manufacturing operations on similar machine tools.

6.22. DEFINING AND CONSTRUCTING A COMPONENT FAMILY

- Group technology involves the machining of parts in families, (Fig. 6.13).
- A component family, for example type A, is a collection of similar (or related) geometrical shapes and/or size, all requiring similar machining operations.
- Alternatively, a type B family may be dissimilar in shape though related by having some machining operations in common and possibly other similarities, such as materials and accuracy limits. As a production method, *group technology may be implemented in three different ways :*
  1. The machining of an A type family on a group of different conventional machines.
  2. The machining of A type and/or B type families on one or several similar conventional machines.
  3. The machining of a B type family on a group of different machines.

A group of machines is an arrangement which enables that particular sequence of operations (required for machining of all parts in a given family) to be performed within the confines of that group.

6.23. CLASSIFICATION AND CODING SYSTEMS

- *Classification* involves arranging items into groups according to some system whereby like things are brought together by virtue of their similarities and are then separated according to a specific difference.

A *code* can be a system of symbols used in information processing in which numbers or letters or a combination thereof are given a certain meaning.

- A classification and coding system should meet the following *basic requirements :*
  1. Be all embracing and offer companywide applications.
  2. Be mutually exclusive.
  3. Be based upon permanent characteristics.
  4. Be specific to user needs.
  5. Be adaptable to future changes.
  6. Be adaptable to computer processing.
- The defining of *component families* is best achieved by the use of a well-designed classification system *e.g.* Brisch, Orpitz, Pera etc.
- All identical and similar components will then be brought together by classification and three basic types of component families will emerge :

(1) *Identical shape and function*

Spur gears, bevel gears and bushes whose individual shapes and functions are identical.

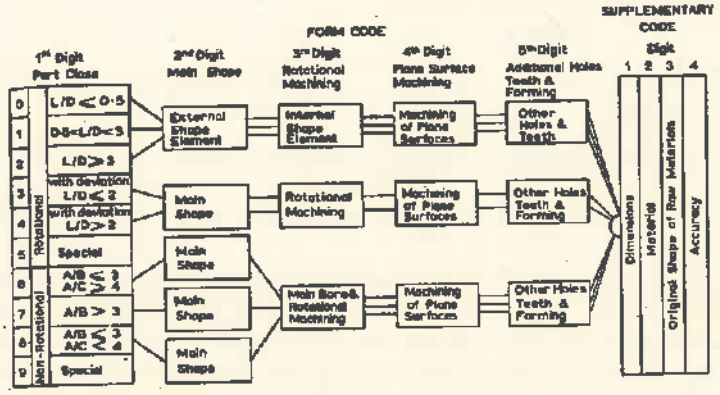
(2) *Identical in shape but different in function.* Bearing flanges, sealing flanges, rings, spacers.

(3) *Similar in shape*

Centre line and non-centre line multi-diameter shafts, bolts, spindles, etc. The establishment of the machine group and tooling for these is normally more difficult than for the two preceding types of families.

– *The most common classification systems are :*

(1) Opitz (2) Brisch mono-code, Brisch poly-code (3) PERA



Designation	Form code	Supplementary code	Sawing	Boring, rough	Turning, centre lathe	Turning, turret	Inspection	Milling keyway	Heat treatment	Grinding, cylindrical	Grinding, surface	Turning, centre lathe	Turning, turret	Inspection	Hobbing, teeth	Shaping, teeth	Milling keyway	Deburring	Inspection	Hobbing, teeth	Grinding, cylindrical	Grinding, surface	Grinding, teeth	Inspection
Spur gear			28	41	01	11	95	64	66	31	33	06	–	95	25	53	54	73	95	25	31	33	34	95
	04166	2409	X	X	X			X	X			X		X		X			X		X	X		
	01106	2409	X	X		X			X				X	X		X					X	X	X	
	14166	2409	X	X	X		X	X		X	X				X		X		X	X			X	X
	01166	2408	X	X		X	X	X		X	X				X				X					
	14166	2408	X	X		X	X								X		X		X		X	X		
	04106	2408	X	X		X	X								X						X	X		
	01106	3478		X	X		X								X						X	X		
	14166	3409	X	X	X		X			X	X						X			X			X	

Fig. 6.12. The Opitz classification system (coding system).

– The *Opitz system* has a more generalised application. It consists of a 5-digit *primary code* and a 4-digit *supplementary code.*

The *primary code* is essentially a geometrical code which groups components by the logical arrangement of shape characteristics and significant features.

The *supplementary* code provides information on component dimensions, type of material and material thickness.

Fixed digital significance exists in certain areas of the code with individual digits describing the same

features of all classes of components and each position within a digit has a corresponding meaning. This makes the code relatively easy to memorize and high rates of coding can be achieved.

From the information and data contained within the classification number it is possible to construct an approximate picture of the shape and size of the component. It is still necessary, however, to use the component drawing for precise dimensions and therefore the company's unique numbering of components must be incorporated within the *total code e.g.*,

AB 5919	90005	2110
Drawing number	Primary code	Supplementary code

6.24. FORMATION OF COMPONENT FAMILY

- A pilot study should be initially carried out by examining simple components first, and gradually progressing to the more complex parts. However, the component family analysis should preferably be based on the complete range of components from the products manufactured by the company.
- The drawings and associated production data of the selected components are collected together, classified and sorted into code number order. The investigation should not be limited to the formation of potential component families, but also to assess the necessary diversity in company operation. This will include the preparation of component family paper work and the scheduling and control of the components into the machine group.
- While this investigation is in progress, the remainder of the drawings, new designs and obsolete drawings still liable to be called forward for spares replacement, should be coded.

It is only one-time exercise and the effort is fully justified particularly, for variety control and the computerization of production planning and control.

6.25. ESTABLISHMENT OF COMPONENT FAMILY

The coding provides the first stage in sorting and makes it possible to gather the components into families. If tabulated lists are visually examined, the naturally occurring families can be easily determined. These families are normally of the type 'identical in shape and function' and 'identical in shape but different in function', and appear as blocks of near identical blocks of code numbers of the listings. These will be the most obvious component families to begin to develop and establish machine groups. Finally, recheck the component codes and tabulations and revise where necessary.

6.26. COLLECTION OF PRODUCTION DATA

- Number and sequence of machining operations, setting times and numbers of each component within a defined period of time need to be collected.
- By analysis of the machining operations and sequence, it is possible to derive the types of machines required to form the *machine group.*
- From the *machining and setting times* and the numbers of each component, the potential load on the machine group may be established. Line balancing however cannot be adequately established until the component tooling requirements have been assessed. This is the first stage in *family formation.*
- The drawing of each component within the family is examined and the type and number of tools necessary to produce the component are determined.
- With the tooling analysis complete, the family is estabilshed and group layout balanced *i.e.* data should now include :

  Geometric shape.

  Maximum and minimum sizes.

Material type.

Form and method of holding

Tools—type and holding.

Machine tools—type and capacity.

From this information the profile and parameters of the component family (Fig. 6.13) are constructed against which the acceptance or non-acceptance of new components into the *family* can be used.

- Once a component family has been formed and integrated into a group layout, it does not necessarily have to remain static. Some components will become obsolete while new components will appear. The more flexibility that can be built into the system, the more one can expect to get out of it.

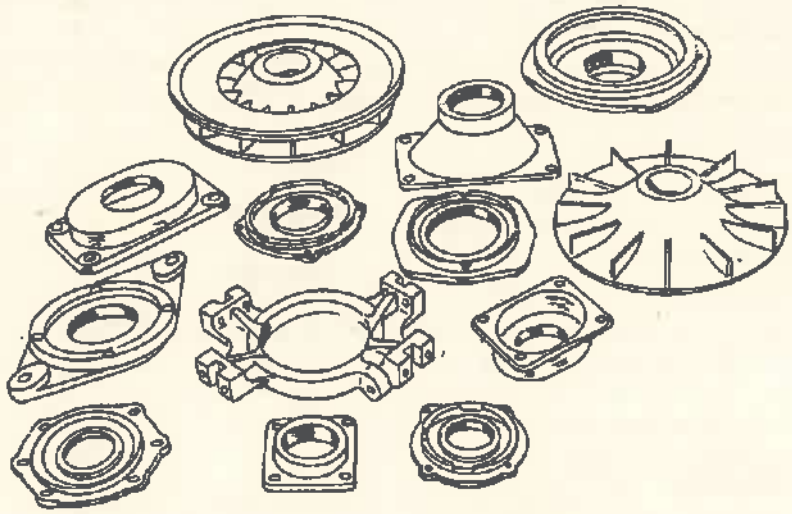


Fig. 6.13. Production Family

N.B. In Fig. 6.13, most components have different *shapes* and *functions*; but all of them require internal boring, face milling, hole drilling and so on. Therefore, it can be concluded that the components are *similar*. The set of similar components can be called a *production family*. From this, process planning work can be facilitated.

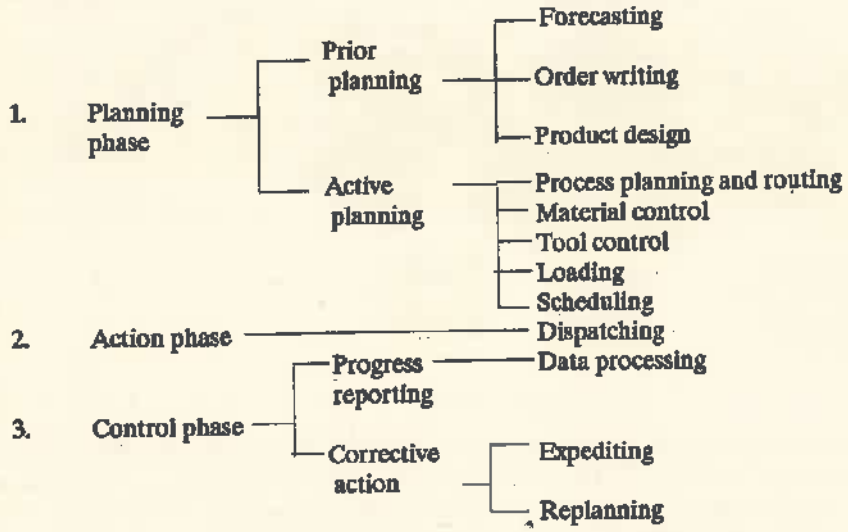
7

Production Planning and Control

7.1. INTRODUCTION

Products are manufactured by the transformation of raw material (into finished goods). This is how *production* is achieved. *Planning* looks ahead, anticipates possible difficulties and decides in advance as to how the production, best, be carried out. The *control* phase makes sure that the programmed production is constantly maintained.

A production planning and control system has many functions to perform, some, before the arrival of raw materials and tools, and others while the raw material undergoes processing. The various *functions* are as follows :



(*a*) *Forecasting.* Estimation of type, quantity and quality of future work.

(*b*) *Order writing.* Giving authority to one or more persons to undertake a particular job.

(*c*) *Product design.* Collection of information regarding specifications, bill of materials, drawings, etc.

(*d*) *Process planning and routing.* Finding the most economical process of doing a work and (then) deciding how and where the work will be done.

(*e*) *Material control.* It involves determining the requirements and control of materials.

(*f*) *Tool control.* It involves determining the requirements and control of tools used.

(*g*) *Loading.* Assignment of work to manpower, machinery, etc.

(*h*) *Scheduling.* It is the time phase of loading and determines when and in what sequence the work will be carried out. It fixes the starting as well as the finishing time for the job.

SHEETAL GAUTAM

(*i*) *Dispatching.* It is the transition from planning to action phase. In this phase the worker is ordered to start the actual work.

(*j*) *Progress reporting :*

(*i*) Data regarding the job progress is collected.

(*ii*) It is interpreted by comparison with the preset level of performance.

(*k*) *Corrective action :*

(*i*) Expediting means taking action if the progress reporting (*j*) indicates a deviation of the plan from the originally set targets.

(*ii*) Replanning—Replanning of the whole affair becomes essential, in case expediting fails to bring the deviated plan to its actual (right) path.

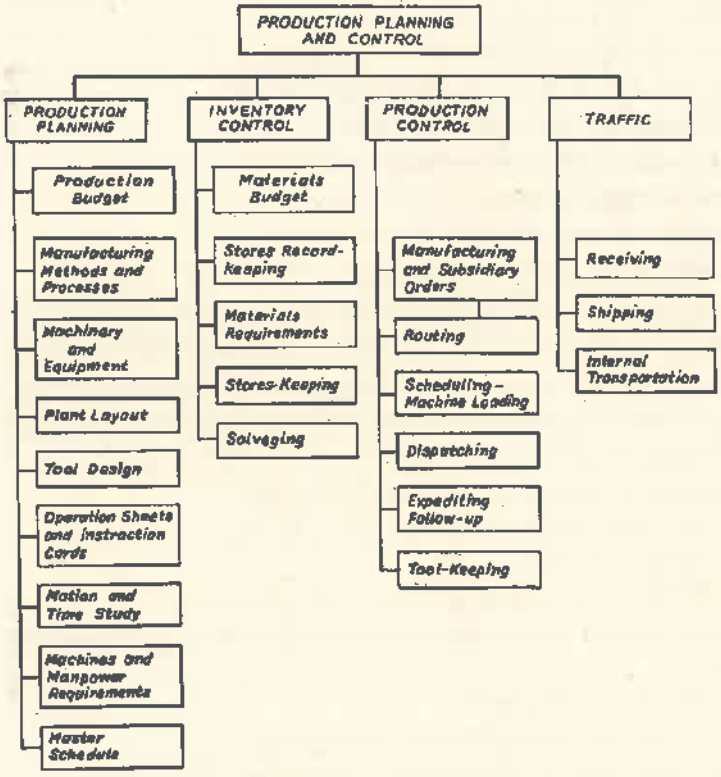


Fig. 7.1. Functional organisation of production planning and control.

7.2. CONTINUOUS AND INTERMITTENT PRODUCTION

Continuous production involves a continuous or almost continuous physical flow of material. It makes use of special purpose machines, and produces standardized items in large quantities. Chemical processing, cigarette manufacturing, and cement manufacturing are some of the industries engaged in continuous production. Continuous production system can be divided into two categories.

(*A*) Mass and flow line production,

(*B*) Continuous or process production.

An intermittent production system is typified by the intermittent or interrupted flow of material through the plant. It makes use of general purpose machines and produces components different in nature and in small quantities. Machine shops, repair and maintenance shops, welding shops, etc., are some of

the examples of intermittent production. Intermittent production can be classified as,

(*C*) Batch production, and

(*D*) Job production.

(*a*) **Characteristics of Mass and Flow Production**

Mass production means the production of items on large scale, employing very specialized machines and processes. Items like metal screws and plastic products are made in mass production and their cycle of manufacture involves one or more operations on the raw material on one machine. Items like air-conditioners, T.V. sets and motor cycles come under flow production and are manufactured in continuous stages from process to process. In this type of production there is a continuous and steady flow of materials.

Various characteristics of mass and flow production are .

(1) There is scope for considerable division of labour.

(2) Machinery is laid as per the sequence of production.

(3) Material handling is reduced to minimum.

(4) Very little time is spent on the resetting of machines.

(5) The flow of work is balanced.

(6) Work cycles are short and of repetitive nature.

(7) Time study can be applied, to advantage, to different operations.

(8) Work-in-progress is small as compared to intermittent production.

(9) Procedures (methods), tools and material handling need proper attention.

(10) Plant layout and facilities are designed to suit production requirements.

(11) Flow production is preferred where there is a continuous and regular product demand.

(12) It offers lowest production cost per unit.

(*b*) **Characteristics of Continuous or Process Production**

Continuous or process production is useful where the product consumes fast (electricity, petrol, chemicals, etc.), and has continuous demand.

Various characteristics of continuous or process production are :

(1) All products undergo the same process. Raw material enters at one point and leaves as finished product at another.

(2) Material handling is automatic.

(3) Plant layout is as per the requirements of production.

(4) Both types of workers, *i.e.*, semi-skilled and skilled are employed.

(5) Outputs and inputs are, respectively, measured and regulated, using sophisticated controls.

(6) Machinery employed is one built to the needs.

(7) Good plant maintenance and effective quality control are the essential requirements.

(*c*) **Characteristics of Batch Production**

(1) It is a very common type of production.

(2) Articles are manufactured in batches as per the specific order procured.

(3) Drugs, clothes, paints, parts manufactured on turret lathes, forging machines and sheet metal presses are a few examples of batch production.

(4) Division of labour is possible.

(5) Flow of material is intermittent.

(6) Plant layout is of the process type.

(7) Automation of processes and mechanisation of material handling may be resorted to.

(8) Proper maintenance of equipment and machinery is essential.

(9) Process and product planning is done for each batch.

(10) Expediting and corrective action are very necessary.

(11) A good production control system must be developed.

(*d*) **Characteristics of Job Order Production**

(1) Flow of material and parts from one location to another is intermittent or discontinuous.

(2) Mechanisation and division of labour is not economical.

(3) Each job order is different from the previous as regards its type, specifications, quality and quantity.

(4) Product design takes a lot of time.

(5) Prior planning becomes difficult.

(6) Schedule is prepared for each component of the product, giving the starting and finishing time.

(7) General purpose machinery and a flexible layout are preferred.

(8) Skilled workers and factory made special attachments or accessories do the needful.

(9) High degree of control is essential.

(10) Products like a special purpose equipment, an uncommon material handling device, a special heat treatment furnace, a large turbogenerator, a special electronic equipment, etc., are job order production items.

(11) The number of items to be manufactured is very small, it may be even one item.

7.3. JOB SHOP, OPEN JOB SHOP, CLOSED JOB SHOP

A **job shop** involves intermittent production [already explained under section 7.2 (*d*)]. Figure 7.2 shows a job shop configuration. *A job shop* consists of a number of machine centres, each with a fundamentally different activity.

A few characteristics of job shop are :

(*a*) A job shop can produce a variety of jobs in small batches.

(*b*) It utilizes general purpose equipment which can be outfitted with special tools, fixtures and dies to do a number of different operations; and thus different jobs can be made with the same basic machinery.

(*c*) In a job shop, the material in-process follows different processing patterns in *batches* through the shop facilities.

(*d*) Unlike flow shop, in a job shop, the work does not flow in serial fashion, *i.e.*, it is not a serially utilized facility. In flow shop, work would have moved from operation 1, 2, 3, 4, 5, *FP*, with no *IPG*. On the other hand in job shop, the job moves through different routes depending upon the work to be done.

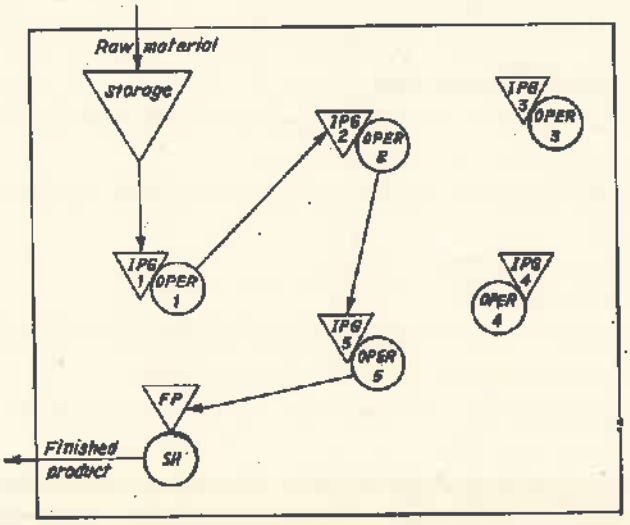
(*e*) A job shop makes to order. Normally *job shops* are *not open* to orders from just any source. They, on the other hand, operate within a field. Examples are, sheet metal fabricating plants, aerospace industry, automobile service centres, etc.

(*f*) A job shop requires highly skilled workers.

(*g*) Job shops normally employ overtimes.

Closed Job Shop. A closed job shop is one which is closed to job orders from outside the organization. The machine shop of a big concern making automobile parts is an example of a closed job shop. It produces inventoriable items of standard design, which have demand in the market. The same items are produced repetitively in cycles.

Open Job Shop. It produces to order and a similar order may never be repeated. An open job shop makes products as per the requirements of the customers. There may be even one (time large) product/ project. The difference between open job shop and a large project is of the scale and complexity of the product.



IPG : In process goods
OPER 1 : Operation 1
FP : Finished product
SH : Shipping

Fig. 7.2. A job shop configuration.

7.4 ONE-TIME LARGE PROJECTS

One-time large projects have the following characteristics :

(*a*) In one-time large projects, normally one large product is manufactured at a time.

(*b*) One-time large project differs from job shop in the sense that there is a vast difference between the two as regards the size and scope of the products to be manufactured.

(*c*) In job shop, the job moves from one facility to another, whereas in one-time large projects, the product being very bulky, the materials and other major components remain at a fixed place whereas workers, tools, portable equipments and other attachments are brought to that place.

(*d*) A job shop has a process layout whereas one-time large projects prefer static product layout.

(*e*) In large projects, normally all the activities are planned at one time, using network analysis techniques (refer Chapter 10).

(*f*) Updating the network is the most important factor which controls the project performance.

(*g*) One-time large projects are controlled from the progress reports on different activities, The schedules of activities are periodically recomputed.

(*h*) Examples of one-time large projects are, fabrication of ships, space vehicles, erection of bridges, repair of big aircrafts, etc.

7.5. FORECASTING

7.5.1. Definition and Concept

1. Forecasting means estimation of type, quantity and quality of future work *e.g.* sales etc.

2. The survival of a manufacturing enterprise depends on its ability to assess, with reasonable accuracy, the market trends several years ahead.

3. Forecasters will be able to make use of sales trends, but these must be considered in the light of expected introduction of new materials, fashion changes, policies of competitors, unseasonable weather, threat of war and the general economic situation expected in the country and foreign markets. These circumstances and others necessitate changes in sales forecast from time to time during the forecast period.

4. Forecast represents a commitment on the part of the sales department and each of its divisions of expected sales. It becomes a goal against which the effectiveness of the sales department will be measured.

5. Forecasting plays a crucial role in the development of plans for the future.

6. Sales budget (estimate) forms the basis for manufacturing budget. It is the sales forecast which enables to determine production quantities, labour, equipment and raw material requirement. (Refer to Chapter No. 28).

7. A sales forecast should be

– Accurate,

– Simple and easy to understand, and

– Economical.

7.5.2. Purpose (or Need) of Sales Forecasting

Sales forecasting is essential because,

(*i*) It determines the volume of production and the production rate.

(*ii*) It forms basis for production budget [step (6) above], labour budget, material budget, etc.

(*iii*) It suggests the need for plant expansion.

(*iv*) It emphasizes the need for product research development.

(*v*) It suggests the need for changes in production methods.

(*vi*) It helps establishing pricing policies.

(*vii*) It helps deciding the extent of advertising, product distribution, etc.

7.5.3. Sales forecasting, Basic elements of

– Forecasting means predicting future events by the best possible means.

– In any sales forecasting analysis, there are four basic elements of economic data that should be used:

1. Trends
2. Cycles
3. Seasonal variations
4. Irregular variations.

– *Trends* are the *long term*, long range movements of a series of economic data. They have little relationship to the month-to-month changes that take place, and they manifest their direction slowly.

- *Cycles* are of *shorter* duration and they are usually featured by alternate periods of expansion and contraction.
- *Seasonal variations* occur within a certain period of year and recur at about the same time and to approximately the same extent from year to year.
- *Irregular variations* are the result of unforeseen or non-recurring events that have an economic influence. A strike in a key industry might cause an irregular variation.

7.5.4. Sales Forecasting Techniques

Forecasting is the formal process of predicting future events that will significantly affect the functioning of the enterprise.

- Sales forecasting techniques may be categorized as follows :
  - (*a*) Historic estimate,
  - (*b*) Sales force estimate,
  - (*c*) Trend line (or Time series analysis) technique,
  - (*d*) Market survey,
  - (*e*) Delphi method,
  - (*f*) Judgemental techniques,
  - (*g*) Prior knowledge,
  - (*h*) Forecasting by past average,
  - (*i*) Forecasting from last period's sales,
  - (*j*) Forecasting by Moving average,
  - (*k*) Forecasting by Weighted Moving average,
  - (*l*) Forecasting by Exponential Smoothing,
  - (*m*) Correlation Analysis,
  - (*n*) Linear Regression Analysis.

(*a*) Historic estimate

- This technique makes use of the assumption that *what happened in past will happen in future*. For example if a concern has sold 5000 blankets in winter last year, it will be able to sell the same quantity in winter this year also.
- Historic estimate is useful if the activity is affected by pattern of seasonality.
- It is useful for determining model, size and colour distribution.
- It is successful only when pattern of events remains unchanged, *i.e.,* if economy is static. This is rarely true except for short periods of time.
- Historic estimate is not scientifically valid and thus it is not an accurate method ; the total sales forecast provided by this method should be modified by other techniques.

(*b*) Sales force estimate

- This technique is based upon the principle—that the persons in contact with the market know best about the future market trends.
- Individual salesmen make sales estimates of their territories and submit it with the District Sales Manager who analyses it, modifies it and sends the same to Factory Sales Manager. Factory Sales

Manager in consultation with other related factory executives formulates the final estimate of sales.

- This technique is useful when an industry is making a limited number of products (*e.g.*, commercial power generating equipment) and there are a few large customers.

(c) Trend line technique

- Trend line technique is employed when there is an appreciable amount of historical data.
- This technique is more reliable than the historic estimate (*a*) above.
- This technique involves plotting historical data, *i.e.*, a diagram (Fig. 7.3) between activity indicator, *e.g.*, tons of material (say past sales) on *Y*-axis and time on *X*-axis.
- A single best fitting line (using statistical technique) is drawn and projected to show sales estimate for future.
- This technique is more accurate as it makes use of a large past data and possesses scientific validity.

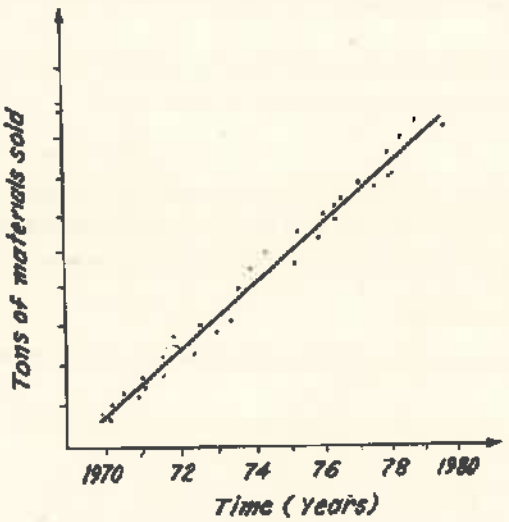


Fig. 7.3. Trend line technique.

- However, it is time-consuming, involves long mathematical calculations and assumes an infinite population of relatively small customers so that the decision of an individual customer cannot have an appreciable effect on total product demand.

(d) Market Survey, *i.e.* Market Research Technique

- This technique finds application when a concern introduces a new product in the market and is interested to estimate its sales forecast. For a new product, naturally, no historic or past data regarding sales will be available.
- This technique may be very informal, utilizing the sales force to *feel out* the potential customers in order to establish the extent of the market or it may be a systematically conducted survey using special mathematical tools.

- Generally, the new product is introduced in a relatively small critical trial area, market reaction is noted and the total sales (country-wide) is projected from these results.

(e) Delphi Method

- A panel of experts is interrogated by a sequence of questionnaires in which the response to one questionnaire is used to produce the next questionnaire. Anyset of information available to some experts and not others is thus passed on to the others, enabling all the experts to have access to all the information for forecasting. The method solicits and collates opinion from experts to arrive at a reliable consensus. This technique eliminates the bandwagon effect of majority opinion.
- Delphi method has fair to very good accuracy for short and long term forecasts.
- The method is applicable to forecasts of long-range and new-product sales.

(f) Judgmental techniques. They involve,

1. *Opinions of consumers and customers.* Questionnaires related to buying the product may be sent to a selected group of consumers and to the customers who have already purchased the product. The information thus received can be very useful in estimating product performance and its probable demand in future.

2. Retail and wholesale dealers can provide some insight into the pace of current and future sales.

3. The opinion of area sales managers can also be quite useful.

(g) Prior knowledge

- This is used by ancillary units which are more or less a part of the large organisation. The large organisation informs each ancillary unit how many component parts to make.
- The forecast estimate is needed only to establish the material and tool requirements, etc.

(h) Forecasting by Past Average

If our objective is the forecast or predict the sales of an item for the next sales period, then using this method,

Forecasted sales for next period = Average sales for previous period

Example

Period No.	*Sales*
1	7
2	5
3	9
4	8
5	5
6	8

$$\text{Forecasted sales for period no. } 7 = \frac{7+5+9+8+5+8}{6} = 7$$

(i) Forecasting from last period's sales

The method eliminates the influence of past (old) data and bases the forecast only upon the sales of the previous period. Using this technique, the forecasts would look as in table given on page 7-10.

Period No.	*Actual Sales*	*Forecast Sales*	*Errors in Forecast*
1	5		
2	4	5	+1
3	8	4	−4
4	7	8	+1
5	4	7	+3
		4	

(j) Forecasting by Moving Average

- This method represents a compromise between the two above explained methods, in that the forecast is neither influenced by very old data nor does it solely reflect the figure of the previous period.
- Consider the historical sales figures shown in table below, which are to be used to construct a sales forecast for the next year. We must use a four-period moving average in this case.

Year	*Period*	*Sales*	*Four-period moving average forecast*
1987	1	50	
	2	60	
	3	50	
	4	40	
1988	1	50	50
	2	55	50
	3	40	48.75
	4	30	46.25
1989	1	35	43.75
	2	45	40
	3	35	37.5
	4	25	36.25
1990	1	35	35
	2	45	35
	3	35	35
	4	30	36.25

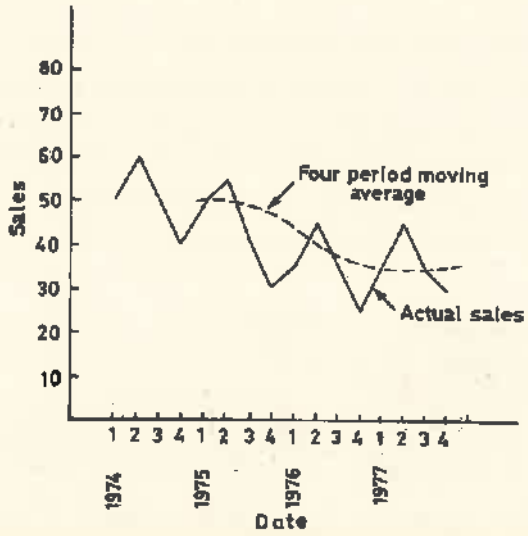


Fig. 7.4. Comparison of moving average forecast sales with actual sales.

– Fig. 7.4 shows that the effect of the moving average is to smooth the sales pattern and it is therefore of more value in establishing trends.

– The use of simple moving average is an adequate method of forecasting, provided sales are subject to neither *seasonal variation* nor marked *secular trends*. A secular trend is one which causes sales steadily to increase or decrease.

(k) Weighted Moving Average Method for Forecasting

– Whereas the simple moving average gave equal effects to each component of the moving average data base, a weighted moving average allows any weights to be placed on each element, providing, of course, that the sum of all weights equals one.

– As an example, suppose that in a four-month period the best forecast is derived by using 40% of the actual sales for the most recent month, 30% of two month ago, 20% of three months ago, and 10% of four months ago. If actual sales experience was as follows,

Month-1	Month-2	Month-3	Month-4	Month-5
100	90	105	95	?

the forecast for month-5 would be

$F_5 = 0.40\ (95) + 0.30\ (105) + 0.20\ (90) + 0.10\ (100) = 97.5$

Suppose sales for month 5 actually turned out to be 110, then the forecast for month-6 would be :

$F_6 = 0.40\ (110) + 0.30\ (95) + 0.20\ (105) + 0.10\ (90) = 102.5$

– The weighted moving average method has a definite *advantage* in being able to vary the effects of past data, but it also has the *disadvantage* of *remembering* the total history for the time period.

(l) Forecasting by Exponential Smoothing

– The main *disadvantages* of the moving average method are :

1. The lengthy calculations involved.
2. The need to keep quantities of historical data.
3. The fact that the normal (or simple) moving average method places *equal weight* on each of the historical figures used.
4. The age of the data, which increase with the number of periods used.

– All of these disadvantages are overcome by the exponential smoothing technique.

Using this technique it is necessary only to retain the previous forecast figure and to know the latest actual sales figure. The technique works by modifying the old forecast in the light of new sales figure, *i.e.*

New forecast = α (latest sales figure) + $(1-\alpha)$ (old forecast)

where α is known as the *smoothing constant.*

– *For example, let*

Forecast sales for last period	= 24
Actual sales for last period	= 22
Forecast sales for next period	$= \alpha(22) + (1-\alpha)24$
Assuming α	= 0.1
∴ Forecast sales for next period	= 0.1(22) + (0.9)24 = 23.8

- The use of this technique permits the forecast to respond to recent actual events, but at the same time retain a certain amount of stability. The amount by which the new forecast responds to the latest sales figure, or the extent to which it is *damped* by the previous forecast, is, of course, determined by the size of the smoothing constant α. The size of α should be carefully chosen in the light of the stability or variability of actual sales, and is normally from 0.1 to 0.3.

The smoothing constant, α, that gives the equivalent of an N-period moving average can be calculated as follows :

$$\alpha = \frac{2}{N+1}$$

For example, if we wish to adopt an exponential smoothing technique equivalent to a nine-period moving average, can be found as follows :

$$\alpha = \frac{2}{9+1} = 0.2$$

- When a *secular trend* is present, the forecast sales obtained by the normal exponential smoothing method will lag behind actual sales, in just the same way as the moving average forecast.

Econometric Forecasting

- In econometric forecasting the analyst tries to uncover the cause-and-effect relationship between sales and some other phenomena that are related to sales. For example, an appliance manufacturer might discover that the sales of television sets respond to the disposable income of customers with a 1-month lag. That is, 1 month after a change in disposable income, there a proportionate change in the sales of T.V. sets.

This process is called *econometric forecasting.* Here, the analyst tries to identify those factors that best explain the level of sales for a product.

- Econometric forecasting utilizes *correlation* and *Regression techniques.* The objective is to establish a cause-and-effect relationship between changes in the sales level of the product and a set of relevant explanatory variables.

(*m*) Correlation Analysis

- Correlation Analysis is frequently used if a relationship can be found between sales and other economic and non-economic phenomena, such as the national income, defense expenditures, population growth, and the weather.

Such forecasts are generally concerned with the sales volume for the entire industry. The forecaster arrives at his company forecast by estimating the company's share of total industry demand.

- One difficulty with correlation analysis is that a past relationship may not continue into the future.
- Correlation techniques are most reliable when a casual relationship can be established between the variables and sales.
- Correlation techniques have been used to develop *demand functions* for a number of products, such as furniture, refrigerators and automobiles.
- It makes use of cause-and-effect relationship between sales and some other phenomena that are related to sales.

- This technique is employed when an organisation finds that the sale of its product has a remarkable relationship with the sales of a leading product of another organisation, *e.g.*, sales of clutch plates is correlated with the sales of trucks produced, (Fig. 7.5).
- In correlation technique, total sales for an industry (*e.g.*, truck manufacturing concern) is found and then based upon the market conditions, the volume of sale for one's own product (*e.g.*, clutch plates) is predicted.

  Such past data when plotted on the graph paper (refer Fig. 7.5) with line of best fit drawn, can predict sales estimate for future.

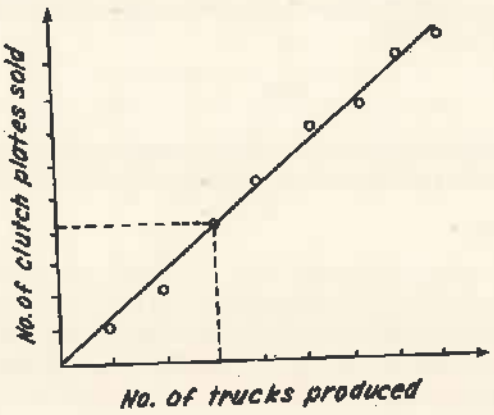


Fig. 7.5. Correlation data.

Sources of correlation data

(*i*) Economic data :

– Survey of current business.

– Monthly labour review.

– Business magazines.

(*ii*) Industry data :

– Trade journals.

– Annual survey of manufacturers.

– Industrial trade associations.

- A *Correlation Coefficient* is a measure of the extent to which two variables (*e.g.* number of trucks sold and clutch plates sold) are associated. In other words, a correlation coefficient is an indication of the extent to which the knowledge of the value of one variable is useful for the prediction of the value of the other. This is the basis of a method of forecasting variously known as *associative predictions* or *economic indicators*.
- Perhaps the most useful coefficient is the *Pearson Product Moment Correlation Coefficient*, which is calculated as follows :

  Coefficient, r, for two variables x and y

$$= \frac{\Sigma(x-\bar{x})\,(y-\bar{y})}{\sqrt{\Sigma(x-\bar{x})^2.\Sigma(y-\bar{y})^2}}$$

where $\bar{x}$ is the mean value of all the individual x values, and

$\bar{y}$ is the mean value of all the individual y values.

The formula measures linear correlation, *i.e.*

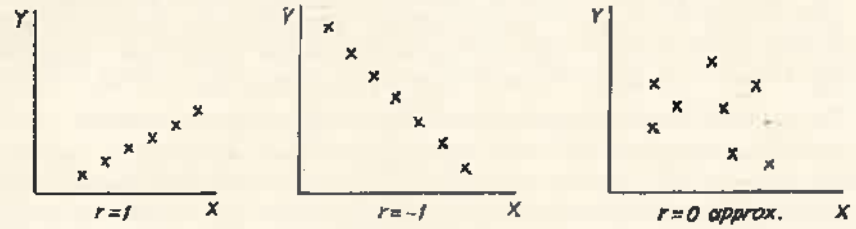


Fig. 7.6. Correlation

Example 7.1

A comparison of monthly sales of an expensive item, against the total number of visits made by salesman during the previous month, yields the following data. Is the correlation of the two variables good enough to enable the number of sales visits, to be adopted as an efficient indicator of future sales ?

Sales(x)	1	3	5	7	11
Visits made(y)	2	4	8	9	10

Solution

x	$(x-\bar{x})$	$(x-\bar{x})^2$	y	$(y-\bar{y})$	$(y-\bar{y})^2$	$(x-\bar{x})(y-\bar{y})$
1	−4.4	19.5	2	−4.6	19.5	20.0
3	−2.4	5.8	4	−2.6	6.9	6.25
5	−0.4	1.6	8	+1.4	1.95	0.56
7	+1.6	2.6	9	+2.4	5.8	3.85
11	+5.6	31.5	10	+3.4	11.5	19.6
$\Sigma x = 27$		61.0	$\Sigma y = 33$		45.45	50.26

$$\bar{x} = \frac{27}{5} = 5.4 \qquad \bar{y} = \frac{27}{5} = 6.6$$

$$r = \frac{\Sigma(x-\bar{x})(y-\bar{y})}{\Sigma(x-\bar{x})^2\ \Sigma(y-\bar{y})^2} = \frac{50.26}{61.0 \times 45.5} = 0.96$$

The correlation between the number of salesman's visits and the number of sales is 0.96, which is sufficient to justify its possible use as a method of short-term sales forecasting.

(n) Linear Regression Analysis

- Although computationally more difficult, this method is a very useful forecasting technique if past data appear to fall about a straight line. However, an estimate of how good the line *fits* the data is computed as part of the procedure.
- Forecasts of demand is related to economic and competitive factors which control or *cause* demand, through least squares regression equation.

- The method is *useful* for short and medium range forecasting of existing products and services.
- Forecasting based on regression methods establishes a forecasting function called a regression equation.
- The regression equation expresses the series to be forecast, such as rupees sales or quantities sold, in terms of *other series* that presumably control the sales or cause them to increase or decrease. An example of other series may be *disposable personal income.* If disposable income is up, sales will increase, and if people generally have less money to spend, sales will go down.

  The empirical relationship is established through the regression equation.
- It has been seen earlier that a linear relationship between two variables x and y is indicated by a high value of the *correlation coefficient.* However, this coefficient does not indicate the true relationship, hence we are unable to estimate either a value of x for a given value of y or *vice versa.* To do this, a *regression* equation must be calculated (Fig. 7.7).

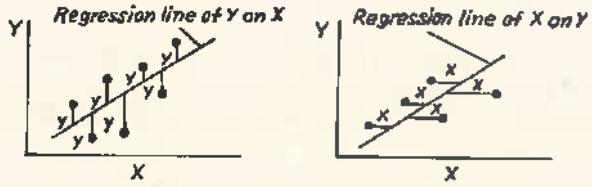


Fig. 7.7. Regression Analysis.

- The regression line for Y on X is the best line for calculating values of Y, and is obtained by minimizing the sum of the squares of the errors of estimation, *i.e.* the y values in Fig. 7.7(a)
- The regression line for X on Y is the best line for calculating values of X, and is obtained by minimizing the sum of the squares of the errors of estimation, *i.e.* the x values in Fig. 7.7(b)

The general equation for the regression line of Y and X is given by :

$$Y = a + bX \qquad \text{....}(i)$$

where a and b are two constant. The values of these two constants are obtained by the following formula :

$$b = \frac{n\Sigma xy - (\Sigma x)(\Sigma y)}{n(\Sigma x^2) - (\Sigma x)^2} \qquad \text{....}(ii)$$

$$a = \frac{\Sigma y + b\Sigma x}{n} \qquad \text{....}(iii)$$

Similarly the general equation for the linear regression of X on Y is :

$$x = a + by \qquad \text{....}(iv)$$

$$b = \frac{n\Sigma xy - (\Sigma x)(\Sigma y)}{n(\Sigma y^2) - (\Sigma y)^2} \qquad \text{....}(v)$$

$$a = \frac{\Sigma x + b\Sigma y}{n} \qquad \text{....}(vi)$$

n = *number of observations*

Example 7.2

Given the data in table below, find the regression line for predicting *growth* and calculate the *growth* for a weight value of 50.

Let growth be variable Y

Let weight be variable X

$\therefore\ Y = a + bX$

Weight (x)	*Growth* (y)	x^2	xy
12	5.5	144	66
18	5.9	324	106.2
24	6.5	576	156
30	7.4	900	222
36	8.2	1296	295.2
42	8.9	1764	373.8
48	8.6	2304	412.8
$\Sigma x=210$	$\Sigma y=51$	$\Sigma x^2=7308$	$\Sigma xy=1632, n=7$

From equations (*ii*) and (*iii*) above

$$b = \frac{7(1632)-(210)\,(51)}{7(7308)-(210)^2} = \frac{714}{7056} = 0.10119$$

$$a = \frac{(51)+0.10119(210)}{7} = 10.32$$

Now, $Y = a+bX$; where $X = 50$.

$\therefore\ Y = 10.32 + (0.10119 \times 50) = 15.379$

The regression line provides only an estimate of the value of Y on X. The uncertainty or accuracy of the estimate can be assessed by calculating the *standard error* of the estimate of Y on X, ($S_{Y.X}$)

$$S_{Y.X} = \sqrt{\frac{\Sigma(y-y_1)^2}{n-2}} \qquad \text{....(vii)}$$

where y = actual value

y_1 = value calculated from regression equation.

The standard error of the estimate of X on Y is given similarly by :

$$S_{X.Y} = \sqrt{\frac{\Sigma(x-x_1)^2}{n-2}} \qquad \text{....(viii)}$$

$S_{Y.X}$ or $S_{Y.X}$ provides a measure of the *closeness of* the relationship between the two variables. The smaller the figure, the closer are the values to the regression line and hence the more accurate is the regression equation for predictive purposes.

7.6 TECHNOLOGICAL FORECASTING

- Since the pace of technological change is so great, and since new products and processes may be keys to a company's future plans, an increasing number of companies are emphasizing regular and complete technological forecasts affecting their industry.
- Technical forecasting may be *defined* as—forecasting the future technology that may affect the operations of an enterprise.
- Those companies which have gone far in developing planning premises from their technological forecasts have tended to be high-technology enterprises. What has been done in these instances

is to encourage members of their technical staffs to be alert to future developments ; to arrange frequent contacts of suppliers customers with development staffs ; to think in terms of the impact of current scientific developments on the future state of technology ; and to develop orderly forecasts of how these developments affect the company's products, processes or markets.

- One of the attempts to make technological forecasting more accurate and meaningful is the use of *Delphi technique.*
- Another method used to forecast the state of technology is *opportunity-oriented.* It looks at the future and raises the question of whether a certain product may be made obsolete by a new development - and, if so, what development—or whether there is any technological breakthrough that might be expected which would solve a problem seen to exist in the development of a certain product. For example, the opportunity-oriented forecast might look at the possible development of an atomic power plant for an automobile and ask whether certain known limitation will probably be solved and when. Or one might forecast when economic desalination of sea-water will occur.
- Another approach has been referred to as the *goal-oriented* forecast. In this case, a decision is made to reach a certain goal, the technological needs for accomplishing it are identified, and analysis is made as to when, and perhaps how, these might be accomplished. Thus, after a decision was made to put a man on the Moon by 1970, the technological requirements of so doing were identified, and time and resource estimates were made as to how to achieve the target.

7.7 PLANNING TO MEET SEASONAL SALES OR DEMANDS

Many products are affected by the pattern of seasonality. Quite some times, this seasonal pattern is fairly predictable unless otherwise influenced by other conditions. Take the example of refrigerators, they are sold during summer. Their sale starts from February and goes up to the months of August or September. Conditions influencing the sales pattern (every year) are, rise in prices, number of competitors, when exactly the summer starts - is it delayed or starts earlier and how severe it is etc. An arbitrary sales record of refrigerators is given in Fig. 7.8. The figure shows that the number of refrigerators sold in the month of June 1976 were less than the number sold in 1975. Moreover, there is a wide fluctuation in the sales from month to month.

For making the forecast of seasonal sales, the past historic data is analysed to explore a pattern of sales fluctuation which may serve as a good guide for future. Figure 7.8 has been plotted using the past data given in the Table 7.1.

TABLE 7.1

Month	*Number of pieces sold*	
	1975	*1976*
January	50	35
February	75	60
March	110	100
April	200	175
May	300	250
June	450	400
July	350	300
August	250	200
September	175	150
October	100	80
November	50	40
December	25	20
Total	2135	1810

The month to month variation in demand presents a big problem before the management. An error in forecasting can bring a loss to the factory. If the products forecast and made are less than the actual demand, the concern loses the profit because of the lost sale ; and if products forecast and manufactured are more than the actual demand, again it is a loss, because a big capital gets tied up and expenses on up-keep and care of the finished goods are additional.

The individual monthly figures of the Table 7.1 (1975-76) (or Fig. 7.8) show a wide variation in the number of pieces sold and as such no useful idea of the sale forecast for the various periods of 1977 can be formulated. The seasonal sales record (Fig. 7.8) becomes better evident when the concept of *moving averages* is applied to it and the curve (*a*) is replotted as (*b*) in the same figure.

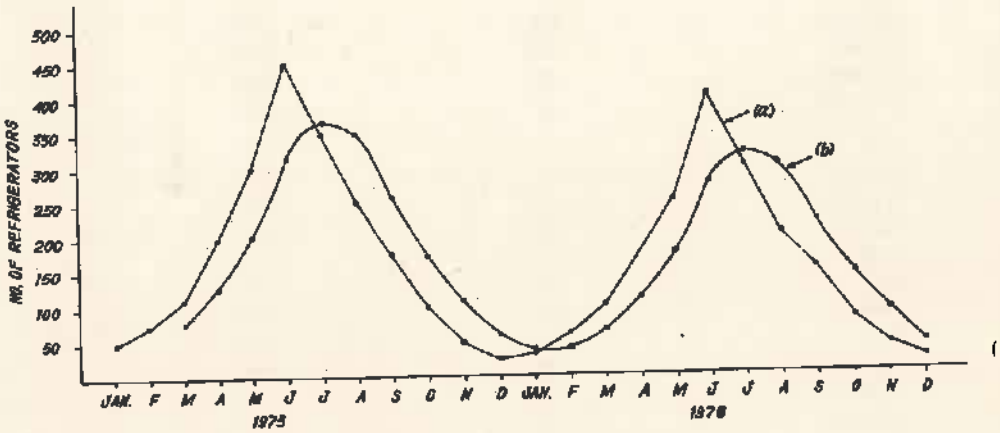


Fig. 7.8. Seasonal sales record.

Curve plotted with moving averages[1] indicates reduced sales fluctuations ; the curve is smoothened and shows seasonal regularity. In other words, when an average demand is estimated by some moving averages (three months, five months or a year) the effects of sales fluctuations are smoothened. An important decision which the management has to take, in time, is that of adjusting itself with the fluctuations in sales and one method of adjusting response to changes is by the use of averaged figures. The period (3 months, 5 months, etc.) of moving averages and the weighting given to each month control the speed of response of management (explained later). The period, *i.e.*, number of months in moving average can be any suitable number, the more the number of months in the moving average, the smoother is the curve. Normally a three months moving average proves much more stable—every month receives one-third weightage. Since the sale of May 1975 can give a better picture about the sale of June 1975 as compared to that predicted by March 1975, sometimes (instead, giving equal weighting to all the months of a moving average) more weighting is given to immediately previous month. The three months moving average for equal weighting of all months is calculated as follows :

The average sale for the month of March is equal to sum of the sales during January, February and March divided by three, For example, 3 months moving averages for March $= \frac{50+75+110}{3} = 78.3$ (Refer Table 7.2). In this manner, Table 7.1 is adjusted as Table 7.2 :

1. Moving average may be defined as the averages updated as new data.

TABLE 7.2

Month	*Actual Sales (from Table 7.1)*	*3 Months Moving Average*
1975		
January	50	
February	75	
March	110	78.3, (50+75+110/3)
April	200	128.3, (75+110+200/3)
May	300	203.3, (110+200+300/3) and so on
June	450	316.6
July	350	366.6
August	250	350.0
September	175	258.3
October	100	175.0
November	50	108.3
December	25	58.3
1976		
January	35	36.3
February	60	40.0
March	100	65.0
April	175	111.6
May	250	175.0
June	400	275.0
July	300	316.6
August	200	300.0
September	150	216.0
October	80	143.3
November	40	90.0
December	20	46.6

Curve (*a*)	Curve (*b*) of Fig. 7.8
Difference between Maximum and Minimum values	
1975...450 (June)−25(Dec)	366.6(July)−58.3(Dec.)
= 425.0	= 308.3
1976...400(June)−20(Dec.)	316.6(July)−36.3(Jan.)
= 380.0	= 280.3

The difference between maximum and minimum values clearly shows a reduction in sales fluctuation with three months moving average. A five months moving average will still smoothen the (actual) sales curve.

Through the method of moving averages smoothens the peaks and valleys of the seasonal sale, it involves lot of work, of additions and divisions (*i.e.*, calculations). This system becomes still more complex if unequal weightages are imparted to different months. Since the recent data gives a better picture of forecast as compared to comparatively older data, for this reason, more emphasis (weighting) is to be laid on the recent data. Another system using *Exponentially Weighted Moving Averages* tracks seasonal effects (in addition to average demand and trend effects) but discounts extreme sales fluctuations - considering them as random effects. The exponentially smoothing system is advantageous over the (normal) moving average method because it involves one only constant, is simple and requires less calculations as compared to unequal weighted moving averages. Like other forecasting techniques this method also relies upon past data to calculate future demands. This system involves a single weighting factor 'α' (known as the smoothing constant) which can be easily adjusted to new conditions (risks, etc.).

The new smoothed average forecast

$= \alpha$ (Actual demand) + $(1-\alpha)$ (old average forecast)

Normally the value of lies between 0.01 and 0.30. A small value of has stronger smoothing effect whereas a large value of reacts fast to real fast to real changes in actual sales or demand. This quick reaction is sometimes risky as it may over-response to random fluctuations. Large value of not always produces better forecasts. A suitable value of can be fixed by experienced judgement or by carrying out certain studies. The method of calculating exponentially weighted moving averages is given below :

As an example, the forecast for the month of march = α (Actual demand for the month of February) + $(1-\alpha)$(old forecast of the month of February). (Refer Table 7.3).

It can be seen that exponentially smoothing considers times the actual demand of the previous month and $(1-\alpha)$ times the old average forecast demand of the previous month which in turn was calculated after considering the data of still previous months. In other words, α times importance is attached to the demand of immediately previous month. Therefore, larger the value of , the more the new forecast will be affected by the immediately previous month's demand.

TABLE 7.3

Month	*Actual demand*	*Forecast for the month of*	$\alpha = 0.2$ *(Assume)*	
January	50	February	say old average forecast is 50	
February	60	March	= 0.2(60)+(1-0.2)(50)	= 52
March	70	April	= 0.2(70)+(1-0.2)(55.6)	= 55.6
April	80	may	= 0.2(80)+(1-0.2)(55.6)	= 60.5
May	90	June	= 0.2(90)+(1-0.2)(60.5)	= 66.4
June	100	July	= 0.2(100)+(1-0.2)(66.4)	= 73.1
July	90	August	= 0.2(90)+(1-0.2)(73.1)	= 76.5
August	60	September	= 0.2(60)+(1-0.2)(76.5)	= 73.2

By trying different values of α , a value of the same can be ascertained which in past served very well the interests of the organization and may do so in future if other things do not change to any major extent.

7.7.1 Strategies Used to Absorb Fluctuations in Demand. Even when smoothened, the seasonal sales curves do not become completely rectified ; fluctuation still remain, of course to a smaller extent. Therefore, to plan production to meet seasonal sales, one or the other following measures are taken by the management. In other words, the fluctuations (increase or decrease) in demands can be met by utilizing the following strategies :

(*a*) If, casually the demand increases, the extra work can be given as subcontracts to other firms.

(*b*) Inventory levels may be adjusted to absorb seasonal fluctuations in demand. The inventory can be dropped to a lower level of (of operations) as the season peak passes away and *vice-versa.* However, an inventory level higher or lower than the economic (or deal) quantity level, involves higher costs.

(*c*) During off peak periods, an industry can shift to different (other) jobs as per their demands. This, of course, requires general or multipurpose equipment and all-round workers.

(*d*) Work force can be increased or decreased to meet the product demand. Keeping more than necessary workers means extra cost and changing work force every time, brings a bad name to the firm.

(*e*) Fluctuations in demand can also be met by varying working hours, *i.e.,* by overtime (more working hours or increased number of shifts) or under time (a few idle hours for all the workers or a portion of work force being completely idle).

(*f*) Increasing or decreasing the prices of the products during high and low demand periods does also help to some extent. Lowering of prices during low demand periods may attract more customers and *vice-versa*. The prices may be reduced by decreasing inventory investment especially if the products are manufactured in small batches. Though it involves increased set-up time and costs, it does not matter much because, even otherwise the workers are not having sufficient work.

(*g*) *Backorders*. Backorders mean the orders which were placed by customers sometimes earlier and which could not be furnished till date. Such orders can be taken up at off peak hours (times) to absorb fluctuations in demand.

7.8. TECHNIQUES FOR ABSORBING FLUCTUATIONS IN DEMAND

It has been explained earlier that the seasonal demands or sales are characterized by fluctuations. The various strategies which can be used for absorbing these fluctuations have already been discussed under section 7.7.1 A few techniques or decision processes employed for planning and absorbing fluctuations are as follows :

(*a*) Graphic technique,

(*b*) Linear programming method,

(*c*) Optimum reaction rate method,

(*d*) Linear decision rule,

(*e*) Heuristic method, and

(*f*) Computer search methods.

Graphic technique and Linear programming methods have been discussed below :

7.8.1 Graphic Technique. The graphic technique is simple and shows clearly the fluctuations in production demand. However, it simply compares different alternative plans and by itself does not generate optimum plan. Moreover it is a static technique.

Production requirement or production demand for the individual months, from January to June and cumulative production demand from January to June have been given in the Table 7.4.

TABLE 7.4

Month	*Production Demand (Units)*	*Cumulative production demand (Units)*
January	240	240
February	340	580
March	380	960
April	240	1200
May	240	1400
June	100	1540

Production demands for the individual months and the cumulative production demand have been marked in the Figs. 7.9 and 7.10 respectively, in dotted lines.

Figures 7.9 and 7.10 show two plans (namely 1 and 2) which may be employed to meet the actual production requirements ; and are discussed below :

Plan-1. It is shown by firm line in Figs. 7.9 and 7.10. It indicates smooth (level) production rate to meet the target demand of 1540 units in 6 months. This is the simplest plan ; the work force remains constant and there is no labour turn over, over time or other costs of hiring, training and work force adjustments. But, fluctuations in demand entail high inventory costs of under and over stocks. Table 7.5 shows the data as per this plan.

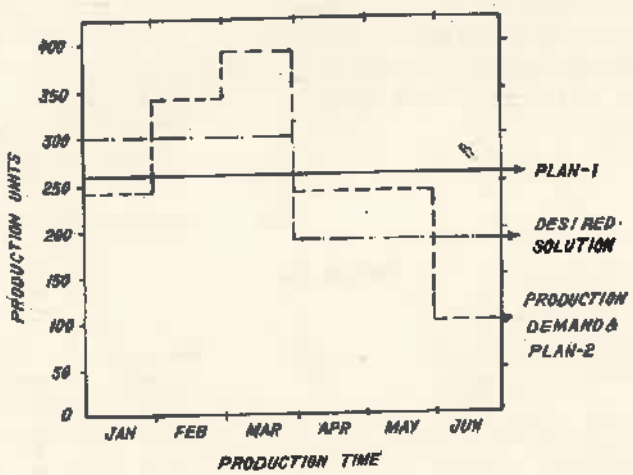


Fig. 7.9. Comparison of (actual) production demand, Plan-1 and Plan-2.

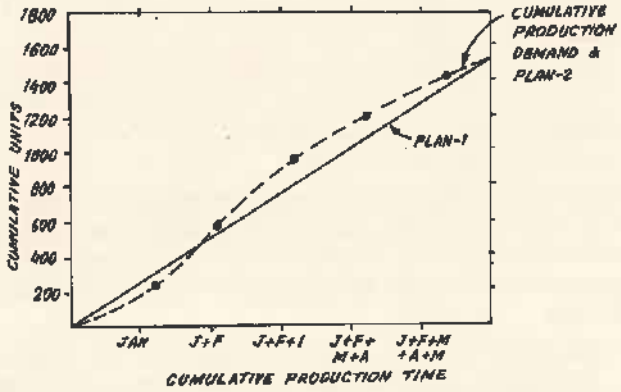


Fig. 7.10. Cumulative production demand, Plan-1 and Plan-2.

TABLE 7.5

Month (N)	*Production Demand (D)*	*Production[1] as per Plan-I*	*Work force required[2] (Nos.)*	*Changes in work force*	*Inventory level*	*Cumulative inventory level*
January	240	260	26	0	+20	+20
February	340	260	26	0	−80	−60
March	380	260	26	0	−120	−180
April	240	260	26	0	+20	−160
May	240	260	26	0	+20	−140
June	100	260	26	0	+160	+20

1. ΣD / ΣN.

2. If each worker produces 10 pieces.

Plan-2. It is shown by dotted line in Figs. 7.9 and 7.10 and it matches exactly the actual production requirements of each month. Such a plan involves high labour turn-over costs and other work force adjustment costs, but the inventory costs move towards zero (*See* Fig. 7.11). Table 7.6 shows data as per this plan.

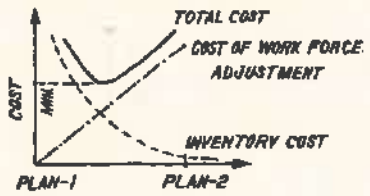


Fig. 7.11. Inventory cost and work force adjustment cost.

TABLE 7.6

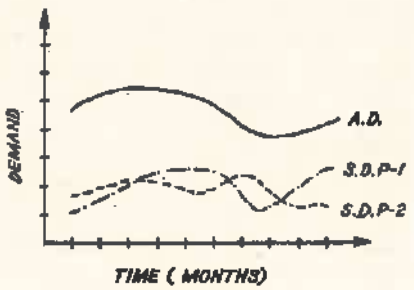
Month	*Production demand*	*Production as per Plan-2*	*Inventory level*	*Cumulative inventory level*	*Work force reqd. (No.)*	*Changes in work force level*
January	240	240	0	0	24	
February	340	340	0	0	34	+10[1]
March	380	380	0	0	38	+ 4
April	240	240	0	0	24	−14[2]
May	240	240	0	0	24	0
June	100	100	0	0	10	−14

1. It indicates that 10 more workers were employed in the month of Feb.

2. 14 workers were asked to leave their jobs in the month of April.

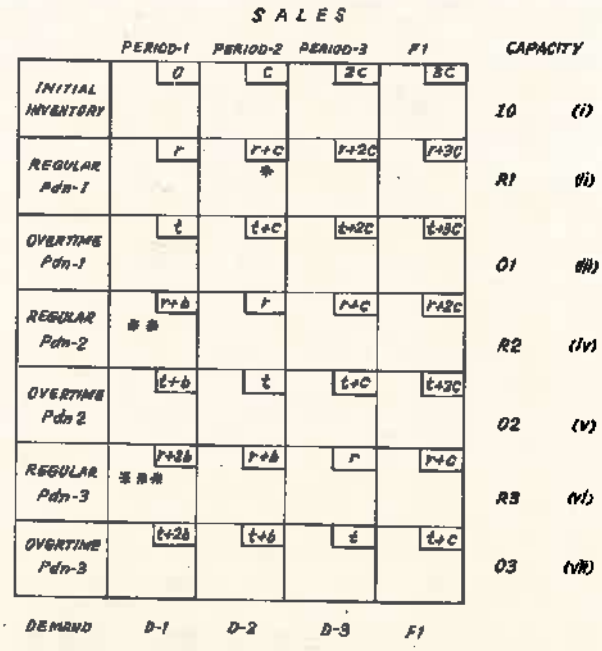
The two plans discussed above represent two extreme solutions. The desired solution will steer a path in between the two in such a way that the total cost becomes minimum (refer Fig. 7.11). The desired solution will represent some combination of, changing work force size, changing production rates, varying degrees of overtimes and subcontracting, and fluctuating inventory levels. The desired solution has been arbitrarily marked in Fig. 7.9.

7.8.2. Linear Programming Method. Both, the simplex and the distribution models can be employed for aggregate planning. In aggregate planning, demands are specified in aggregate quantities like total number of scooters sold in a year, etc. Figure 7.12 gives the concept of aggregate demand.



AD = Aggregate (total) Demand.
SDP-1 = Seasonal Demand of Product-1.
SDP-2 = Seasonal Demand of Product-2.

Fig. 7.12. Concept of aggregate demand.



FI : Final Inventory.

R_1, R_2 & R_3 : Regular time production capacities for periods 1, 2 and 3 respectively.

O_1, O_2 & O_3 : Over-time production capacities for periods 1, 2 and 3 respectively.

c : Inventory carrying charge per unit per period.

r : Regular time production cost per unit of output.

t : Over-time production cost per unit of output.

b : Back order cost per unit per period of back order.

Fig. 7.13. Distribution matrix.

As the first step of the (Linear Programming) technique, aggregate levels are prepared and then a model is built to develop the plan. The model taken into considerations various requirements like under time, over-time, inventory, back orders, subcontracting, etc. In the distribution matrix the sales requirements as well as the capacity limitations, in the form of initial inventory, regular time (production) capacity, over-time (production) capacity and sub-contracting capacity must be met. The combined (regular production, over-time production, subcontracting production and the inventory) cost is to be minimized. Figure 7.13 shows a distribution matrix for three periods of sale. Rows for subcontracting production can be added if required.

* When a unit of demand in period-2 (*D*-2) is manufactured on regular time production of period-1 (Regular *Pdn-1*) the inventory carrying cost (for that unit) is added to the production cost and thus the total cost becomes $(r+c)$ and so on.

** When demand in period-1 (*D*-1) is assigned to regular time production in period-2 (Regular *Pdn*-2), the back order cost b is added and thus the total cost becomes $(r+b)$.

***If the demand in period-1 is assigned to regular time production in period-3 (Regular *Pdn-3*) the total cost will be $r+b+b = (r+2b)$.

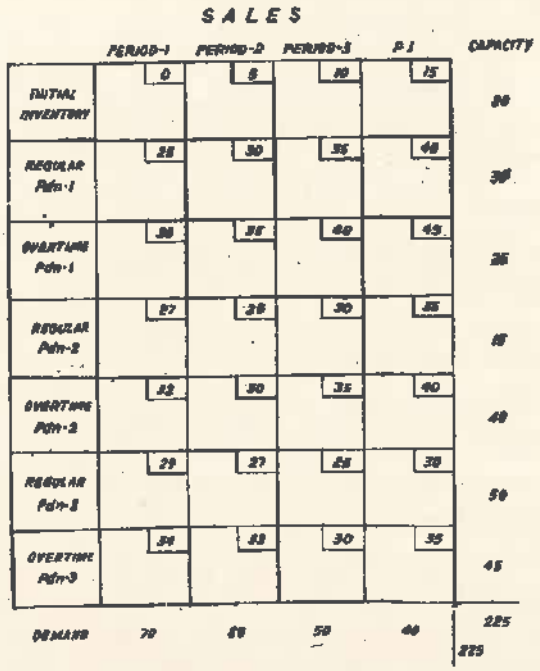


Fig. 7.14. Distribution matrix with capacity, demand and cost values.

In order to find optimum solution consider the distribution matrix of Fig. 7.14 where capacities and demands have been shown alongwith the various cost values. The costs have been calculated by assuming that

c = Rs. 5, r = Rs. 25, t = Rs. 30 and b = Rs. 2.

This distribution matrix can be solved by using the North-West corner method as described in Chapter 11. The solution matrix thus obtained will show the number of units which should be assigned to regular production, and to over-time production in three different periods in order to minimize the total cost.

7.9. PROCESS PLANNING

Definition and Concept

- Process planning means the preparation of work detail plan.
- Since a process is required to manufacture a product, it is necessary to plan the process.
- Process planning is determining the most economical method of performing an operation or activity.
- Process planning comes after it has been decided as what is to be made.
- Process planning develops the broad plan of manufacture for the component or product.
- Process planning takes as its input the drawings or other specifications which show what is to be made and forecasts or orders which indicate the product quantity to be manufactured.

Information Required to do Process Planning

- Quantity of work to be done along with product specifications.

- Quality of work to be completed.
- Availability of equipments, tools and personnel (giving dates, etc.).
- Sequence in which operations will be performed on the raw material.
- Names of equipments on which the operations will be performed.
- Standard time for each operation.
- When the operations will be performed.

Process Planning Procedure

The different steps involved are :

1. **Selection of Process :**

- A process is necessary in order to shape, form, condition and join materials and components with the help of machines and labour in order to convert raw material into a finished product.
- One should select the most economical process (A breakeven chart similar to one discussed in Chapter 27 may be useful for the purpose) and sequence that satisfies the product specifications.
- The selection of process depends upon :

(a) Current production commitments. If enough work has already been allocated to more efficient equipments, the current work may have to be passed on to less efficient machines to complete the same in time.

(*b*) *Delivery date.* An early delivery date may :

(*i*) Force the use of less efficient machines,

(*ii*) Rule out the use of special tools and jigs as they will take time for design and fabrication.

(c) Quantity to be produced :

- Small quantity will not probably justify the high cost of preparation and efficient set-ups. Thus, quite possible they may have to be made on less efficient machines and *vice-versa*.

(d) Quality standards :

- Quality standards may limit the choice of making the product on a particular machine, etc.

2. **Selection of Material**

- Material should be of right quality and chemical composition as per the product specifications.
- Shape and size of material should restrict the scrap (*i.e.*, material removed for getting the product shape).

3. **Selection of Jigs, Fixtures and Other Special Attachments.** These supporting devices are necessary :

- to give higher production rate ;
- to reduce cost of production per piece.

4. **Selection of Cutting Tools and Inspection Gauges.** They, respectively, are necessary to :

- Reduce production time.
- Inspect accurately and at a faster rate.

5. Make the *process layout* indicating every *operation* and the sequence in which each operation is to be carried out.

6. Find *set-up time* and standard time for each operation.

7. Manifest process planning by documents such as *Operation and Route sheets*, which summarize the operations required, the preferred sequence of operations, auxiliary tools required, estimated operation times etc. (Refer Fig. 7.27).

7.10. ECONOMIC BATCH QUANTITY

- If the number of components to be produced is very large, they cannot be manufactured in one batch.
- Under such conditions it is required to find out—how many pieces (or components) should be produced in one batch so that it is most economical; and this batch size is known as *Economic Batch Quantity*.
- There are two types of costs (Fig. 7.15)

(*a*) *Which increase with the batch size, such as :*

(*i*) Working capital investment in materials and labour,

(*ii*) Cost of handling and storing materials,

(*iii*) Insurance and tax charges, and

(*iv*) Interest on capital investment, etc.

(*b*) *Which decrease with the batch size, such as :*

(*i*) Cost (per unit) of setting up machines,

(*ii*) Cost of preparing paper work that enters and controls the production of the order, *e.g.*, cost of preparing process sheets, issuing shop order, etc.

The above-mentioned costs, *i.e.*, (*a*) and (*b*) are plotted and the total cost curve is determined by adding (*a*) and (*b*) cost curves graphically (refer Fig. 7.15).

- **Mathematically,** *EBQ* can be determined as follows :

Assume :

Q is economic batch quantity.

R is annual requirements.

S is preparation and set-up cost, each time a new batch is started.

C is constant cost per piece (material, direct labour and overheads).

and I is inventory carrying charge rate per year (it is usually between 0.1 and 0.25).

Therefore,

$$\text{Average inventory} = \frac{Q}{2}$$

Value of average inventory

$$= \frac{Q}{2} \times C$$

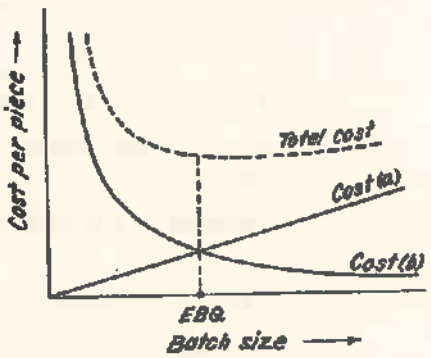


Fig. 7.15. Economic Batch Quantity (*EBQ*).

Cost of carrying inventory

$$= \frac{Q}{2} \times C \times I \quad \text{...(a)}$$

Number of set-ups during a year

$$= \frac{R}{Q}$$

$$\text{Cost of set-ups} = \frac{R}{Q} \times S = \frac{RS}{Q} \quad \text{...(b)}$$

The total cost, T is obtained by adding cost equations (a) and (b).

$$\therefore \quad T = \frac{QCI}{2} + \frac{RS}{Q}$$

For T to be *minimum*, put $\frac{dT}{dQ} = 0$

$$\frac{dT}{dQ} = \frac{CI}{2} - \frac{RS}{Q^2} = 0$$

$$\therefore \quad Q = \sqrt{\frac{2RS}{CI}} \quad \text{...(c)}$$

Example 7.1. Find the economic batch quantity using the data given below :

Set-up cost = Rs. 20 per set-up

Annual requirements or yearly consumption of parts = 1000

Inventory carrying cost = 10% of value/year

Cost per part = Rs. 2

Solution. Given S = Rs. 20.

R = 1000

C = Rs. 2

I = 10% = 0.1

Using above derived equation (c)

$$E.B.Q. = \sqrt{\frac{2 \times 1000 \times 20}{2 \times 0.1}} = 447 \text{ parts.}$$

– Therefore the number of batches to be made for manufacturing the parts are $\frac{1000}{447} = 2.24$ which is not practical.

– Nearest, 2 batches can be made and therefore the *modified EQB* = $\frac{1000}{2}$ = 500.

Example 7.2. (a) What is meant by Economic Batch Quantity ; derive the formula for *E.B.Q.*

(*b*) Determine *EBQ* from the following data :

Total sales in a year	= 1500 units
Set-up cost per job order	= Rs. 1800
Cost of unit product	= Rs. 120
Inventory carrying charges	= 10% of the value of the product

[Ans. *670 ; modified value 750*]

Example 7.3. Determine the *EBQ* from the following data :

Total sales in a year	= 2000 pieces
Set-up cost per job order	= Rs. 2000
Cost per piece	= Rs. 125
Inventory carrying charges	= 12% of the value of the product

[Ans. *730 ; modified value 666*]

7.11. TOOL CONTROL

Concept

- Tool control implies (1) determining tool requirements (2) procuring necessary tools and (3) controlling/maintaining tools once they have been procured.
- A tool or process planner must calculate tool requirements prior to the time of production to ensure that proper tools will be available when needed. Lost time resulting from incomplete tool planning can be expensive as well as causing work to delay.
- In order to facilitate tool control and to limit the investment in tool inventory, it is important to standardize wherever possible all the tools within an organisation.

Need for

Tool control is very important to ensure :

(1) Against loss through theft or negligence and production delays through misplacement or non-availability of tools.

(2) That the investment in tool inventories is minimized consistent with proper tool availability.

Procedure of

Two methods are commonly used to control the issue and receipt of tools to and from the workers:

(1) *The Brass ring system.* Brass rings with worker's identification number marked on them are issued to every worker. When he draws a tool from the crib, he gives one of his rings to the attendant and the ring is hung on a peg at the tool bin. When the worker returns the tool, the ring is returned to him.

This method is very simple and can be used where the workers are not much educated. However it invites dishonesty because of the ease with which counterfeit rings can be made. The method also does not provide any means of determining tool usage.

(2) *The Mc Caskey System*

- This system is based upon 3-part carbon backed form, (Fig. 7.16). The worker fills it out and presents it to the tool crib attendant when he wishes to withdraw a tool. One copy of the form is

maintained under a clip with the worker's name or his *clock number* and a second copy under a clip of the *tool number*. The third copy is given to the worker for *identification of the tool*.

- The copy filed under tool number provides ready reference that, particular tool is not available when a later request is made for it.
- Periodic checks of the slips under the worker's clip will indicate if tools are being hoarded or held for an excessively long time.
- When the tool is returned along with the third copy of the form which the worker had kept for his information (identification of tool), the copy under the worker's clip is removed and given to the worker.

  The copy under the tool number clip is removed and placed behind the tool inventory card at the back of each clip. Every month, the slips behind the card are counted to indicate tool usage and the individual slip thrown away.
- This system is widely used in manufacturing establishments because of its excellent control features.

TOOL ORDER SLIP 2535

Tool Order no. _____

Dept. _____ Bin no. _____

Clock no. _____ Date _____

Quantity	Size	Kind of tool

Signature _____

Fig. 7.16. Tool order slip.

7.12. LOADING

- Loading means assignment of work to manpower, machinery etc., without specifying when the work is to be done.
- Loading results in a tabulated list or chart showing the planned utilization of the machines or work stations in the plant (refer Fig. 7.17).
- The objective of the loading function is to maintain an up-to-date picture of the available capacity in the plant.
- Loading can be defined as the study of the relationship between *load* and *capacity* at the places where work is done. The information provided by loading is used (1) to ensure the efficient utilisation of the plant and labour in a factory, (2) to help in the setting of reliable delivery

promises, (3) and to assist in the forward planning of the purchase of new plant.

- *Load* 1(v) To assign work to the capacity available at particular work centres. 2(n). The total of the standard times of all the work assigned to a given work center plus allowances for machine idle time, ancillary time and down time ; and for substandard performance.
- *Capacity* can be defined as the *time* available for work at work centres expressed in machine hours or in manhours.
- **Aims of loading**

  (1) To check the feasibility of production programmes.

  (2) To assist in the efficient planning of new work.

  (3) To assist in balancing the plant to the existing load.

  (4) To assist in the fixing of reliable delivery promises.
- A load chart (Fig. 7.17) shows the productive capacity that has been *sold* and at the same time the available productive capacity. Load chart may be prepared for each machine or a group of machines available in the factory. Load charts, as such, are not too common because loading function is usually combined with scheduling and only one set of charts is maintained : The schedule charts.

Machines	*Daily-Machine Capacity (Hours)*	*Assigned Orders (Hours)*					
		January					
		1	*2*	*3*	*4*	*5*	*6*
Lathes	96	80	32	48	40	64	
Milling Machines	64	64	56	64	32	0	
Drilling Machines	32	24	16	16	0	0	

Fig. 7.17. A Machine load chart.

7.13. SCHEDULING AND CONTROL OF PRODUCTION

Introduction. Once the planning (work) to meet sales is complete and a set of decisions have been formulated using Graphical or Linear programming methods (section 7.8) the next step is the implementation of the decisions through detailed plans and schedules. Schedules are made for the use of facilities like equipment and manpower.

Scheduling and Control of production focus attention on the following :

(*a*) Knowing the total overall production targets—how to determine the amount of each product to be manufactured if there are products of different types and sizes ?

(*b*) How to decide about and deploy work force (different types of workers and kinds of skills) and equipment to achieve the target production rate ?

(*c*) How to determine individual work assignments.?

(*d*) What should be the information system to feed back quickly and accurately the actual output duly compared with the scheduled one ?

Scheduling and Control of production have one stage in between them, which is known as *dispatching* and it will be discussed under Sec. 7.18. In general, first of all the order is scheduled, then it is dispatched for necessary operation (on the raw material) and lastly the progress of the order is tracked, to be certain that the schedule is being met. This (last) phase of tracking the progress of an order and making corrections (if necessary) is known as *control of production*.

7.14. SCHEDULING

Concept. In brief, scheduling means—when and in what sequence the work will be done. It involves deciding as to when the work will start and in a certain duration of time how much work will be finished. Scheduling deals with orders and machines, *i.e.*, it determines which order will be taken up on which machine and in which department by which operator. While doing so, the aim is to schedule as large amount of work as the plant facilities can conveniently handle by maintaining a free flow of material along the production line.

Scheduling may be called the time phase of Loading. Loading means the assignment of task or work to a facility whereas scheduling includes in addition, the specification of time and sequence in which the order/work will be taken up.

A production schedule is similar to a railway time table and shows which machine is doing what and when. A production schedule, is a statement of target dates for all orders or operations in hand and reveals their starting and finishing dates. Scheduling finalises the planning phase of Production Planning and Control System.

Factors Affecting Scheduling. The following factors affect production scheduling and are considered before establishing the scheduling plan.

(*a*) *External factors :*

1. Customer's demand,
2. Customer's delivery dates, and
3. Stock of goods already lying with the dealers and retailers.

(*b*) *Internal factors :*

1. Stock of finished goods with the firm,
2. Time interval to process finished goods from raw material. In other words—how much time will be required to manufacture each component, subassembly and then assembly (*i.e.*, the final product),
3. Availability of equipment and machinery ; their total capacity and specifications,
4. Availability of materials ; their quantity and specifications,
5. Availability of manpower (number, type and kind of skills),
6. Additional manufacturing facilities if required, and
7. Feasibility of economic production runs.

Scheduling Procedure and Techniques. Scheduling normally starts with the *Master Schedule*. Figure 7.18 shows the master schedule for a foundry shop.

A master schedule resembles central office which possesses information about all the orders in hand. Master schedule, in Fig. 7.18, is a weekly breakdown of the production requirements. The total capacity in any week is of 100 hours of work in the foundry shop.

As the orders are received, depending upon their delivery dates (or priorities, if any) they are marked on the master schedule. When the shop capacity is full for the present week the newly acquired orders are carried over to the next week and so on. A master schedule is thus updated continuously, it depicts a running total of the production requirements and shows the work ahead—yet to be completed. Master

schedule is actually the basis for all subsequent scheduling techniques.

MASTER SCHEDULE FOR THE FOUNDRY SHOP

Maximum Production 100 hrs
Minimum Production 8 hrs

WEEK-1	WEEK-2	WEEK-3	WEEK-4
15	18	20	15
25	25	12	10
30	29	32	
35			

Fig. 7.18. Master schedule for a foundry shop.

A Master Schedule possesses the following advantages, disadvantages and applications.

Advantages

1. It is simple and easy to understand,
2. It can be kept running (*i.e.*, current),
3. It involves less cost to make it and maintain,
4. It can be maintained by non-technical staff, and
5. A certain percentage of total weekly capacity can be allocated for rush orders.

Disadvantages

1. It provides only overall picture, and
2. It does not give detailed information.

Applications

It finds applications :

1. In big firms, for the purpose of loading the entire plant,
2. In Research and Development organisations, and
3. For the overall planning in foundries, computer centres, repair shops, etc.

After framing the overall picture of production requirements through a Master Schedule chart, the detailed schedules are thought of and made for each component, and subassemblies so that all parts are available at the time of assembly. There are a number of visual aids and techniques, both in the form of conventional charts and commercially available boards, which aid in detailed scheduling. The technique to be employed for scheduling purposes depends upon the type of production (intermittent or continuous), type and frequency of tasks, demand patterns, etc. A useful scheduling device normally portrays planned production, actual performance and their comparison. Actually, the Gantt Chart (refer Fig. 7.20) forms the basis of commonly used scheduling techniques.

Some of the techniques (besides master schedule) employed for Loading and Scheduling purposes are :

(*a*) Perpetual schedule ;

(*b*) Order schedule ;

(*c*) Loading by schedule period ;

(*d*) Commercial devices.

(*a*) **Perpetual Scheduling.** Like master scheduling, it is also simple and easy to understand, is kept current, involves less costs and can be maintained by clerical staff. But, the information which it provides is very gross and at the same time it is not clear from the chart—when the work will take place.

Making of perpetual schedule involves two steps :

(*i*) Preparation of Load Analysis sheet from the orders in hand. Figure 7.19 shows a load analysis sheet.

LOAD ANALYSIS SHEET

ORDER NO.	LOAD IN HOURS/DAYS SECTION A	SECTION B	SECTION C
X-320	25	10	16
Y-210	10	15	10
Y-3M	18	20	8
Z-150	8	25	—

Fig. 7.19. Load analysis sheet.

(*ii*) The total load against each section is added up and knowing the weekly capacity of a section (department), the number of weeks load against each department is calculated and plotted on a Gantt load chart as shown in Fig. 7.20.

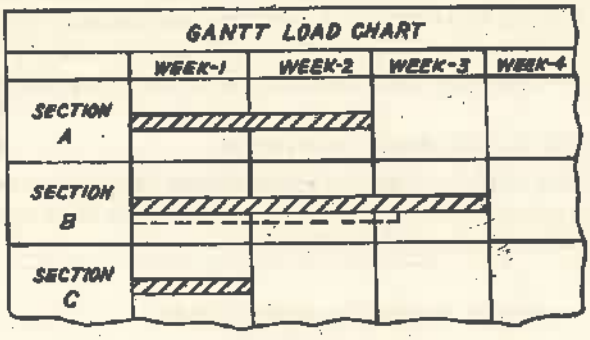


Fig. 7.20. Gantt load chart.

The shaded bars show the actual work load against each section.

Additional information, if any (regarding the work load), can be indicated by dotted line.

(*b*) **Order Scheduling.** It is a most elaborate technique. Fig. 7.21 shows an order schedule chart. Time is marked horizontally and the vertical axis shows the particular facility (say a machine). The information required to generate an order schedule is, regarding the number of parts to be manufactured, name of the machines, their set-up times, total production time and the date of completion of the order.

The scheduling is started by placing the last operation at the date of completion and then working

backwards. For example, if order *X* takes 3 days to complete and it is to be delivered to the customer on 7th of January, the work will be started on 5th of January.

Order schedule chart has the following advantages and limitations.

Advantages

(1) It is very detailed.

(2) The earliest possible completion dates can be met.

Limitations

(1) It is very costly.

(2) It requires accurate (production) time standards and good communication system.

(3) It is difficult to maintain effectively if there are many active orders.

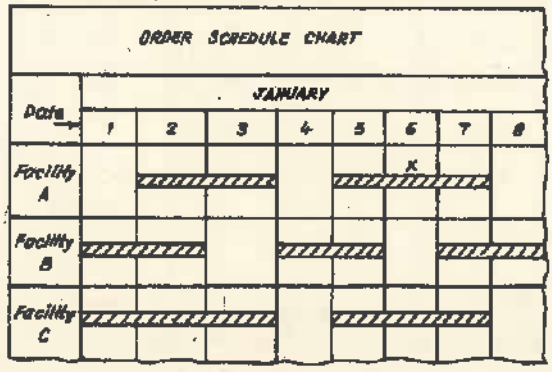


Fig. 7.21. Order schedule chart.

(*c*) **Loading by Schedule Period.** The task is broken into different operations which will be required to turn raw material into finished product. A Gantt type of chart (*See* Fig. 7.22) is employed for scheduling purposes. The rows, mark different facilities and each column denotes a time period (TP). There are as many time periods as the number of operations. The first operation is carried out in the time period-1, second operation in time period-2 and so on. It is however not specified that, within the time period, when the operation will start and finish; but the operation is very much supposed to be completed during that particular time period. The shop supervisor does the detailed scheduling within the framework of the specified time period.

The shaded bars show the work ahead of each facility.

This type of scheduling involves a longer in-process (total) time because only one operation is to be performed in one time period. However, this makes it more flexible as an operation can be taken up at the most convenient time within the specified time period.

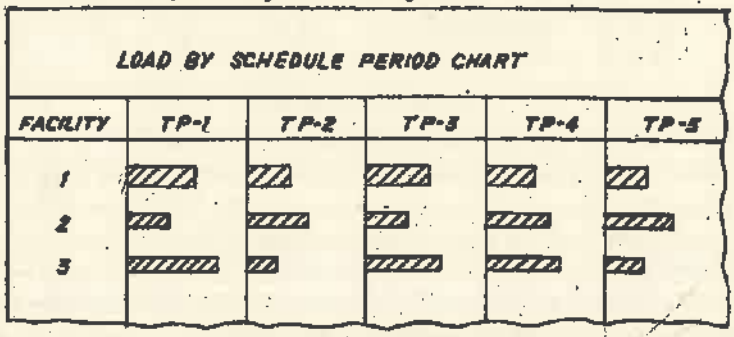


Fig. 7.22. Load by schedule period chart.

(c) Some of the Commercial Devices for Loading and Scheduling are :

(a) Produc–Trol Board,

(b) Sched-U-Graph,

(c) Board master,

(d) Magnetic boards, and

(e) Roll charts, etc.

(a) **Produc-Trol Board.** Fig. 7.23 show a Produc-Trol board.

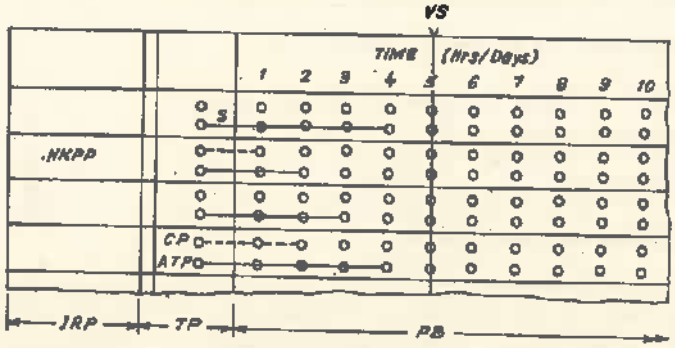


Fig. 7.23. Produc-Trol Board.

IRP : Index record panel.

TP : Tape pegs.

S : Strings.

PB : Peg board having two rows of holes for each pocket.

HKPP : Heavy craft paper pockets. Each machine is assigned a pocket. A card bearing information pertaining to the machine is inserted in the pocket.

ATP : It is a tape peg showing actual work load for each machine.

CP : It is a coloured peg (shown dotted) that gives special information ; for example last week's load.

VS : Vertical string showing today's date and the work load position.

(b) **Sched-U-Graph.** It is shown in Fig. 7.24.

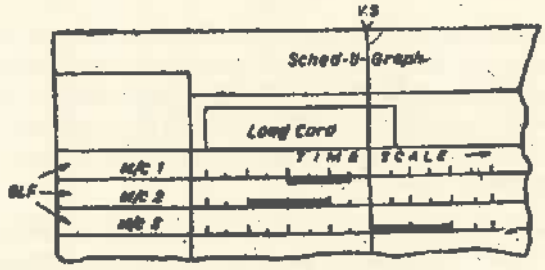


Fig. 7.24. Sched-U-Graph.

OLF : *Overlapping flap.* Every flap is projecting about 12 mm below (out) the previous one, and has bottom (12 mm) portion transparent. A card is made for each operation (to be done) on a machine. The card has written on it every thing about a job.

The bottom (12 mm) of the card is coloured and the card is cut to a length depending upon the time the job will take on a particular machine. The black strips in Fig. 7.24 correspond to the coloured bottoms of the cards and indicate which machine will be busy during which period. The progress made against each order can also be shown by strips of other colours.

7.15. MANUFACTURING SCHEDULE

- A master schedule is too general to permit adequate day-to-day planning by line supervision, and is usually unnecessary in a small organisation.
- Weekly departmental *manufacturing schedules* supplement the master schedule and must be made to reflect immediate factors, some of which are

  (1) Tool downtime due to broken and worn tools,

  (2) Equipment downtime for repair and maintenance,

  (3) Shortages and defects in materials,

  (4) Absenteeism and

  (5) Cancellations and rush orders.
- The weekly schedule should take advantage of the most economical setup sequence in a process where more than one part is produced on the same line. It is important to arrange the order of work on the weekly schedule, to minimize setup time.

Sometimes much of the same tooling can be used for certain operations on parts *A* and *C*. Part *B*, requiring a different setup on the same machine, should then follow part *C* rather than precede it. The operating supervisor can help greatly in working out these combinations.

- Successive master schedules are corrected from the variations reflected in the manufacturing schedules. Weekly manpower requirements are based on the manufacturing schedules and excessive fluctuations must be avoided.

7.16. SCHEDULING AND THE COMPUTER

- Since Scheduling is the main process carried out in production control, it is worth to consider the relationship between the computer and scheduling.
- The computer is an extremely versatile tool which can be programmed to undertake almost any *data processing* task.
- In many types of industry, much of the data required for scheduling is relatively *fixed* in relation to time. In this category can be included the data contained in parts lists, route cards and plant lists. Many of the data processing needs of production control use this type of data. Examples are, *explosion** to find *parts* requirements, *implosion*** to find the requirement of common *materials* and *loading* to calculate forward loads on machines and direct workers. For these types of data processing, the computer is ideal.
- *Continuous data* (such as store receipts, store issues, products dispatched etc.) is used by production control in the compilation of stock records, shortage lists and operations statistics.

* An *explosive industry* produces a *small* number of different products, by joining a large number of different components *e.g.* Machine Assembly.

** An *implosive industry* produces a *large* number of different products from a small number of different material items or components *e.g.* Foundry.

Computer, again, can do the actual data processing much more accurately and quickly than is possible *manually*.

A.B.C. Co., Ltd.	Period : 2nd Quarter 1991		
Production order	Date : 15.3.1991		
Item	April	May	June
1 Ton Air conditioners	550	450	350
1.5 Ton Air conditioners	600	500	400
Water coolers	500	400	300
Approval	PPC Manager _____		
	Sales Manager _____		
	Production Manager _____		

Fig. 7.25. Production order.

7.17. CONTROL OF PRODUCTION (PRODUCTION CONTROL)

Scheduling completes the planning phase of Production Planning and control. The next is 'Dispatching', the action phase which has been discussed under Section 7.18. After dispatching is the control phase or control of production which consists of two parts (*a*) Progress reporting, and (*b*) Corrective action. Both these parts have been discussed in the Section7.20 under Progress control. Production control phase or progress control means the same thing. The concept of control and control of production is as follows :

A control system involves four stages namely : (*i*) Observation, (*ii*) Analysis, (*iii*) Corrective action, and (*iv*) Post-operation evaluation. A production control system considers these elements in its different functions.

The control of production is necessary to be sure that the production schedules are being met and the job will be delivered as per the predecided (scheduled) plans. Production control involves an information feedback mechanism and a system of corrective action. Production control follows up the scheduled plans, compares the actual output with the planned one, and points out deviation, if any, so that the same can be corrected through the adjustments of men, materials and machines.

In brief, a production control group:

(*a*) receives work progress reports;

(*b*) compares them with the scheduled plans;

(*c*) removes causes of delays in production;

(*d*) modifies the schedules or plant capacities; and

(*e*) expedites the work.

7.18. DISPATCHING

Introduction. Dispatch function executes planning function. It is concerned with getting the work started. Dispatching ensures that the plans are properly implemented. It is the physical handing over of a manufacturing order to the operating facility (a worker) through the release of orders and instructions in accordance with a previously developed plan of activity (time and sequence) established by the scheduling section of the production planning and control department. Dispatcher transmits orders to

the various shops. Dispatch function determines—by whom the job shall be done and it co-ordinates production. It is the key point of a production communication system. It creates a direct link between production and sales.

A dispatcher is familiar with the productive capacity of each equipment. He always keeps an eye over the progress of orders which move at different speeds on different routes.

Dispatch Procedure. The product is broken into different components and components into operations. A route sheet for the part (component) *C* having three operations on it is shown in Fig. 7.26. The various steps of dispatch procedure for each operation are listed below, in sequence.

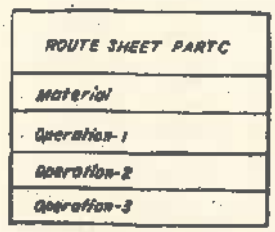


Fig. 7.26. Route sheet.

(a) Store Issue Order. Authorise stores (department) to deliver required raw material.

(b) Tool Order. Authorise tool store to release the necessary tools. The tools can be collected by the tool room attendant.

(c) Job Order. Instruct the worker to proceed with the operation.

(d) Time Ticket. It records the beginning and ending time of the operations and forms the basis for worker's pay.

(e) Inspection Order. Notify the inspectors to carry out necessary inspections and report the quality of the component.

(f) Move Order. Authorise the movement of materials and components from one facility (machine) to another for further operations.

In addition, there are certain other dispatch aspects which have to be taken care of,

1. All production information should be available before hand.
2. Various order cards, and specification drawings should be ready.
3. Equipments should be ready for use.
4. Progress of various orders should be properly recorded on the Gantt charts or display boards.
5. All production records should be properly maintained.

Centralized and Decentralized Dispatching. Dispatch function may be centralized or decentralized.

In a *Centralized* dispatch system, a central dispatching department, orders directly to the work station. It maintains a full record of the characteristics and capacity of each equipment and work load against each machine. The orders are given to the shop supervisor, who runs his machines accordingly. In most of the cases, the supervisor can also give suggestions as regards loading of men and machines under him. A centralized system has the following advantages :

1. A greater degree of overall control can be achieved.
2. Effective co-ordination between different facilities is possible.
3. It has greater flexibility.
4. Because of urgency of orders, changes in schedules can be affected rapidly without upsetting the whole system.
5. Progress of orders can be readily assessed at any time because all the information is available at a central place.
6. There is effective and better utilization of manpower and machinery.

In a *Decentralised* dispatching system the shop supervisor performs the dispatch functions. He decides the sequence of handling different orders. He dispatches the orders and materials to each equipment and worker, and is required to complete the work within the prescribed duration. In case he

suspects delay, with due reasons of the same, he informs the production control department. A decentralised dispatching system has the following *advantages :*

1. Much of the red tape is minimized.

2. Shop supervisor knows best about his shop, therefore, the work can be accomplished by the most appropriate worker and the machine.

3. Elaborate reports and duplication of postings can be avoided.

4. Communication gap is reduced.

5. It is easy to solve day-to-day problems.

6. It keeps the natural urge of a section to be self-sufficient.

The advantages of a centralized system, more or less give an idea about the disadvantages of the decentralized system and *vice versa.*

Level of Dispatch Office. Dispatching can be introduced at Plant Manager's level, Shop Superintendent's level, at the level of Shop Supervisor or at a Specialist's level.

Dispatching, at the level of *Plant Manager* though keeps him informed about all the plant activities and seeks his guidance, yet it may not work very well; because, firstly he (Plant Manager) does not have time to go through each and every detail carefully and secondly it takes a long time for the information to pass down the line to the workers.

Dispatching at *Shop Superintendent's* level, again, though keeps him better informed, but does not function well because his basic nature of duties (to look whether the operating facility is performing the scheduled work at an acceptable level of performance or not) do not leave much spare time with him to take care of the overall dispatch function in detail.

Dispatching when introduced at *Shop Supervisor's* level, seems to be the best. This system possesses the following *Advantages* :

1. Higher levels are not disturbed.

2. Shop supervisor knows best about his shop and thus dispatching can be more effective.

3. The schedule is passed on to the workers in no time.

The *Disadvantage* in this case is that clerical work for the supervisor increases.

Introducing dispatching at the level of a *Specialist* (a dispatcher not from within the line organization) has the following advantages and disadvantages.

Advantages

(1) Shop supervisor is relieved of the clerical work.

(2) The system provides extra manpower.

(3) The system provides special guidance and advice.

(4) Dispatching is done more efficiently.

(5) Effective co-ordination can be attained.

Disadvantage

The traditionally acceptable practice, that a supervisor assigns the job to the workers under him and supervises them, is lost.

7.19. ROUTING

Introduction. Routing lays down the flow of work in the plant. It determines what work is to be done and where and how it will be done. Taking from raw material to the finished product, routing decides the path and sequence of operations to be performed on the job from one machine to another. The purpose is to establish the optimum sequence of operations. Routing is related to considerations of layout,

temporary storage of in-process inventory and material handling.

Routing in continuous industries does not present any problem because of the product type of layout, where the equipment is laid as per the sequence of operations required to be performed on the components (from raw material to the finished products).

In open job shops, since, every time the job is new, though operation sheets (sometimes) may serve the purpose, but the route sheets will have to be revised and this involves a greater amount of work and expertise.

Routing Procedure. Various procedural steps are as follows :

(*a*) The finished product is analysed from the manufacturing standpoint in order to decide how many components can be made in the plant and how many others will be purchased (Make/Buy decision) from outside through vendors, by subcontracting, etc. Make/buy decision depends upon the work load in the plant, availability of equipment and personnel to manufacture all components, and the economy associated with making all components within the plant itself.

(*b*) A parts list and a bill of materials is prepared showing name of the part, quantity, material specifications, amount of materials required, etc. The necessary materials, thus, can be procured.

(*c*) From production standards—machine capacities, machine characteristics and the operations which must be performed at each stage of manufacture are established and listed in proper sequence on an operation and route sheet, (*See* fig. 7.27). The place where these operations will be performed is also decided.

Actually, operation sheet and route sheet are separate. An operation sheet shows every thing about the operations, *i.e.*, operation description, their sequence, type of machinery, tools, set up and operation times, whereas a route sheet besides listing the sequence of operations and relation between operation and machine, also details the section (department) and the machines to whom the work will flow. First two columns of Fig. 7.27 are mainly those of route sheet which show the manufacturing route for given component.

OPERATION & ROUTE SHEET

Component No. _____ Drawing _____

Name of Component _____

_____ Quantity _____

Material _____ To be completed on _____

_____

ROUTING		OPERATION NO.	OPERATION DESCRIPTION	TOOLS REQD.	FIXTURE & OTHER ACCESSORIES	TIME		
SECTION	MACHINE					SET UP	OPERATION	TOTAL

Fig. 7.27. Operation and route sheet.

The difference between an operation sheet and a route sheet is that an operation sheet remains same for the components if the order is repeated but the route sheet may have to be revised if certain machines are already committed to other orders (jobs) on hand. Except this small difference, both the sheets contain practically the same information and thus are generally combined into one sheet known as 'operation and route sheet'.

(*d*) The next step is to determine the lot size or the number of components to be manufactured in one lot or batch. In the case of an order from a particular customer, it is generally equal to a number within 10% of the order quantity. In other cases the principle of economic batch quantity can be applied (refer Chapter 24) to determine the batch size.

(*e*) Standard scrap factors (single or cumulative) and the places (*i.e.*, after a particular operation or assembly) where scrap is very likely to occur are identified. The actual scrap in each batch can be recorded on the control chart. Causes for points out of control limits are explored and corrected. The variables like workers, machinery and schedules may also be adjusted to minimize scrap.

(*f*) The cost of the component is analysed and estimated through the information obtained in steps (*a*) to (*e*) above. The cost consists of material and labour charges, and other specific and general indirect expenses.

7.20. PROGRESS CONTROL

Introduction. Once the actual production has started, it becomes essential to keep an eye at the progress of the work so that, if required, timely corrective action can be taken. Progress control means—trying to achieve the standards set, *i.e.*, a certain level of efficiency or a certain volume of production in a specified duration. The system of progress control should be such that it furnishes timely, adequate and accurate information about the progress made, delays and under- or over-loading.

Steps Involved in Progress Control

(*a*) Setting up a system to watch and record the progress of the operating facility (production section).

(*b*) Making a report of the work progress or work accomplishment.

(*c*) Transmission of report to :

1. Control group for necessary control action, and
2. Accounting group for recording material and labour expenditures.

(*d*) Interpretation of the information contained in the progress report by the control group.

(*e*) Taking corrective action, if necessary.

The above-mentioned five steps have been briefly discussed as under :

(*a*) **System to Record the Work Accomplishment.** Progress charts are normally employed for this purpose. They compare the work progress against a prescribed target, and point out the failure to achieve the same; thus progress charts draw attention for an action or investigation.

The chart construction may have the following four forms :

1. The Bar chart,
2. The Curve chart,
3. The Gantt chart, and
4. Mechanical chart.

1. *The Bar Chart* (Fig. 7.28) consists of a number of bars. Each bar has its length proportional to the activity duration. A bar chart is generally used to point out and analyze interrelated data which otherwise is difficult to read.

2. *A Curve Chart* is a graph between two variables (like, number of days and number of items produced) marked along X and Y axis. As the days pass, the number of items being produced are marked over the graph. When all such points are joined they indicate the production trend (See Fig. 7.29).

Both the bar and curve charts show the past data. They are not readily adaptable to current or future action.

3. *The Gantt Chart* was developed by Henry L. Gantt. It is frequently used to keep track of multiple machine schedules. Gantt chart is actually a modified bar chart, wherein load is marked against a time scale with one horizontal bar or line allocated to each machine. A Gantt chart displays the following :

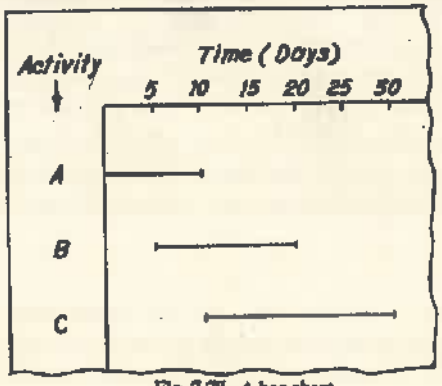


Fig. 7.28. A bar chart.

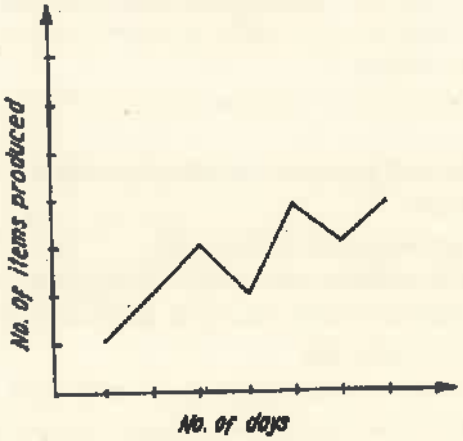


Fig. 7.29. A curve chart.

(1) Plans for future,

(2) Progress on present operations,

(3) Past achievements till date,

(4) Relationship among several variables,

(5) It focuses attention on situations threatening delays,

(6) It tells whether a plan has fallen short and if the delivery dates can be met, and

(7) A cursor attached to the Gantt chart (*See* Fig. 7.30) can be moved across the chart to know the work progress till any particular day.

Two *basic types of Gantt chart* are used extensively for production control.

(*i*) **Order Control Chart.** Time (in weeks/days) is marked along the horizontal axis and orders in hand are listed along the vertical axis (*See* Fig. 7.30). The amount of work planned or scheduled is shown by the firm line and the machine on which the order will be processed is marked on the line. The actual progress of various orders is shown dotted. Cursor placed at today's date indicates that order *A*-372 is going as per schedule. Work on order *B*-260, started one week before the schedule (starting) date and it is about 70% complete which otherwise would have been only 50% as per the plan. Thus order *B*-260 is

ahead of the schedule. Order *C*-300 which started on the scheduled date, due to some reasons, has got delayed by one week.

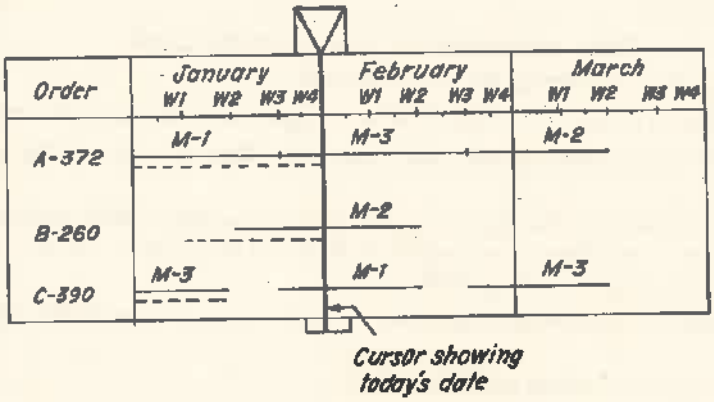


Fig. 7.30. Order control Gantt chart.

(*ii*) **Machine Load Chart.** Time is marked along the horizontal axis and various machines are listed along the vertical axis (*See* Fig. 7.31). The amount of work planned and the actual progress made have been shown by firm and dotted lines respectively. Orders by their numbers have been marked on the horizontal firm lines. Cursor set at today's date shows that machine-3 is working as per schedule. Machine-2 started work on order *B*-260 before the scheduled date and the progress is very good. Machine-1 which completed the order *A*-372 in time, for some reasons could not take up the order *C*-390.

From the above Gantt charts the progress of various orders and machine loading can be seen at a glance. Order *C*-390 has fallen behind the schedule and needs expediting (control action). Machine-1 is loaded up to the middle of February, however machine-2 is available for the third week of February, whereas Machine-3 can be booked only after the middle of March.

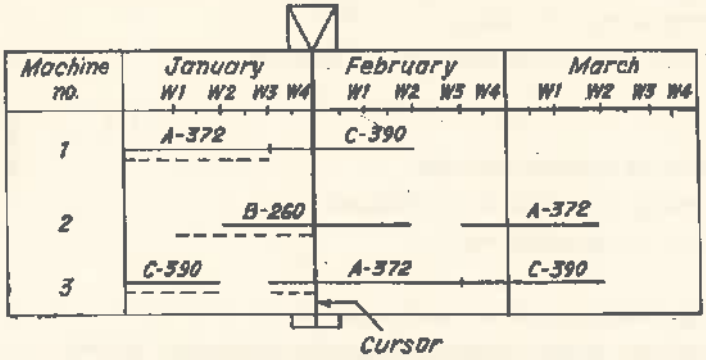


Fig. 7.31. Machine load Gantt chart.

4. *Mechanical Charts.* They include wall charts, visible index files and other scheduling devices like Produc-Trol board, Board master, Sched-U-Graph, etc. which are commercially available. These equipments have added signalling devices like pegs, strings, clips, etc., to focus the attention on the situations needing corrective action.

(*b*) **Making a Report of Work Accomplishment**

1. The progress report should contain the following information in order to evaluate actual performance against the anticipated plan and to take corrective action, if any :

(*i*) *Job Identification.* It includes order number and operation number.

(*ii*) Time of report, and

(*iii*) Work completed.

2. A progress report should contain absolute minimum of information.

3. *Progress Reporting Time.* Progress can be reported :

(*i*) at fixed intervals of time, *i.e.*, weekly, monthly, or yearly depending upon the project duration ;

(*ii*) after the work has been completed, or after each stage of the work is completed ; it depends upon the size of the work ;

(*iii*) by using the principle of 'Management by Exception'; according to which, one reports only those things and at that time when they (things) require an action by the planning group. It is assumed that unreported events are going as per the schedule.

(*c*) **Transmission of Report.** The progress report may be transmitted by employing any one of the following systems :

(*i*) Written system (pre-written papers),

(*ii*) Oral system (Telephone, radio, etc.), and

(*iii*) Electronic system (Telautograph, teletype equipment, etc.).

(*i*) Written System

Advantages

(1) It provides a record for future reference,

(2) The chances of misinterpreting the report are minimized, and

(3) A good amount of necessary information can be supplied.

Disadvantages

(1) There are chances of papers being misplaced in transit ;

(2) Generally, it takes more time for the report to reach the other end ;

(3) File keeping is necessary ; and

(4) There is a tendency to send large amount of information.

(*ii*) Oral System

Advantages

(1) Progress can be reported in no time.

(2) Doubts, if any, can be clarified instantly, and

(3) File work is very much minimized.

Disadvantages

(1) There is no detailed record for future reference,

(2) There are more chances of misinterpreting the report, and in addition

(3) Only brief information can be sent.

(*iii*) Electronic System

Advantages

(1) It possesses all the advantages of the written system, and

(2) Progress can be reported much faster.

Disadvantages

(1) Equipments required are costly, and

(2) Trained operators are needed.

Based upon the above systems the commonly used *techniques for sending progress reports* are :

(i) Pre-written or Pre typed Papers. These are sent through messengers from one department to another.

(ii) Pre-written Papers Using Pneumatic Tube Equipment. Papers are put inside a capsule, which is then placed inside a tube, running from one department to another. The capsule is shot by air to its destination.

(iii) Teletype Equipment. It has a key board similar to a typewriter. Pressing different keys gives rise to electric signals which are transmitted to receiving stations where the message is recorded.

(iv) Telautograph Equipment. There is a sending unit and a receiving unit. The sending unit has a stylus which is used to write the report. A pen in the receiving unit records the exact movements of the stylus (of the sending unit) and thus besides the written matter sketches and graphs can also be communicated.

(v) Telephone and Intercommunication Equipment.

(vi) Radio and Loudspeaker. They are especially useful for outdoor applications to control the movements of materials handling equipments and earth moving machinery.

(vii) Closed Circuit T.V. It is employed for keeping an eye over the processes emitting harmful radiations.

(e) **Corrective Action.** Factors creating the need for corrective action are,

(A) External Factors. These factors are beyond the control of the organisation ; for example :

(i) Change in the priority of orders due to the arrival of some new orders or due to the cancellation of a few previous orders ;

(ii) Delay in receiving equipments, tools, or raw material. This may be due to strike or theft at the vendor's end or due to the reasons that the raw material which arrived earlier was substandard and hence, was returned for replacement ;

(iii) Unexpected rush orders.

(B) Internal Factors. These factors results from within the organisation ; for example :

(i) Labour turnover or mass absenteeism,

(ii) Lack of necessary instructions and materials,

(iii) Late staring of the work, tea breaks, etc.

Methods to take Corrective Actipn

(1) *Schedule Flexibility.* It means keeping the schedule flexible to accommodate unexpected events. Planning is done only for a percentage of the total working time (say for seven hours out of eight hours shift) and the remaining time is kept free to take care of the unexpected jobs. The percentage of time kept free for rush order, etc., is decided from the past experience.

(2) *Capacity Modification.* The following three methods can be employed for modifying the capacity of an organisation :

(*a*) Changing the number of working hours, either by employing more workers or by using over-time with the same number of workers.

(*b*) Changing the amount of work within the plant by appropriate Make/Buy decisions or by subcontracting the work to others.

(3) *Schedule Modification.* If the situation is otherwise non-manageable even afer adoping he above-mentioned measures, the previously established plan can be modified to suit the new set of conditions.

(*c*) **Follow Up or Expediting.** The manufacturing activity of a factory is said to be *in control* when the actual performance is as per the planned performance. Follow up or expediting regulates the progress of materials and the components through the production process. Follow up serves as a catalytic agent to fuse the various separate and unrelated production activities into the unified whole that means progress. Follow up is concerned with the reporting of production date and the investigating of any deviation from the predetermined production (or time) schedules. Follow up ensures that the promise (*i.e.* of delivery dates) is backed up by performance.

– The work within the organisation can be expedited by the following two principles :

(*i*) The exception principle, and

(*ii*) The fathering principle.

In *exception principle,* the scheduling group (on the basis of progress reports), explores the jobs behind the schedule. The expediting group takes up such jobs, procures necessary materials, tools, etc., *i.e.,* (expediting group) solves all problems related to these jobs and intimates the scheduling group to reschedule them.

According to *fathering principle* each expeditor is made responsible for a job or a group of jobs for which he arranges the tools, materials, equipment, etc. Such a system works very well for controlling large projects.

7.21. FLOW CONTROL OF MATERIAL, COMPONENT PARTS AND SUBASSEMBLIES TO MATCH THOSE OF FINISHED (FINAL) PRODUCT

The function of Flow (Production) Control is to match up the rates of flow of parts, subassemblies and final assemblies. Each part should be ready before the time of subassembling and each subassembly should be made available at the time and place of assembly in order to make the final product. Flow control achieves this by keeping the parts and subassemblies flowing to the assembly line.

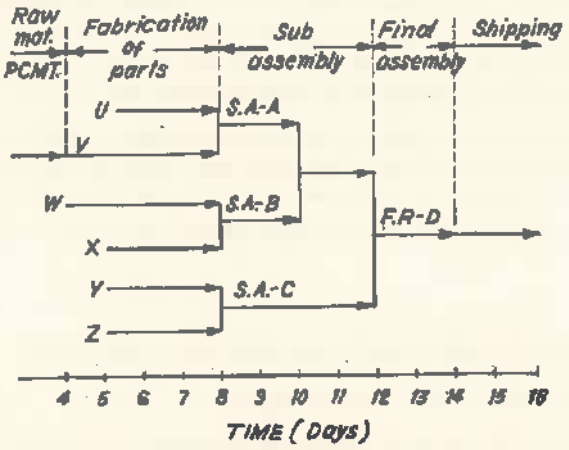
Flow control can be perfected through the following :

(*a*) **Operation Time.** It amounts the time required to manufacture each part, to make one subassembly and to execute one assembly. This information can be had from the operation sheet.

(*b*) **Line Balancing.** The assembly line should be balanced, (refer Chapter 4). Each work station should have the same operating time and the various operations should be sequenced properly. There should be perfect balance between the output rates of the parts and the subassemblies. However, it is not always possible that the parts reach in a steady stream immediately before subassembly. This may be because of the limitations as regards materials, men and equipments or it may be economical to manufacture and supply parts in batches. The flow control section has to cope with such situations and thus carry big inventories and arrange facilities for storage.

(*c*) **Routing and Scheduling.** A combination route and schedule chart showing the fabrication of parts subassemblies and final assembly (*See* Fig. 7.32) in proper sequence, upon a time scale proves to be very advantageous, especially, when there is smooth flow of work. The chart shows that the fabrication of parts V and W starts on the 4th day and the work on parts U, X, Y, and Z is taken up on the fifth day. All the components should be ready to make subassembly at the beginning of the 8th day and subassemblies should be made available for the assembly of final product on the 12th day. The assembly is over at the end of 13th day and the final product can be shipped on the 14th day.

Knowing the delivery date and the time required to fabricate each part, subassembly and assembly, the chart can be worked out from right to left. Thus obtained date for starting the fabrication of parts and then modified in the light of existing shop loading conditions (known from Produc-Trol board or Sched-U-Graph, (section 7.14) is used to arrive at the actual date to start the manufacture of each part.



Raw material *PCMT* : Raw material procurement,
S.A.-A : Subassembly *A*., *F.P.-D* : Final product-*D*.

Fig. 7.32. Route and Schedule Chart.

(*d*) **Control of Parts, Subassemblies and Assembly.** A supervisory function coupled with an appropriate information feedback system keeps a check whether the small parts arriving in lots and big parts coming continuously are available at the right time, in proper quantities, types and sizes for making subassemblies as per the scheduled plans.

The difference between the control of parts, subassemblies and assemblies is that, parts may be in thousands, sub-assemblies in hundreds and assemblies in tens. It is always convenient to make an assembly out of subassemblies than from individual parts. The subassemblies are made continuously at a rate which matches the final assembly line requirements. Control of a subassembly line is easier as compared to that of an assembly because the former involves lesser number of parts. Normally a few parts and subassemblies are always made extra and are kept in stock to take care of rejects, repair services, etc. This has to be considered while scheduling. Lastly, the control of final assembly needs—checking that each final product gets the proper combination of subassemblies which in turn have that of individual parts.

7.22. LINE OF BALANCE (LOB)

Introduction and Concept

- LOB is a manual *planning* and *scheduling technique similar* in nature to MRP (material resource planning).
- This method was developed by the U.S. Navy during World War II. It is most appropriate for assembly operations involving a number of distinct components. In essence, it employs the principle of *management-by-exception* through a comparison of progress of individual components with the time schedule for completed assemblies. Regular progress checks reveal the future effect of any current delays and indicate the degree of urgency for corrective action.
- It complements Gantt technique in determining *production status.*

While the Gantt chart/technique primarily relates information on the effective and efficient *utilization of resources* (*e.g.,* machine loading, man loading), LOB is more product-oriented.

LOB is not directly concerned with the resources expended but is utilized in determining *production progress* in terms of per cent of task completion. Major bottlenecks in the production process are emphasized.

- LOB technique can be regarded as a slightly more sophisticated form of the Gantt chart, the objective being to study the progress of jobs at regular intervals, to compare progress on each operation with the progress necessary to satisfy the eventual delivery requirements, and to identify those operations in which progress is unsatisfactory.
- LOB technique is an example of management-by-exception since it deals only with the important or crucial (exceptional) operations in a job, establishes a schedule (or plan) for them and attracts attention to those which do not conform to this schedule. It is particularly useful where large batches of fairly complex items, requiring many operations, are to be completed/delivered over a period of time.

LOB Technique

- LOB technique consists of five main stages, all utilizing graphic aids :

(1) A graphical representation of the *delivery objective*.

(2) A chart of the *production program* showing the sequence and duration of all activities required to produce a product.

(3) A *progress chart* of the current status of component completion.

(4) A *Line-of-Balance* drawn to show the relationship of component progress to the output needed to meet the delivery schedule.

(5) *Analysis of progress*

(1) Objective Chart

- The objective chart (Fig. 7.33) shows the expected schedule of products (*i.e.* scheduled deliveries) and the actual completion rate (*i.e.*, actual deliveries made by a date).
- A dip in the actual deliveries line below the scheduled deliveries line is an obvious cause for alarm.

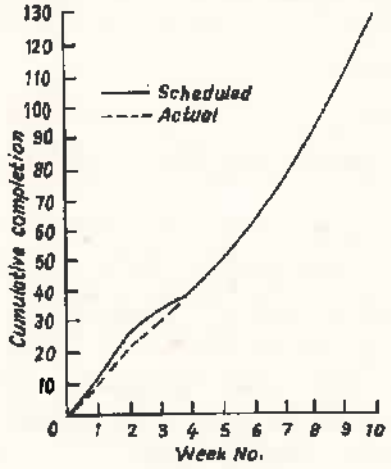


Fig. 7.33. Objective chart.

(2) Program Plan

- A chart of the operations required to complete one unit of the finished product is called the

program plan (Fig. 7.34).

- Each major row of activities is associated with one component of the final assembly.
- The final completion date is zero and the time scale runs from right to left. This plan shows that items *B* and *C* must be combined (operation 14) two days before completion. Item *C*, prior to this combination, undergoes two conversion operations, the second must be finished five days before final completion, and the first, two days before that. Purchase of the material for item *C* must be completed by ten days before final combination. The item with longest lead time, 17 days is *B*.
- The completed chart serves as a reference to the amount of lead time by which each event must precede final completion. Events must be completed by their respective lead times to maintain anticipated output.

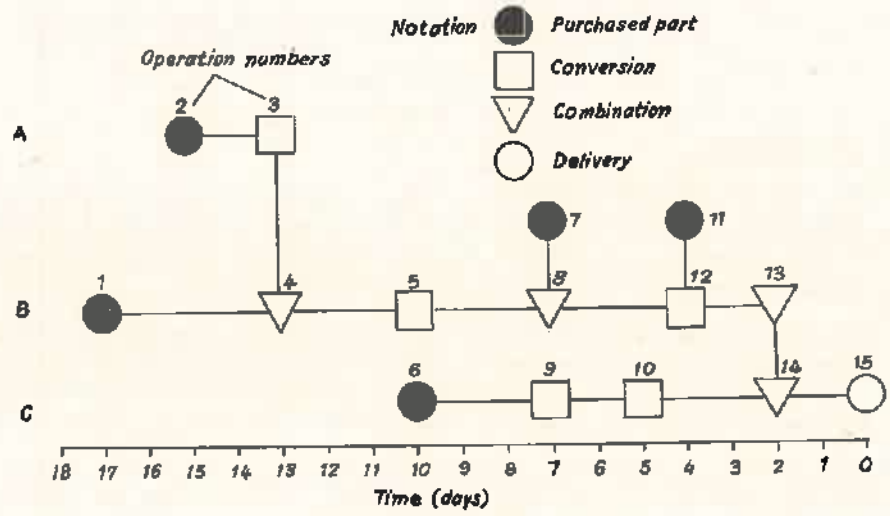


Fig. 7.34. Program Plan.

- *Objective chart* and *Program plan* are prerequisites for use of the LOB technique. They need to be constructed only once for any job, unlike the following documents *i.e.* (3) & (4) which must be constructed each time the schedule and progress is examined.

(3) Progress chart

- Progress chart shows the number of items which have been finished at each of the critical or important operations at a given date.
- Suppose, for example, the review date is week No. 4 (Fig. 7.33), by which, according to objective chart, 40 items should have been completed i.e. 40 items should have passed operation 15 (Fig. 7.35) of the program plan. The number of items that have completed this and each of the other operations can be obtained simply by checking inventory levels.

The results can then be depicted by means of a *histogram*. Fig. 7.34 shows the program progress chart at week No. 4.

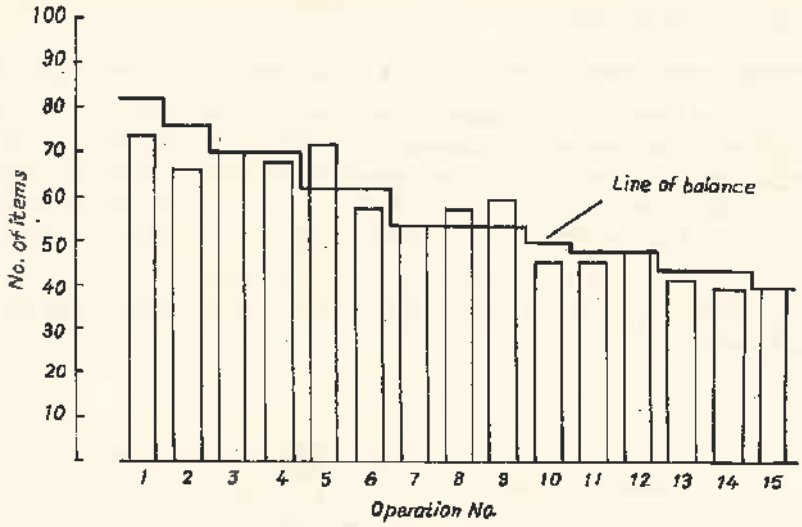


Fig. 7.35. Progress chart.

(4) Line-of-Balance

- Since the object of the exercise is to compare *actual progress* with *scheduled progress*, the information given in progress chart (Fig. 7.35) must be compared to required progress. This is done by constructing a *line* on the progress chart which shows the requisite number of items which should have been finished at each operation at the time of review.

- This *line*—the *Line-of-Balance*—can be constructed *analytically* or *graphically*, the latter method being perhaps the more convenient. The L.O.B. shows the total number of items which should have been finished at each operation. Clearly, since a cumulative completion of 40 items is required for week No. 4, a total of 40 items must have completed operation 15 by this date.

Operation 14 has a lead time of two days, consequently at week No. 4 sufficient items must have completed operation 15 to ensure that completion requirements two days later are satisfied.

From the objective chart the delivery for week No. 4 plus two days is 44 units (assuming five working days per week). The longest lead time—operation 1—is 17 days consequently at week No. 4 sufficient items to satisfy the delivery requirements for week No. 4 plus 17 days *i.e.* 82 units, should have finished. The graphic procedure shown in Fig. 7.36 is a convenient way of performing these calculations.

(5) Analysis of Progress

- In comparing required progress with actual progress it is again convenient to work backwards, beginning with the last operation (15). From Fig. 7.35 (progress chart) it is clear that the requisite number of completed items have been delivered to the customer (operation 15=40), a fact which is reflected by the actual performance line on the objective chart.

- If *shortage* occurs, we must obviously attempt to ascertain the reasons. If operations other than those considered as critical are the cause of shortages, then those operations must be included in subsequent versions of the progress and line-of-balance chart.

Advantages

The L.O.B. is a simple and useful planning and control technique, its main advantages being

(1) Like network analysis (PERT, CPM etc.), it formalises and enforces a planning discipline which in itself is useful.

(2) It is a simple but powerful procedure, which relies on several assumptions.

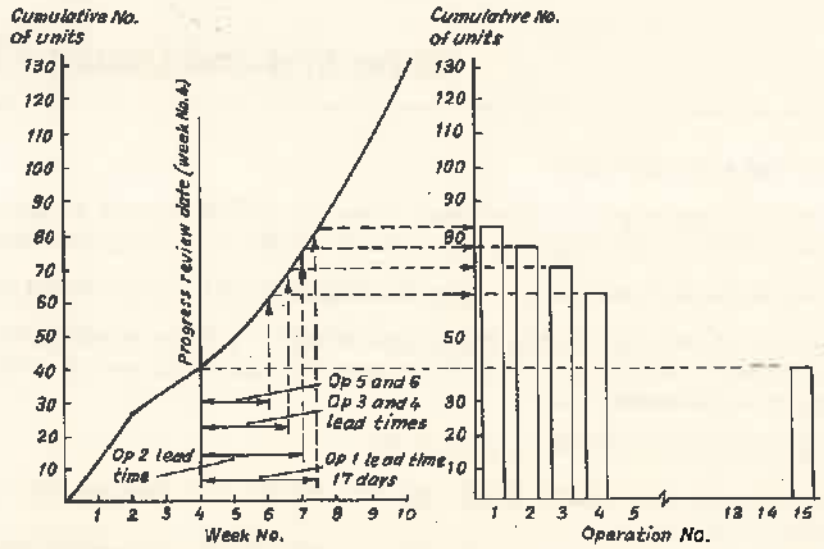


Fig. 7.36. Construction of a line of balance.

Applications/Uses

- In many larger manufacturing firms, LOB is no longer used, particularly since the development of MRPII(article24.11),which links shop floor control into an integrated system for material planning and control. However, LOB has some advantages in that it is more customer-oriented than MRP. Many small firms and nonmanufacturing organizations still find it a useful technique.
- LOB technique has also been computerized. Several computer programs have been written and use of these, particularly where many operations are involved and progress reviews are frequent, simplifies the application of lines of balance.

8

Inspection and Quality Control

8.1. DEFINITION AND CONCEPT

- An item or component or product which is manufactured is required to perform certain functions. The act of checking whether a component actually does so or not is called **Inspection.**
- In other words, *Inspection* means checking the acceptability of the manufactured product.
- Inspection measures the qualities of a product or service in terms of predecided standards. Product quality may be specified by its strength, hardness, shape, surface finish, chemical composition, dimensions, etc.

8.2. PURPOSES OR OBJECTIVES of Inspection are :

(*i*) Inspection separates defective components from non-defective ones and thus ensures the adequate quality of products.

(*ii*) Inspection locates defects in raw materials and flaws in processes which otherwise cause problems at the final stage. For example, detecting the parts not having proper tolerances during processing itself, will minimize the troubles arising at the time of assembly.

(*iii*) Inspection prevents further work being done on semi-finished products already detected as spoiled.

(*iv*) Inspection makes sure that the product works and it works without hurting anybody, *i.e.,* its operation is safe.

(*v*) Inspection detects sources of weakness and trouble in the finished products and thus checks the work of designers.

(*vi*) Inspection builds up the reputation of the concern as it helps reducing the number of complaints from the customers.

8.3. KINDS OF INSPECTION

(*a*) Roving, process, patrolling or floor inspection,

(*b*) Fixed inspection,

(*c*) Key-point inspection, and

(*d*) Final inspection.

(a) Roving inspection :

- The inspector walks round on the shop floor from machine to machine and checks samples of the work of various machine operators or workers.

– Floor inspection :

(*i*) helps catching errors during process itself, *i.e.*, before the final production is ready ; and

(*ii*) It is more effective and desirable because the work need not be transported to a centralized (inspection) place.

(*b*) ***Fixed inspection :***

– The work is brought at intervals for inspectors to check.

– Fixed inspection discovers defects after the job has been completed.

– Fixed inspection is used when inspection equipments and tools cannot be brought on the shop floor.

– It is a sort of centralized inspection, the worker and the inspector do not come in contact with each other ; thus it eliminates any chances of passing a doubtful product.

(*c*) ***Key-point inspection :***

– Every product (more or less) has a key point in its process of manufacture.

A key point is a stage beyond which either the product requires an expensive operation or it may not be capable of rework.

– Inspection at a key point segregates and thus avoids unnecessary further expenditure on poor and substandard parts, which are likely to be rejected finally.

(*d*) ***Final inspection :***

– The final inspection of the product may check its appearance and performance.

– Many destructive and non-destructive inspection and test methods such as tensile, fatigue, impact testing, etc., and ultrasonic inspection, X-ray radiography, etc., respectively, are available for final inspection of the products manufactured.

– Final inspection is a centralized inspection and it makes use of special equipments.

8.4. INSPECTION OF INCOMING MATERIALS, RAW OR RECEIVED MATERIALS

– Incoming raw materials are inspected in order to :

(*i*) eliminate those materials which do not meet specifications and are likely to cause trouble during processing ; and to

(*ii*) evaluate vendor's quality and ability to supply acceptable materials.

– Raw materials involving high transportation charges are checked by the buyer at vendor's end whereas others are inspected as soon as received at purchaser's plant.

– Inspection of raw materials may involve a visual check up only, a dimensional check, a test of physical properties and chemical composition, etc.

– Raw materials depending upon their characteristics and use may require a *Sampling Inspection* (refer Section 8.19) or *100% Inspection* (as in purchased aircraft component parts).

– After inspection, the right quality parts are sent either to stock room or assembly lines.

8.5. INPROCESS INSPECTION

– ***An effective inprocess inspection eliminates,***

(*i*) defects so that the subsequent operation is not badly affected ;

(*ii*) a defect which may be concealed in the final product (*e.g.,* after painting, etc.) ;

(*iii*) extra work from being performed on rejectable materials.

– ***Inprocess inspection is carried out by ;***

(*a*) Workers doing the job.

(*b*) Inspectors from the inspection department.

– ***Inprocess inspection may check,***

(*a*) A first few parts of the new machine set up, or a new operation.

(*b*) A part before it moves for the next operation.

(*c*) A part before it goes for an expensive operation.

(*d*) A part after a series of manufacturing operations.

(*e*) Parts before sub-assembly or final assembly.

(*f*) A part before it is being sent for plating or painting.

(*g*) A part before it moves to the next department.

– For inprocess inspection, the inspectors are stationed at specific stages in the manufacturing process.

– Automatic sizing and gauging equipments which can check a large number of dimensions simultaneously are sometimes built in the processing machinery. A feedback system automatically resets the machine to correct for the error measured by the automatic gauging equipments.

8.6. INSPECTION OF FINISHED GOODS

[refer to section 8.3 (*d*) also]

– An unthorough inspection of finished and final goods may permit faulty products to be dispatched to the customers, because it is the last chance of detecting imperfections in the products manufactured.

– The finished goods inspection is

(*a*) *Visual* to ascertain appearance and dimensions ; and

(*b*) *Functional* to ensure that the product will work to specification.

8.7. STATISTICAL QUALITY CONTROL—DEFINITION AND CONCEPT

Statistics. Statistics means data, a good amount of data to obtain reliable results. The science of statistics handles this data in order to draw certain conclusions. Statistical techniques find extensive applications in quality control, production planning and control, business charts, linear programming, etc.

Quality. Quality is a relative term and is generally explained with reference to the end use of the product. For example, a gear used in a sugar-cane juice extracting machine though not of the same material and without possessing good finish, tolerance and accuracy as that of a gear used in the head stock of a sophisticated lathe may be considered of good quality if it works satisfactorily in the juice

extracting machine. Thus, a component is said to be of good quality if it works well in the equipment for which it is meant. *Quality* is thus defined as fitness for purpose. Taking another example, a good quality car (wheel) lifting jack may prove itself a bad quality product when tried on a five or seven-and-a-half tonner (vehicle).

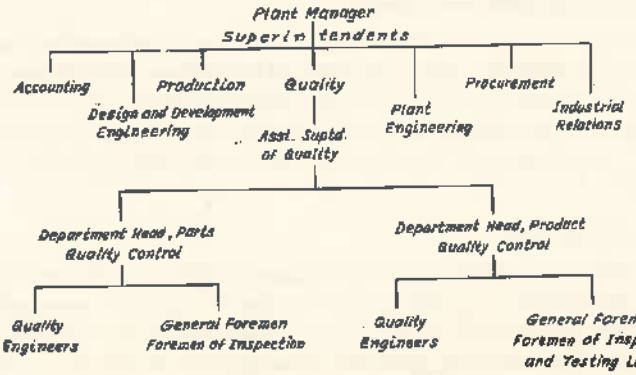


Fig. 8.1. Organization of an inspection department.

Control. Control is a system for measuring and checking (inspecting) a phenomenon. It suggests when to inspect, how often to inspect and how much to inspect. In addition, it incorporates a feedback mechanism which explores the causes of poor quality and takes corrective action.

Control differs from 'Inspection', as it ascertains quality characteristics of an item, compares the same with prescribed quality standards and separates defective items from non-defective ones. Inspection, however, does not involve any mechanism to take corrective action.

8.8. STATISTICAL QUALITY CONTROL : BASIC FUNDAMENTALS

A quality control system performs inspection, testing and analysis to conclude whether the quality of each product is as per laid quality standards or not. It is called statistical quality control when statistical techniques are employed to control quality or to solve quality control problems. Statistical quality control makes inspection more reliable and at the same time less costly. It controls the quality level of the outgoing products.

Using statistical techniques, S.Q.C. collects and analyses data in assessing and controlling product quality. The technique of S.Q.C. was though developed in 1924, it got recognition in industry only during second world war. The technique (S.Q.C.) permits a more fundamental control. It scientifically fixes the process tolerances.

The fundamental basis of statistical quality control is the theory of probability (discussed under Section 8.9). According to the theories of probability, the dimensions of the components made on the same machine and in one batch (if measured accurately) vary from component to component. This may be due to inherent machine characteristics or the environmental conditions. The chance or condition that a sample will represent the entire batch or population is developed from the theory of probability.

Relying itself on the probability theory, S.Q.C. evaluates batch quality and controls the quality of processes and products. S.Q.C. uses three scientific techniques, namely ;

1. Sampling inspection,
2. Analysis of the data, and
3. Control charting.

100% inspection as compared to sampling inspection is very tiring and costly. This being continuous and monotonous, the chances of error in inspection also get increased. On the other hand, if a random

sample is selected from a lot and relying on probability concept it is assumed to represent the lot, there is much saving in the cost and labour involved in inspection. Moreover in certain cases as tensile or fatigue testing or analysing the chemical composition of an alloy, sampling is left as the only method of inspection. Sampling plans control the average outgoing quality. The results are analysed by determining mean, range, standard deviation and the control limits for prefixed level of confidence. S.Q.C. also decides the size of the sample and describes its reliability.

As the control limits are plotted and individual observations marked on a graph paper it takes the shape of control chart (*See* Fig. 8.14). The jig-jag lines of the control chart present visually whether the quality of the product is improving or going down. Control charting keeps a continuous eye on the processes and machines. It immediately tells if any process or machine is getting out of adjustment. The causes leading to such conditions are explored and a corrective action is immediately taken to improve product quality.

8.9. PROBABILITY CONCEPT

The probability concept is important for an Industrial Engineer as it forms the basis of statistical quality control. The understanding of the probability theory becomes necessary in order to follow sampling Inspection and operation of control charts. Though there does not seem to be a commonly agreed precise definition for probability, generally speaking, there should be a numerical scale to make consistent measurements for comparing the probabilities of two or more occurrences. A probability generally refers to totality of possible occurrences. A probability is a mathematical measure of the likelihood of an occurrence. If m be the number of times a specific event occurs and n is total equally likely results of the trial, the probability of occurrence of this event is m/n. For example, if a bag contains 100 balls, 50 red and 50 black, and one ball at random is picked through the bag, the probability that it will be a red ball is 50/100=0.5 and the probability that it will be a black ball is again 50/100=0.5.

Addition Law of Probability. If events are mutually exclusive, that is, only one event can occur at a time, and the probability of occurrence of first event is p_1, of second event p_2, then the probability p of occurrence of first or second event is equal to p_1+p_2, *i.e.*, $p=p_1+p_2$ and also the sum of the probabilities of all such (mutually exclusive) events is equal to one. Taking the same example (as above) of a bag containing 50 black and 50 red balls, the probability of picking a red ball, $p_1=50/100=0.5$; the probability of picking a black ball, $p_2=50/100=0.5$; thus according to Addition Law of Probability, the probability p of occurrence of first event or second event is 0.5+0.5=1 that means there is full certainty or 100% probability or surety of occurrence of either of the two events, which is correct because there are balls of only two colours, red and black (in the bag). Moreover, the sum of probabilities of all mutually exclusive events should be = 1, which is also true.

Multiplication Law of Probability. According to this law, unlike that of addition, the events are mutually independent (and not mutually exclusive). Therefore, under this condition, the probability of the events occurring together or in a particular order is given by the product of the individual probabilities of the events.

Example 8.1 : If 4 dice (each having six faces and corresponding numbers 1 to 6 marked on them) are thrown, calculate the probability that all dice will show odd numbers (*i.e.*, 1, 3 or 5).

Solution. Out of six numbers, three are odd, *i.e.*, 1, 3, 5 and three are even, *i.e.*, 2, 4 and 6. Thus, the probability of occurrence of an odd number in each dice is 3/6=0.5. An odd number can occur on any dice or on all dice. Thus the probability that all the four dice will show odd numbers is

$$0.5 \times 0.5 \times 0.5 \times 0.5 = 0.0625.$$

The laws of probability explained earlier are related to single trials, *i.e.*, when one ball is drawn from the bag at a time and before conducting the next trial it (previously drawn ball) is put in the bag again.

If, however, instead of taking out one piece (ball), one has to draw a number of pieces at a time as in sampling inspection the following treatment will hold good provided a small number of pieces or

components are drawn (for inspection) from a large batch or lot.

Sampling. It means drawing a small number of components, for inspection, from a large size batch.

Assume a batch contains 10,000 piston pins out of which 150 are defective. A sample of 4 pins is drawn for inspection.

The probability for the first drawn pin to be defective

$$= 150/10{,}000 = 0.015$$

The probability for the second, third and fourth pins to be defective lies between 150/9,999 and 149/9,999, 150/9998, and 148/9998, and 150/9,997 and 147/9,997, respectively. All these probability values, *i.e.*, 150/10,000, 150/9,999, 149/9,999, 150/9,998, 148/9,998, 150/9,997 and 147/9,997 do not seem to differ much from each other and they can be safely assumed to be constant over the sample drawn. In other words, the probability of drawing a defective piston pin from a large lot, is constant for all components of the small sample drawn.

Let p be the probability of a component being defective,

and q be the probability of a component being non-defective.

Taking the above example.

$$p = \frac{150}{10{,}000} = 0.015 \text{ and } q = (1 - 0.015) = 0.985$$

(Since $p_1 + p_2$ or, here $p+q=1$).

For such cases where the probability of success, p, (*example :* drawing a defective component) and that of failure, q, (*example* : drawing a non-defective component from the lot) remain constant for all the components in the sample drawn in n trials (one piece is drawn in a trial, without replacing the previously drawn piece), the probability of achieving r successes is given by the term $p(r)$ of the Binomial Expansion of $(q+p)^r$

$$(q+p)^n = \sum_{r=0}^{r=n} {}^nc_r q^{n-r} . p^r$$

Therefore, $p(0) = q^n = (0.985)^4 = 0.941$(Approx).....(*a*)

$$p(1) = {}^nc_1 q^{n-1} p^1 = {}^4c_1 (0.985)^3 (0.015)$$

$$= \frac{4!}{(4-1)! \times 1!} (0.985)^3 (0.015)$$

$$p(2) = {}^nc_1 q^{n-2} p^2 = {}^4c_2 (0.985)^2 (0.015)^2$$

$$p(r) = {}^nc_r q^{n-r} . P_r$$

From Eqn. (*a*) above it can be inferred that, the probability of drawing a non-defective piston pin is 0.941. In other words, if a random sample of four pins is drawn from the batch of 10,000 piston pins, a non-defective pin will be found 9,410 times.

8.10. THE POISSON DISTRIBUTION

Concept

- The Poisson distribution appears frequently in the literature of management science and finds a large number of managerial applications.
- It is used to describe a number of managerial situations including the arrivals of patients at a health clinic, the distribution of telephone calls going through a central switching system, the arriving of vehicles at a toll booth, the number of accidents at a crossing, and the number of

looms in a textile mill waiting for service.

– All these examples have a common characteristic. They can all be described by a *discrete random variable* that takes on non-negative integer (whole number) values 0, 1, 2, 3, 4, 5 and so on ; the number of patients who arrive at a health clinic in a given interval of time will be 0, 1, 2, 3, 4, 5 and so on.

Characteristics

– Suppose we use the number of patients arriving at a health clinic during the busiest part of the day as an illustration of Poisson Probability Distribution Characteristics :

(1) The average arrival of patients per 15-minute interval can be estimated from past office data.

(2) If we divide the 15-minute interval into smaller intervals of, say, 1 second each, we will see that these statements are true :

(*a*) The probability that exactly one patient will arrive per second is a very small number and is constant for every 1-second interval.

(*b*) The probability that two or more patients will arrive within a 1-second interval is so small that we can safely assign it a 0 probability.

(*c*) The number of patients who arrive in a 1-second interval is independent of *where* that 1-second interval is within the larger 15-minute interval.

(*d*) The number of patients who arrive in any 1-second interval is not dependent on the number of arrivals in any other 1-second interval.

It is acceptable to generalize from these conditions and to apply them to other processes of interest to management. If these processes meet the same conditions, then it is possible to use a Poisson probability distribution to describe them.

Calculating probabilities using Poisson distribution. The probability of exactly x occurrences in a Poisson distribution is calculated using the relation

$$P(x) = \frac{\lambda^x e^{-\lambda}}{x!}$$

where $\lambda =$ the average (mean) of the distribution.

$x =$ the specific value of the discrete random variable in which we are interested.

$e =$ 2.718, the base of natural logarithms.

Example 8.2. Consider a small rural hospital where the past records indicate an average of 5 patients arrive daily. The demand for emergency room service at this hospital is distributed according to a Poisson distribution. The hospital incharge wants to calculate the probability of exactly 0, 1, 2, 3, 4 and 5 arrivals.

Solution.

$$P(x) = \frac{\lambda^x e^{-\lambda}}{x!}$$

$$P(0) = \frac{(5^0)(e^{-5})}{0!} = \frac{1 \times 0.00674}{1} = 0.00674$$

$$P(1) = \frac{(5^1)(e^{-5})}{1!} = \frac{5 \times 0.00674}{1} = 0.03370$$

$$P(2) = \frac{(5^2)(e^{-5})}{2!} = \frac{25 \times 0.00674}{2 \times 1} = 0.08425$$

$$P(3) = \frac{(5^3)(e^{-5})}{3!} = \frac{125 \times 0.00674}{3 \times 2 \times 1} = 0.14042$$

$$P(4) = \frac{(5^4)(e^{-5})}{4!} = \frac{625 \times 0.00674}{4 \times 3 \times 2 \times 1} = 0.17552$$

$$P(5) = \frac{(5^5)(e^{-5})}{5!} = \frac{3125 \times 0.00674}{5 \times 4 \times 3 \times 2 \times 1} = 0.17552$$

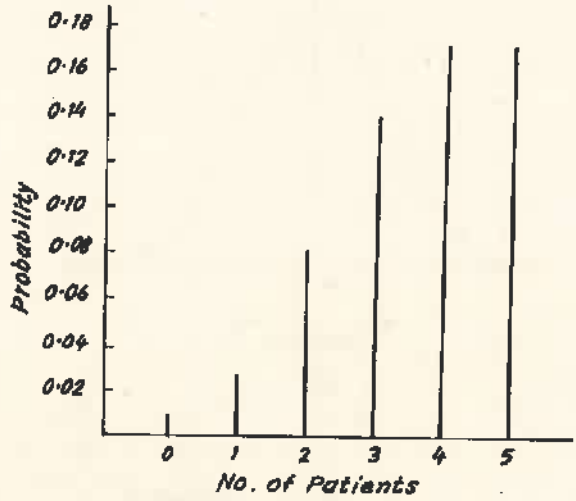


Fig. 8.2. Poisson probability distribution of demand for emergency room service (0 through 5 calls).

- Probability values for any number of calls (i.e. beyond 5 in this example) can be found by making additional calculations.

8.11. NORMAL DISTRIBUTION

Concept

- An important continuous probability distribution is the *normal distribution* or the *Gaussian* distribution.
- The most important distribution in statistics is the Normal Distribution. This distribution has a symmetric bell-shaped form and tends to infinity in both directions.
- The normal distribution occupies an important *place in management science* for two reasons :

(1) It has properties that make it applicable to a number of managerial situations in which decision-makers have to make inferences by drawing samples.

(2) The normal distribution comes quite close to fitting the actual observed distribution of many phenomena, including output from physical processes and human characteristics (*e.g.* height, weight, intelligence) as well as many other measures of interest to management in the social and natural sciences.

Characteristics

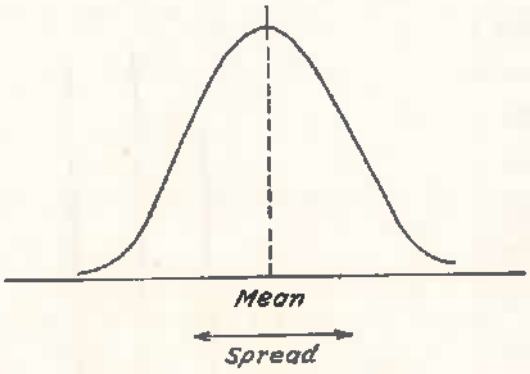
- Fig. 8.3 shows a normal distribution. The diagram indicates its several important characteristics :

(1) The curve has a single peak.

(2) It is bell shaped.

(3) The mean (average) lies at the center of the distribution and; the distribution is symmetrical around a vertical line erected at the mean.

(4) The two tails of the normal distribution extend indefinitely and never touch the horizontal axis.



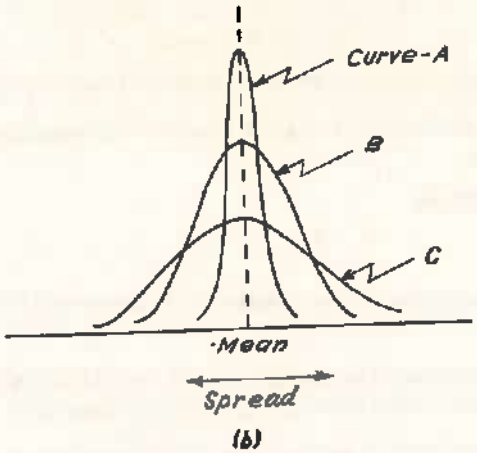


Fig. 8.3 (*a*) Normal Distribution Curve.

(*b*) Normal distribution curves having same mean but different spreads.

– Any normal distribution is defined by two measures : (*i*) the *mean* ($\bar{x}$) which locates the center, and (*ii*) the *standard deviation* (σ) which measures the spread around the center.

– *In Normal Distribution :*

Range of x : $-\infty$ to ∞

Density : $f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[\frac{-(x-m)^2}{2\sigma^2}\right]$

Mean : $\bar{x} = m$

Variance : Var $(x) = \sigma^2$

8.12. DISTRIBUTION PATTERN

Statistical quality control relies upon theory and concept of probability, and probability basically accepts the possibility of variation in all things. Generally, the variations occurring in (industrial processes or) products manufactured by an industry are classified as :

(*a*) Variations due to assignable causes, and

(*b*) Random or chance variations.

The variations (say in length or diameter of a component) which occur due to assignable causes possess greater magnitude as compared to those due to chance causes and can be easily traced. Various assignable causes leading to variations may be, differences amongst the skills of the operators, poor raw material and machine conditions, changing working conditions, mistake on the part of a worker (as in getting peculiar colour shade if he mixes different colours in wrong proportions), etc.

The chance variations occur in a random way and they can hardly be helped out as there is no control over them. For example, a random fluctuation in voltage at the time of enlargement (in photography) may produce a poor quality print. Chance variation is also due to some characteristics of the process or of a machine which function at random ; for example a little play betwen nut and screw at random may lead to back-lash and (hence operate the cutting tool accordingly) thus result in a different final machined diameter of every job. The non-homogenity (say difference in hardness along the length) of a long bar may result in difference in surface quality or finish. The chance factors effect each component in a separate manner. Chance factors may cancel effect of each other also. When accurately measured, the dimensions of most of the components will concentrate close to the middle of the two extremes. This is called *Central Tendency*. In other words the maximum number of components will have sizes equal to or approximately close to the middle size and the sizes bigger or smaller than the middle size will be least frequent and lie near the two extremes. When the measured sizes of all the products are plotted against the frequency of occurrence of each size, in the form of a graph and the curve is smoothened, it resembles bell shape (*See* Fig. 8.4) and approximates Normal Distribution curve. The example 8.3 given below, explains central tendency and frequency distribution curve.

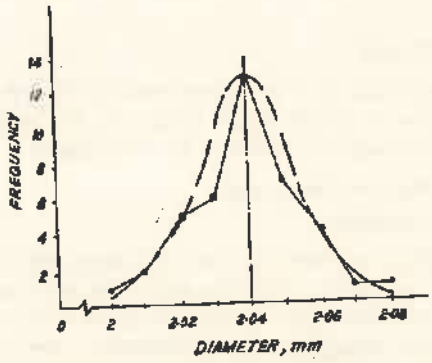
Example 8.3. 40 spindles were manufactured on a machine and their diameters in mm as measured are given below :

2.01	2.02	2.04	2.04	2.04	2.03	2.01	2.02	2.03	2.06
2.02	2.04	2.05	2.03	2.04	2.05	2.02	2.03	2.04	2.06
2.05	2.04	2.04	2.02	2.03	2.05	2.06	2.03	2.04	2.05
2.04	2.05	2.08	2.05	2.04	2.07	2.00	2.04	2.06	2.04

This data can be tabulated as follows :

Frequency Distribution Table

Dimension (Diameter, mm)	*Tabulation*	*Frequency*
2.00	|	1
2.01	||	2
2.02	𝍸	5
2.03	𝍸 |	6
2.04	𝍸 𝍸 |||	13
2.05	𝍸 ||	7
2.06	||||	4
2.07	|	1
2.08	|	1



Frequency polygon (firm lines).
Frequency distribution curve (dotted lines)—a bell shape curve which approximates Normal Distribution curve.

Fig. 8.4. Frequency polygon and frequency distribution curve.

The approximate normal distribution curve (of Fig. 8.4) shows the simplest 'pattern of distribution'. Depending upon the type of thing being measured there is generally a *Pattern of Distribution* that indicates the way in which a dimension can vary. Figure 8.4 shows an approximate normal curve divided in half and half about the mean size, *i.e.* (2+2.08)/2=2.04 mm, thereby indicating that there are approximately equal number of items smaller and larger than the mean size on either side of the normal dimension.

– Figure 8.5 shows a **Bar Chart** plotted from the data given in the frequency distribution table. A bar chart makes use of and places bars at different values of measured dimensions. The height of each bar is proportional to the frequency of particular measured dimension (*e.g.*, diameter).

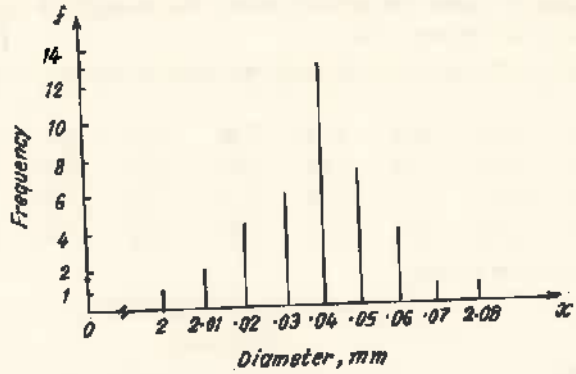


Fig. 8.5 A Bar Chart.

– Figure 8.6 shows a **Histogram** which is another way of presenting frequency distribution graphically. Histogram makes use of constant width bars ; the left and right sides of the bar represent the lower and upper boundary of the measured dimension respectively. The height of each bar is proportional to the frequency within that boundary ; for example, it can be seen from Fig. 8.6 that the frequency between 2.035 and 2.045 mm diameters is 13.

Various patterns of distribution are shown in Fig. 8.7. Such patterns generate under different circumstances as explained under :

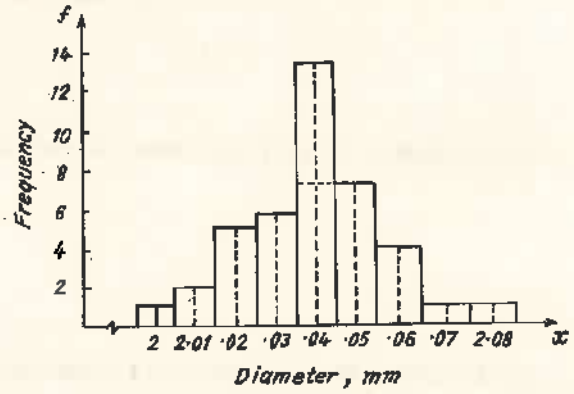


Fig. 8.6. Histogram.

1. Normal Distribution :

(*a*) Symmetrical – Producing items within tolerances, 1(*a*)-1

Producing items not within tolerances. 1(*a*)-2

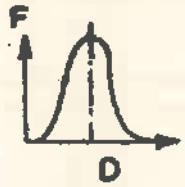
(*b*) Skewed,

(*c*) Leptokurtic.

(*d*) Platykurtic.

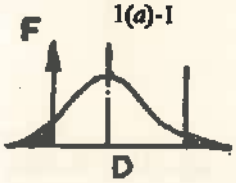
2. *Bimodal.*

3. *Triangular :*



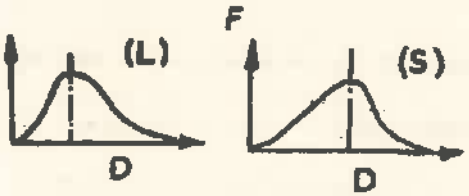
1(*a*)-1

1(*a*)-1 *Symmetrical.* This distribution pattern marks a stable process, producing items within tolerances.



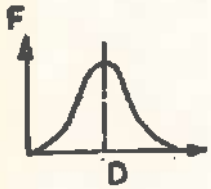
1(*a*)-2

1(a)-2 This distribution pattern is of a process which is stable but is not able to produce items within tolerances.



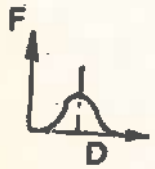
1(*b*)

(*b*) *Skewed.* The normal curve is pulled to one side. It shows that either there are more number of products larger (*L*) than the normal or smaller (*S*) than the normal.



1(c)

(c) *Leptokurtic.* It has peak higher than a normal curve.



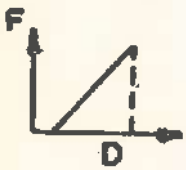
1(d)

(d) *Platykurtic.* It has peak lower than a normal curve.



2.

2. Bimodal. It has two peaks. Such a distribution pattern shows that either the products made on two different machines have got mixed up or the process is not stable.



3.

3. Triangular. The distribution pattern seems to be the result of a defective machine whose characteristics are changing in one direction with the passage of time.

Fig. 8.7. Distribution patterns.

8.13. CONFIDENCE LIMITS

The necessity of employing an interval (*i.e.*, confidence limits) instead a sample mean (*i.e.*, a sample value) has been explained in Section 8.16. The confidence or control limits are calculated with the help of a statistical measure known as standard deviation, σ, which is given by

$$\sigma = \sqrt{\frac{\Sigma (x-\bar{x})^2}{n}} \qquad ...(i)$$

where, $\bar{x}$ is the mean value of the x values for the sample pieces, $(x-\bar{x})$ is the deviation of an individual value of x, and n is the number of observations.

σ can be calculated easily by another relation also, given as under

$$\sigma = \sqrt{\left\{\frac{\Sigma fd^2}{n} - \left(\frac{\Sigma fd}{n}\right)^2\right\}}, \qquad \text{where } d = x-k$$

and k is any number, preferably the central value of x series where x represents the observed reading or measured values of say, diameters of the spindles, ohmic resistance values of resistors, etc. The following example will explain how to calculate standard deviation :

Example 8.4. Find $\bar{x}$ (mean) and σ.

x	f	$d=x-k^*$	fd	fd^2
5	5	−7	−35	245
7	10	−5	−50	250
10	15	−2	−30	60
12	20	0	0	0
15	14	3	42	126
18	11	6	66	396
20	6	8	48	384
	$\Sigma f=n$		Σfd	Σfd^2
	$=81$		$=41$	$=1461$

$$\bar{x} = k + \frac{\Sigma fd}{n}$$

$$= 12 + 41/81$$

$$\therefore \bar{x} = 12.5$$

$$\sigma = \sqrt{\frac{\Sigma fd^2}{n} - \left(\frac{\Sigma fd}{n}\right)^2}$$

$$= \sqrt{\frac{1461}{81} - \left(\frac{41}{81}\right)^2}$$

$$\sigma = 4.22$$

After calculating the value of standard deviation, σ, the upper and lower control limits can be decided. As shown in Fig. 8.8, 1σ limits occupy 68.27% of the area of the normal curve and indicate that one is 68.27% confident that a random observation will fall in this area. Similarly 2σ and 3σ limits occupy 95.45% and 99.73% area of the normal curve and possess a confidence level of 95.45% and 99.73%. For plotting control charts (in statistical quality control) generally 3σ limits are selected and they are termed as *control limits*. They present a band (MN) within which the average dimensions of (sample) components are expected to fall. 2σ limits are sometimes called *warning control limits*.

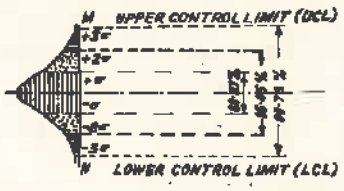


Fig. 8.8. Control limits.

8.14. MEASURES OF CENTRAL TENDENCY

– Most frequency distributions exhibit a *Central tendency i.e.* a shape such that the bulk of the observations pile up in the area between the two extremes, (Fig. 8.9). The measure of this central tendency is one of the two most fundamental measures in all statistical analysis.

– There are three principal measures of central tendency.

(i) Mean ($\bar{X}$)

– The mean is calculated by adding the observations and dividing by the number of observations.

For example : Patients treated on 8 days.

Day No.	1	2	3	4	5	6	7	8
No. of patients treated	86	52	49	42	35	31	30	11

$$\text{Mean} = \frac{\Sigma x}{N} = \frac{86 + 52 + 49 + 42 + 35 + 31 + 30 + 11}{8} = \frac{336}{8} = 42 \text{ patients}$$

– Arithmetic mean is used for symmetrical or near symmetrical distributions or for distributions which lack a clear dominant single peak.

* Assume $k = 12$ (the middle value of x)

– The arithmetic mean, X, is the most generally used measure in quality work. It is employed so often to report average size, average yield, average percent of defective etc., that control charts have been devised to analyze and keep track of it. Such control charts can give the earliest obtainable warning of significant changes in the Central value.

(ii) Median

– It is the *middle-most* or *most central* value when the figures (data) are arranged according to size. Half of the items lie above this point and half lie below it.

– It is used for reducing the effects of extreme values, or for data which can be ranked but are not economically measurable (shades of colours, odors etc.) or for special testing situations.

If, for example, the average of five parts tested is used to decide whether a life test requirement has been met, then the lifetime of the third part to fail can sometimes serve to predict the average of all five and thereby the decision of the test can be made much sooner.

– To find the median of a data set, just array the data in ascending or descending order. If the data set contains an odd number of items, the middle item of the array is the *median*.

– If there is an *even* number of items, the median is the average of the two middle items. In formal language, the

$$\text{Median} = \text{the}\left(\frac{n+1}{2}\right)\text{th item in a data array}$$

where n is number of items in the array

Example 8.5. *Data set containing odd number of items.*

Item in data array	1	2	3	4	5	6	7
Time in minutes	4.2	4.3	4.7	4.8	5.0	5.1	6.0
				↑ Median			

Example 8.6. *Data set containing even number of items.*

Patients treated in emergency ward on 8 consecutive days.

Item in data array	1	2	3	4	5	6	7	8
Number of patients	86	52	49	43	35	31	30	11

$$\text{Median} = \left(\frac{n+1}{2}\right)\text{th item in a data array} = \frac{8+1}{2} = 4.5\text{th item,}$$

that is, the average of 4th and 5th item $= \frac{43+35}{2} = 39.$

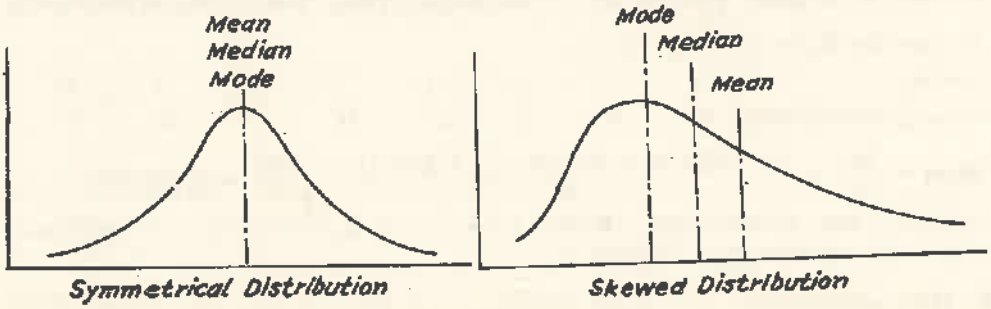


Fig. 8.9. Mean, Median and Mode.

Therefore, 39 is the median number of patients treated in the emergency ward per day during the 8-day period.

(iii) **Mode**

- It is the value which occurs most often in data set.
- It is used for severely skewed distributions, describing an irregular situations where two peaks are found, or for eliminating the effects of extreme values.
- To explain mode, refer to data given below which shows the number of delivery trips per day made by a Redi-mix concrete plant.

Trips arranged in ascending order for 20 days.

0	2	5	7	15
0	2	5	7	15
1	4	6	8	15
1	4	6	12	19

← The modal value is 15 because it occurs more often than any other value (three times).

- The modal value of 15 implies that the plant activity is higher than 6.7 (which is *mean)*. The mode tells us that 15 is the most frequent number of trips, but it fails to let us know that most of the values are under 10.

8.15. PROCESS AND MACHINE CAPABILITIES

Definitions

- A process capability study is a determination of the total *spread* of the process as determined by measuring the product produced under controlled conditions.

  The process capability is independent of the specification but is determined by (*i*) the condition of the machine, (*ii*) operator skill (*iii*) tooling (*iv*) type of operation and (*v*) raw materials used.
- The chance variables in a manufacturing process generate what is known as the *process capability* : that variation in product quality that is created by the manufacturing process.

Concept

- Every process has an inherent *variability* which can be evaluated by determining its *standard deviation* (σ) on the basis of a series of individual measurements for the quality characteristic under consideration.
- A controlled process can be expected to produce individual parts with measurements spread over a band 6σ units wide (*i.e.*, 3σ limits).

  For example, if a milling operation had a σ of 0.02 mm, the total spread for the process would be $6 \times 0.02 = 0.12$ mm. We would expect the thickest piece to be about 0.12 mm thicker than the thinnest one. If the process is going to be capable of meeting the specification tolerance, the specified tolerance must be at least as great as at ± 0.06 mm (a total spread of 0.12 mm), but for practical purposes should be ± 0.085 (a total spread of 0.17 mm) to allow for variations in set-up and tool wear.

Use

- The *process capability* or *machine operating accuracy* studies have been used to assure proper maintenance of machines.
- They have also been used as a basis for equipment replacement programs.

  The expense of a new, high-cost machine was saved for one company when it was shown that the

old machine had operating accuracy to meet specification requirements.

– *Process capability* analysis can involve a variety of *techniques* suitable for different problems. The simplest of all is to take a sample of consecutive pieces from a process, measure the characteristic under study, and plot the individual measurements in chronological order on a chart containing the tolerance limits.

– A complete *analysis of process capabilities* consists of five elements :

1. The specification tolerance.
2. The determination of whether the process average is *centered* midway between the tolerance limits.
3. Measurement of the inherent (piece to piece) variability of the process.
4. Measurement of the actual variability over a period of time.
5. Causes of the difference between inherent and actual variability.

– An effective way of making the analysis is by means of a control chart and a frequency distribution. A number of samples are taken over a period of time. Each sample consists of consecutively made pieces (to use as a basis for measuring piece-to-piece variability). The analysis proceeds :

(*a*) Calculate the average $\bar{X}$ and range R of each sample.

(*b*) Calculate the grand average $\bar{\bar{X}}$. This measures the centering (aim) of the process.

(*c*) Calculate control limits and plot average and range control charts (refer Fig. 8.10). This measures the stability of the process *i.e.,* the extent to which it changes with time.

(*d*) Calculate process capability as $\pm 3\sigma$ based on the *within* sample variation. This measures the piece-to-piece variability of the process. Its value is $3\bar{R}/d_2$ (where $\sigma = \bar{R}/d_2$)

Sample Size	d_2	*Sample Size*	d_2
2	1.128	6	2.534
3	1.693	7	2.704
4	2.059	8	2.847
5	2.326	9	2.970
		10	3.078

(*e*) Record all the individual values into a frequency distribution and histogram.

(*f*) Calculate the actual variability or spread as $\pm 3\sigma$ of the total data in the frequency distribution.

– Refer Fig. 8.10(*a*). Note that the control limits on sample averages are narrower than the tolerance limits on individual values because averages vary less than individuals.

– If the process is found to be *stable*, the spread (6σ) and capability will be approximately equal.

– If the process is *unstable*, the spread will be greater than the capability.

– If the capability (piece-to-piece variation) is within tolerance limits, then finding and eliminating the causes of the out-of-control points will remove the time-to-time variability, reduce the spread and solve the problem.

– If the capability is outside the tolerance limits [Fig. 8.10(*d*)] then only a basic process change or widening the tolerances will completely solve the problem.

Thus the combination of control charts of average and range, plot of individuals and histograms have complemented each other in the diagnosis of causes and remedies.

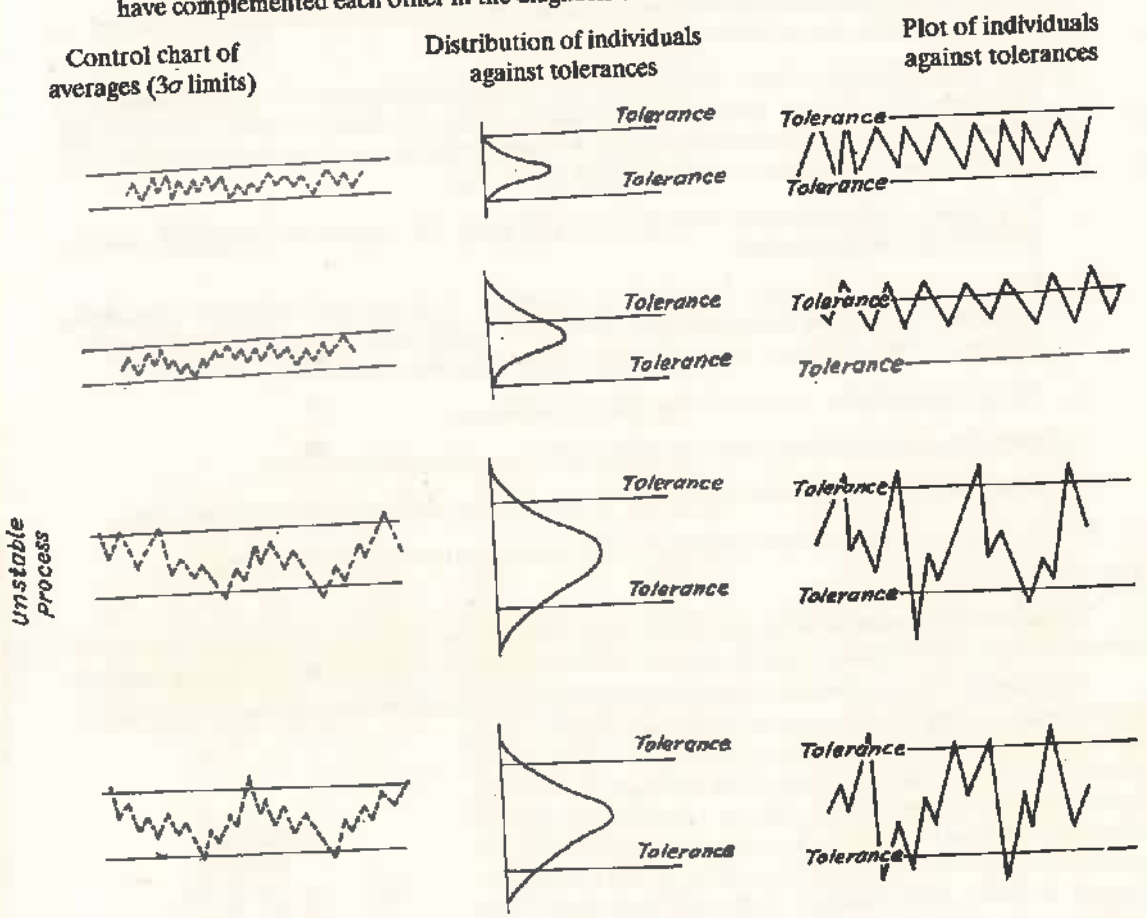


Fig. 8.10. Results of process capability analysis.

– In all cases the *process* is the combination of *machine, material, method* and *operator*. All these contribute to the final variation in the product.

Machine Capabilities

– Machines are generally designed to do something : develop linear or rotary motion, cut metal, govern speed etc. But repeated runs do not always give exactly the same results. The width of the band of such inherent variation is the important factor that determines the success of the working product.

– *Machine capabilities* change with time, and because the change can take place in a relatively short time period, this possibility should be constantly in the mind of the engineer.

– *Affecting machine capability*, sometimes to a marked degree, are such things as machine wear, tool wear, lubrication and coolant conditions, the operators, and the machinability of the

material.

Hence the machine capability determined at one time may or may not be an indication later on of the inherent ability to hold to a tolerance.

— It generally is not too difficult to determine the change(s) to bring about a marked reduction in the supposedly inherent variation of a machine's results. The best an engineer can do in this direction is to reduce, by technical changes, the largest components of variation until these *three* are about equal, *within-unit, unit-to-unit,* and *time-to-time.*

Any further improvement in machine capability would involve a major change in machine design or operating principle.

— Before selecting and buying a machine, one should know whether the machine he is specifying is adequate to hold the design tolerance (assuming normal operation and maintenance of the process). Several methods are in use for determining machine capability :

1. Try out of product as made by the machine in actual use.
2. Measurement (*i.e.* testing) of the machine itself as in case of machine tools.
3. Measurement of the product (turned out by the machine) against the product tolerances.
4. Measurement of the process capability of the machine in terms of 6σ of its product.

8.16. ESTIMATION

Statistical quality control tells what should be the sample size and how much reliable will be that sample. In other words, a criteria can be decided on the basis of which a lot will be accepted or rejected.

A common thing in statistics is the *Estimation* of parameters on the basis of a sample. A sample mean is generally not enough as its value may not be same as the mean size of the total lot, out of which the sample is drawn. Thus it is better to indicate the reliability of the estimates and provide limits which may be expected to contain the true value. An example will clarify the point. Let a batch of spindles contain 100 pieces. Diameter of each spindle is measured and the mean batch diameter is found as 3.48 mm. Next, a sample of five spindles is picked from random places in the lot, their diameters are measured and mean sample diameter is calculated. In rare cases it may be the same as mean batch diameter, (*i.e.*, 3.48 mm) otherwise not. Considering this, it seems appropriate to attach limits to mean batch diameter, (like 3.48±0.03 mm), that is 3.51 mm and 3.45 mm will be the two sizes in between which if the size of a spindle lies, the spindle will be accepted otherwise rejected. These two sizes represent confidence limits which can be found by knowing the area under the normal curve which the two sizes (3.51 mm and 3.45 mm) occupy.

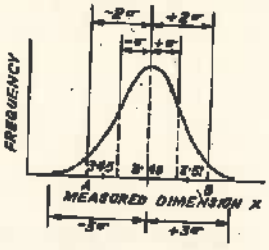


Fig. 8.11. Confidence limits.

Assume that the two values of X are such that they lie at A and B (*See* Fig. 8.11). It shows 95.45% confidence level which means that there is only 4.55% chances that the random observation (measured dimension of the spindle) will not represent the facts or it will not fall between the selected batch mean diameter limits. The greater the value of σ the wider will be the distance AB for the same confidence level.

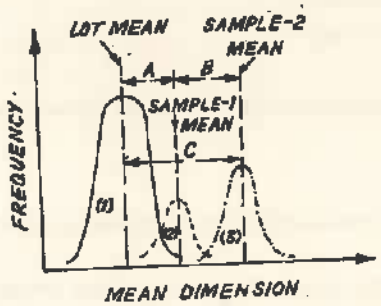
The following relationship determines sample size for a particular level of confidence.

$$s.p = C\sqrt{\frac{p\,(1-p)}{N}}$$

where s = The desired accuracy of results (say ±5%),
p = % of occurrence (expressed as decimal),
N = sample size,
C = 1 for a confidence level of 68.27%,
1.96 for a confidence level of 95%,
2 for a confidence level of 95.45%,
and 3 for a confidence level of 99.73%.

8.17. SIGNIFICANCE TESTING

Introduction. Significance tests are employed to make decisions on the basis of small information available from the samples. With all such decisions an amount of risk is involved. Consider a lot or batch of piston pins to be inspected for their diameters. A sample of say 5 piston pins is drawn at random from the lot, diameters are measured and sample mean is averaged out. Another sample of 8 piston pins is drawn and again sample mean is calculated. Lastly the whole lot is inspected as regards its diameter and mean lot diameter is found out. It will be observed that, not necessarily the mean of sample 1, sample 2 and the lot will have the same value. The chances for such a coincidence are very little. So the question arises how big the difference between the mean of one sample and the other, or of one sample and the lot must be so that it can be called *Significant*. Figure 8.12 shows the difference between the means of two samples (mentioned above) and the lot. It appears as if distributions (1) and (2) belong to the same population whereas (1) and (3) are significant distance apart.



A. difference between lot mean and sample 1 mean.
B. difference between sample 1 mean and sample 2 mean.
C. difference between lot mean and sample 2 mean.

Fig. 8.12. Significance testing.

The lot mean has its own standard deviation and the two sample means have their own values of standard deviation. The following relation connects the values of standard deviation of the sample and the lot

$$\sigma_s = \frac{\sigma_L}{\sqrt{n}},$$ where σ_s is standard deviation of the sample mean.
σ_L is the standard deviation of the lot distributions.
and n is the size of the sample.

It is not difficult to find the probability that a sample mean will be $K\sigma$ (K times the standard deviation) away from the lot mean, where K is a number.

Procedure. In significance testing first of all a hypothesis is set which is then tested. The hypothesis can be—the mean tensile strengths of the pieces taken from existing and modified ferrous alloys are not different. This hypothesis will next be rejected or accepted. The samples from the two ferrous alloys will be tested as regards their tensile strengths and statistics will be computed from the measured strength values.

The criteria for the rejection of hypothesis depends upon the difference (distance) between the lot mean and the sample mean or sample to sample mean. Depending upon the actual problem, the rejection may be made if this distance exceeds the significant value or it is less than the significant value. For example, an existing ferrous alloy contains alloying elements *A*, *B* and *C* and a number of pieces of this alloy (samples) when tested give a tensile strength of *X* tonnes/cm^2. The alloy is modified by the further addition of an element *D* and when again a number of pieces of the modified alloy are tested, a mean strength of *Y* tonnes/cm^2 is observed. Now, the modified alloy will be accepted only if it can take fairly high tensile load as compared to the previous alloy. In other words, the two samples means (*See* Fig. 8.12) must be significant distance apart in order to prove that the modified alloy is better.

Take another example ; from the same lot two or more samples are selected, their dimensions are measured and sample means calculated. Naturally the lot will be accepted only when the means of samples are close to one another and the distance between them does not increase beyond the signicant value.

– The value of the significant (distance) difference depends upon :

(*a*) Standard Deviation or the variability of the size or dimension (say diameter in case of piston pins). The greater the standard deviation, for a difference (between the means) to be significant, it (difference) should be more.

(*b*) Sample size (number of pieces in one sample). The larger the sample, for a difference to be significant, it (difference) should be smaller.

(*c*) *Level of significance.* It indicates the level (0.1%, 5%) at which the difference is significant.

– Three variations under significance testing can be considered :

(*a*) Testing two random samples as regards their sample means.

(*b*) Testing a sample mean against a lot mean.

(*c*) Testing sample means of two samples, one being manufactured by the existing process and the other by the modified process.

– Four different *cases* can be analysed :

(*a*) Testing the difference between sample mean and lot mean employing bigger sample size (say containing more than 25 pieces).

(*b*) Testing the difference between sample mean and lot, population, or true mean, employing small sample size (say containing less than 25 pieces).

(*c*) Testing the difference between sample mean and the mean of another sample from another lot employing large sample size.

(*d*) Testing the difference between sample mean and the mean of another sample from another lot employing small sample size.

The case (*a*) above, has been discussed in the following example :

Example 8.7. An accurate saw was supposed to cut pieces from a bright M.S. bar in normal lengths of 3.4 mm. After some time it was found that instead the nominal value, it was cutting pieces of 3.48 mm length. Twenty-five pieces were tested for significance. They had a mean of 3.48 mm and a standard deviation of 0.12 mm. Test the significance and decide whether the hypothesis that the pieces cut afterwards were oversized is true or not.

Solution. A sample containing 25 pieces or more can be regarded as a large sample and thus the relation for finding the significance level *t* is as follows :

$$t = \frac{\bar{X} - \bar{x}}{\frac{\sigma}{\sqrt{n}}} \qquad \text{...(1)}$$

where $\bar{X}$ is lot or population mean,

$\bar{x}$ is the sample mean,

σ is standard deviation,

n is the sample size,

and $\frac{\sigma}{\sqrt{n}}$ is standard error of mean

As given in the problem, $\bar{X}$=sample mean (since there is no lot mean)

$= 3.48$ mm

$\bar{x} = 3.40$ mm

$\sigma = 0.12$ mm

and $n = 25$

Substituting the values in equation (1) above

$$t = \frac{3.48-3.40}{\frac{0.12}{\sqrt{25}}} = 3.33 \qquad \text{...(2)}$$

It can be proved that

(*a*) t=1.96* indicates *just significant* level,

(*b*) t=3.09 indicates *very significant* level, and

(*c*) t=3.5 indicates *very very significant* level.

Coming to the problem, the value of t as calculated above in equation (2) is 3.33 which indicates a very *significant* level and hence the hypothesis that the pieces cut afterwards were oversized is true.

8.18. ANALYSIS OF VARIANCE

Variance is the square of standard deviation,

$$\text{Variance} = \sigma^2 = \left[\frac{\Sigma fd^2}{n} - \left(\frac{\Sigma fd}{n}\right)^2\right]$$

Analysis of variance is a very powerful technique in the discipline of Experimental statistics. It solves those problems where, even t-test (described in significance testing) is unable to make clear which, of the many significant differences, really indicate the true differences. Moreover, analysis of variance can be very much used for analysing the results of enquiries conducted in the field of industrial engineering, agriculture, etc. There can be

(*a*) Variance *between* varieties or variance between treatments (*i.e.*, alloy making), and

(*b*) Variance *within* varieties or variance within treatments.

In other words there is variance between different treatments and variance between the samples having the same treatment.

The variance within the treatments is smaller than the variance between the treatments and always there is some cause if a good amount of difference between the variances is seen.

The following example will clarify the procedure of analysis of variance and for testing the significance of differences.

* 1.96σ limits give a confidence level of 95% and the chance of a sample being outside the 1.96σ limits is 100−95%=5%.

Example 8.8. Two different treatments X and Y were given to an alloy. When three pieces with each treatment were tested they gave the following properties (values). Formulate a table of analysis of variance and find out the significance of difference between the properties of two treatments.

Treatments	*Properties*		
	Sample 1	*Sample 2*	*Sample 3*
X	20	22	12
Y	12	10	8

Solution. First of all the variance between and the variance within the treatments is calculated. The following table is formed.

Mean properties of all treatments $= \dfrac{20 + 22 + 12 + 12 + 10 + 8}{6}$

$= 14$

Treatments	*Samples*	*Properties of samples*	*Mean properties of treatments*	*Deviation of properties of each treatment from its mean property*	*Square of deviation*	*Deviation of mean property of each treatment from the mean property of both treatments*	*Square of Deviation*
	1	20		20−18=+2	4	18−14=4	16
X	2	22	$\dfrac{20+22+12}{3}$	22−18=+4	16		
			$=18$				
	3	12		12−18=−6	36		
	1	12		12−10=+2	4	10−14=−4	16
Y	2	10	$\dfrac{12+10+8}{3}$	10−10=0	0		
			$=10$				
	3	8		8−10=−2	4		
					64*		32

And, sum of squares of deviations for, between treatments

$= 32 \times$ No. of samples in a treatment $= 32 \times 3$

$= 96.$

The number of degrees of freedom for, between the treatments (n_b) and for, within the treatments (n_w) are given by

$n_b = (r-1)$

$n_w = r(n-1)$, where r is the number of treatments and n is the number of samples in each treatment.

$n_b = (2-1) = 1$

$n_w = 2(3-1) = 4$

Referring to the table of 5% point of the F distribution**, the value of F for $n_b = 1$ and $n_w = 4$, is 7.71 ...(i)

* Sum of squares of deviations for, within treatments, *i.e.*, 64.

** Statistical tables and formulas by A. Hald, John Wiley & Sons.

The next step is the formulation of the table of analysis of variance.

Case	*Sum of squares of deviations (a)*	*Degrees of freedom (b)*	*Mean square of variance, (a)/(b)*
Within treatments	64	4	64/4=16
Between treatments	96	1	96/1=96

From this table

$$\frac{\text{Variance between treatments}}{\text{Variance within treatments}} = \frac{V_b}{V_w} = F = \frac{96}{16} = 6 \qquad ...(ii)$$

Comparing (*i*) and (*ii*) above ; the 5% value of F for n_b and n_w degrees of freedom is 7.71 which is more than the calculated value 6, *i.e.,* (*ii*). Hence the difference of properties in the treatments is not significant.

8.19. SAMPLING INSPECTION

A *Sample* may be defined as the number of items or component parts, drawn from a lot, batch or population (for inspection purposes).

Inspection. Any item or component or product which is manufactured is required to perform certain functions. The act of checking whether a component actually does so or not is called inspection. In other words, Inspection means checking the acceptability of the manufactured product. The act of inspection serves two purposes. First, it separates defective components from non-defective ones and thus ensures the adequate quality of the product. Secondly, inspection locates defects in raw materials and flaws in processes which otherwise cause problems at the final stage. For example, detecting the parts, not having proper tolerances during processing itself will minimize the troubles arising at the time of assembly.

Sampling. Sampling is an act of drawing samples from a batch on random basis. Sampling depends upon statistical probability and therefore samples must be collected from all sides and different depths of the box containing the lot or batch (of component parts) so that every part has an equal chance of being selected. The samples should be collected at regular intervals (say every hour, every four hour, everyday, etc.) from the entire production run. The purpose is to obtain a sample truly representative of the lot.

The *Sample Size* normally increases with the lot size and depends upon the degree of quality to be assured. The sample size can be found from the preformulated statistical tables. The following relation, also, serves as a good guide for calculating sample size—which is equal to $\sqrt{2N}$ where N is the batch or lot size.

Sampling Inspection. Sampling inspection is a technique to determine whether a lot or population should be rejected or accepted on the basis of the number of defective parts found in a random sample drawn from the lot. If the number of defective parts exceed a predefined level, the lot is rejected.

As compared to 100 *Percent Inspection*, the sampling inspection claims the following :

Advantages

(*a*) It involves less amount of inspection to achieve a predecided degree of certainty about the quality.

(*b*) It consumes less time, and is less expensive.

(*c*) Fatigue and boredom incurred by the inspectors is much less, hence their operating efficiency remains high.

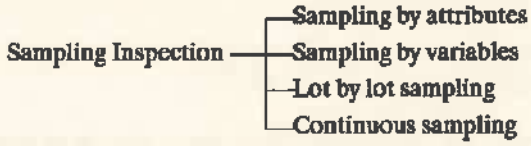
(*d*) It is more accurate because in 100 percent inspection, errors get introduced because of the fatigue and boredom incurred by the inspectors due to large inspection work of repetitive nature.

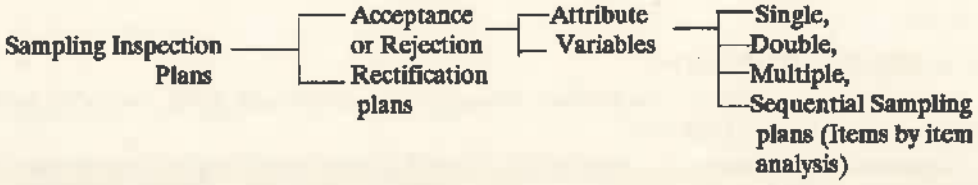
(*e*) Since fewer pieces are inspected, no damage is done to the remaining pieces of the lot as they are not handled.

(*f*) In certain cases where the components are to be inspected by destructive testing or where a powder is to be chemically analysed, 100 percent inspection can never be employed.

(*g*) Rejection of a complete batch on the basis of a sample decidedly pressurizes for improvements in quality.

Classification. Sampling inspection and sampling plans may be classified as follows :





(Acceptance) Sampling Inspection by Attributes

Introduction. Attribute (Yes or No) inspection is used to differentiate between a defective and a non-defective part and the part is rejected or accepted without using quantitative measures. For example, if out of a sample taken from a lot a predefined number of bullets fire, the lot is accepted otherwise rejected. Attribute inspection is very important and also very common. The parts can be inspected at an isolated calm place away from the production floor. Firstly, *attribute inspection is used* where components are obviously defective and non-defective. Secondly, where it is very difficult and costly to measure the quality characteristics of a product, *e.g.,* measuring the quality of paint on a refrigerator. Thirdly, attribute inspection finds applications where the manufacturer does not see any need to measure the exact job dimensions and he feels that *go* and *no go* type of inspection can serve his purpose—as in shafts, spindles or rings. The greatest amount of sampling inspection is done using attributes.

Suppose a (manufactured) lot contains N components. The purchaser would like that the lot should contain no defective components but the manufacturer knows that under normal conditions the defective parts are not likely to be eliminated completely. Ultimately manufacturer and purchaser strike a balance and come to an agreement that if the lot contains more than say X number of defective components, the lot will be rejected. One way to find the number of defective parts is 100% inspection which is costly and this cost again in one way or the other is recovered from the purchaser. Considering the above, both parties bring sampling inspection into the picture.

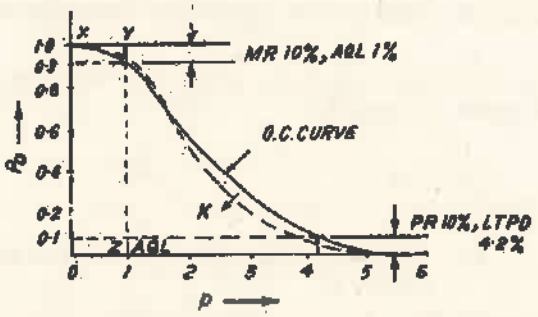
By going into the details, one finds that there is always some probability or doubt associated with the sampling inspection. A sample not necessarily always represents the true condition of the lot as it gets biased due to the human element involved in drawing the sample from the lot. It is quite possible that by chance the sample may contain all good components, but the remaining pieces in the lot may have a big number of defective components or all the sample pieces may turn out to be defective but otherwise the lot may be excellent. So it involves a risk both to the purchaser as well as to the manufacturer. But, certain risk will have to be borne by the two parties if they go for sampling inspection. These risks are plotted on a graph and the result is *Operating Characteristic (O.C.) Curve*, (*See* Fig. 8.13).

Steps Involved in Inspection by Attributes

1. Select a Sampling Plan. The first thing is to fix the proportion defective which will decide whether to accept a lot or to reject it. A purchaser always thinks about the cost of making a wrong decision, *i.e.*, the loss he will have to bear in case he accepts a bad lot on the basis of a good sample. By changing the parameters (a and n) of an O.C. curve he can easily choose the most appropriate curve for him, the one which involves minimum purchaser risks.

Figure 8.13 shows an operating characteristic curve.

(*a*) *Manufacturer's Risk.* It is the small probability of a batch being good or even better than A.Q.L. but yielding a bad sample and thus getting rejected. In other words it is the probability of rejecting a good lot which otherwise would have been accepted.



Manufacturer's risk 10%, *AQL* 1%

P_a : Probability of batch getting accepted.
p : Percent defective
AQL : Acceptable Quality Level
LTPD : Lot Tolerance Percent Defective.
PR : Purchaser's risk.
R : Manufacturer's risk.

Fig. 8.13. Typical operating characteristic curve.

(*b*) *Purchaser's Risk.* It is the probability of a lot being bad or even worse than the limiting quality but yielding a good sample and thus getting accepted. In other words it is the probability of a defective batch being accepted which otherwise would have been rejected.

(*c*) *Acceptable Quality Level (A.Q.L.).* It indicates a small proportion of bad components in a lot such that the lots having less than this proportion of bad components have a high probability of getting accepted.

(*d*) *Lot Tolerance Percent Defective (L.T.P.D.) or Limiting Quality (L.Q).* It indicates a small proportion of bad components somewhat larger than Acceptable Quality level in a lot such that the lots having more than this proportion of defective components have a small probability of getting accepted.

If a batch contains N pieces and a sample containing n of them is taken out, the batch will be accepted if the number of defective pieces (d) do not exceed the acceptance number (a). If the batch size is large as compared to sample size, which is commonly the situation in industrial applications, the operating characteristic curve is independent of the batch size. However (n) and (a) influence the shape of an O.C. curve. As n or a both increase, the O.C. curve shifts inside towards K (*See* Fig. 8.13). The dotted inner curve is for a greater value of n as compared to that of the outer O.C. curve.

2. Determine the Operating Characteristic Curve for the Chosen Sampling Plan. As described in step-1, a single sampling plan involves two parameters, (n)—the sample size and (a)—the acceptance

number ; and a batch is rejected or accepted depending upon the criteria whether the number of defective components d in a sample (of n components) is more than the acceptance number (a) or not.

The shape of operating characteristic curve depends upon the value of (a) and (n) and accordingly it defines the risks involved or the probabilities of a good lot being rejected and a bad lot being accepted. A balance has to strike regarding the value of n. A large sample size raises the cost of selecting, handling and inspection. A small sample size does not truly represent the lot ; the O.C. curve shifts away from the ideal curve ($OXYZ$) (*See* Fig. 8.13) and the chances of error increase.

The concept of ideal O.C. curve having rectangular operating characteristics ($OXYZ$) (See Fig. 8.13) is that the lots having not more than 1% defective components will definitely be accepted and others with more than 1% (defectives) will certainly be rejected.

The following example will explain how to calculate the probability of a lot being accepted or rejected.

Example 8.9. Find the probability of a lot being accepted if it has a coming quality 5% defective, a sample size of 40 and an acceptance number 1.

Solution.

Given $p = 0.05$

$n = 40$

$a = 1$ and since for being accepted d should not exceed a, therefore, $a = d = 1$.

We know from Section 8.9 that

$$P = \sum_{r=0}^{r=a} {}^{n}c_r \; q^{n-r} p^r \quad : \text{ changing it as per symbols used above,}$$

$$p = \sum_{d=0}^{a} {}^{n}c_d p^d (1-p)^{n-d}, \text{ since } r = d, \text{ and } q = (1-p)$$

Therefore,
$$P = \sum_{d=0}^{1} {}^{40}c_d \; (0.05)^d (0.95)^{40-d}$$

Expanding it,

$$P = (0.95)^{40} + \frac{(40)!}{(39)!\,(1)!} (0.05)^1 (0.95)^{39}$$

$$= (0.95)^{40} + (40 \times 0.05)\,(0.95)^{39}$$

$$P = 0.39905 \qquad \text{... (i)}$$

The probability can also be found from the 'Statistical tables of cumulative Binomial Probabilities'. For

$n = 40$

$a = 1$

and $p = 0.05$

the value of probability is 0.3991 and thus it is very much the same value as calculated in (i) above.

Sampling by Variables. When inspection is carried out by measuring the quality characteristics of a product, for example its dimensions, *i.e.*, diameter, length, thickness, weight, etc., it is called Inspection by Variables.

Variables involve the averages of measurements whereas attributes deal with percentages of parts rejected. Inspection using variables is mostly done on the shop-floor and is important for the control of operations.

Inspection using variables is more detailed, contains more information, but involves higher inspection and other costs, per unit, as compared to attribute inspection.

The manufacturer has to decide at some stage-which inspection to use, of course depending upon the requirements of his product.

8.20. SAMPLING PLANS. Sampling plans using attribute or variables are :

(*a*) *Single Sampling Plans.* A lot is accepted or rejected on the basis of a single sample drawn from that lot.

(*b*) *Double Sampling Plans.* If it is not possible to decide the fate of the lot on the basis of first sample, a second sample is drawn and the decision is taken on the basis of the combined results of first and second sample.

(*c*) *Multiple Sampling Plans.* A lot is accepted or rejected based upon the results obtained from several samples (of parts) drawn from the lot.

(*d*) *Sequential Sampling Plan (Item by item analysis).* Sequential sampling involves increasing the sample size by one part at a time till the sample becomes large enough and contains sufficient number of defectives to decide intelligently whether to accept or reject the lot.

Other aspects of sampling inspection are :

(*a*) *Rectification Plans.* Under such plans, lots rejected by acceptance sampling procedure are subjected to 100% inspection in order to separate defective pieces from non-defective ones. The defective pieces may be rectified, if possible, or replaced.

(*b*) *Lot by Lot Sampling Inspection.* The components are formed into lots and each lot is accepted or rejected on the basis of the quality of one or more samples drawn from the lot. The pieces in the samples may be inspected by using variables or attribute data.

(*c*) *Continuous Sampling Inspection.* In this system the current inspection results give an idea whether to go for sampling inspection or 100% inspection (*i.e.*, screening inspection) for inspecting the next items.

(*a*) Single Sampling Plan

– Under this plan, a lot is accepted or rejected on the basis of a *single* sample drawn from that lot.

– *Method*

1. Draw a single sample of size n *i.e.* of n component parts. The sample size may either be

– calculated, or

– found from tables.

2. Inspect the sample and find the number of defective components.

3. If defective pieces exceed the acceptance number C, the lot is rejected and *vice versa*.

4. In case the lot is rejected, inspect each and every piece of the lot and replace the defective parts or salvage and correct the defective parts.

– *Calculation of sample size*

Given AQL or $p_1 = 2\%$

$LTPD = 9.2\%$

(For concept of AQL and $LTPD$ refer section 8.19)

$$\therefore \text{ Operating ratio, } R_o = \frac{LTPD}{AQL \text{ (or } p_1)} = \frac{9.2}{2} = 4.6$$

From Table 8.1, for $R_o = 4.6$; Acceptance number $C = 4$ and $np_1 = 1.97$

TABLE 8.1

(Producer's risk = Consumer's risk = 5%)

R_o	C (or a)	np_1
4.6	4	1.97
4.0	5	2.61
3.6	6	3.29

Thus sample size $= \frac{np_1}{p_1} = \frac{1.97}{2\%} = 99.$

– *Determination of sample size from the table (8.2)*

TABLE 8.2

Lot size	*Sample size*	*Allowable percent defective*				
		1	*2*	*3*	*4*	*5*
		C	*C*	*C*	*C*	*C*
up to 499	75	1	2	3	4	5
500–799	115	2	3	4	6	8
800–1299	150	3	4	5	8	10
1300–3199	225	4	5	8	11	14
3200–7999	300	5	7	10	14	18
8000–21999	450	6	9	14	20	26

For a lot size of 850 and allowable percent defective 3%.

Table 8.2 gives a sample size of 150 and acceptance number, c as 5.

This means from the lot containing 850 parts, at random pick up 150 parts, inspect them and find out the number of defective pieces. If defective pieces are up to 5, accept the lot ; if their number is 6, 7, 8 or more, reject the lot.

– *Characteristics of Single Sampling Plan*

(*i*) A single sampling plan is easy to design, explain and administer.

(*ii*) It is the only practical type of sampling plan under conveyorized production conditions when only one sample can be selected.

(*iii*) It involves a lower cost of training and supervising employees, transporting and sorting samples, etc.

(*iv*) It very accurately estimates lot quality.

(*v*) It is more economical than double sampling plan when lots have their % defectives close to the AQL.

(*vi*) It involves a bigger sample size than the double sampling plan.

(*vii*) It involves record keeping less than that of double and multiple sampling plans.

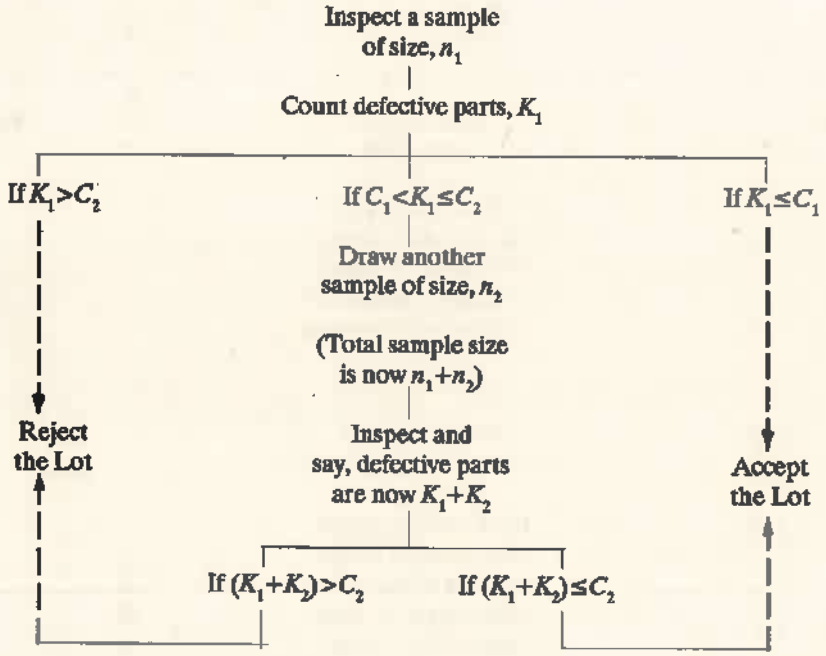
(*viii*) A single sampling plan provides maximum information concerning the lot quality because each sample can be plotted on the control chart.

(*b*) Double sampling plan

- If it is not possible to decide the fate of the lot on the basis of the first sample, a second sample, is drawn out of the same lot and the decision whether to accept or reject the lot is taken on the basis of the combined results of first and second samples.

- *Double sampling plan procedure*

Given C_1 and C_2 as acceptance numbers ; $C_2 > C_1$



- *Characteristics of double sampling plan*

(*i*) A double sampling plan is more expensive to administer than a comparable single sampling plan.

(*ii*) It involves less inspection than that required for a single sampling plan.

(*iii*) Double sampling plan is easier to sell to the personnel because psychologically the idea of giving a second chance to a lot before rejecting it exercises popular appeal.

(*iv*) It permits a smaller first sample than the sample size of the corresponding single sampling plan.

(*v*) A double sampling plan involves more overheads than a single sampling plan.

(*vi*) It involves more record keeping than a single sampling plan.

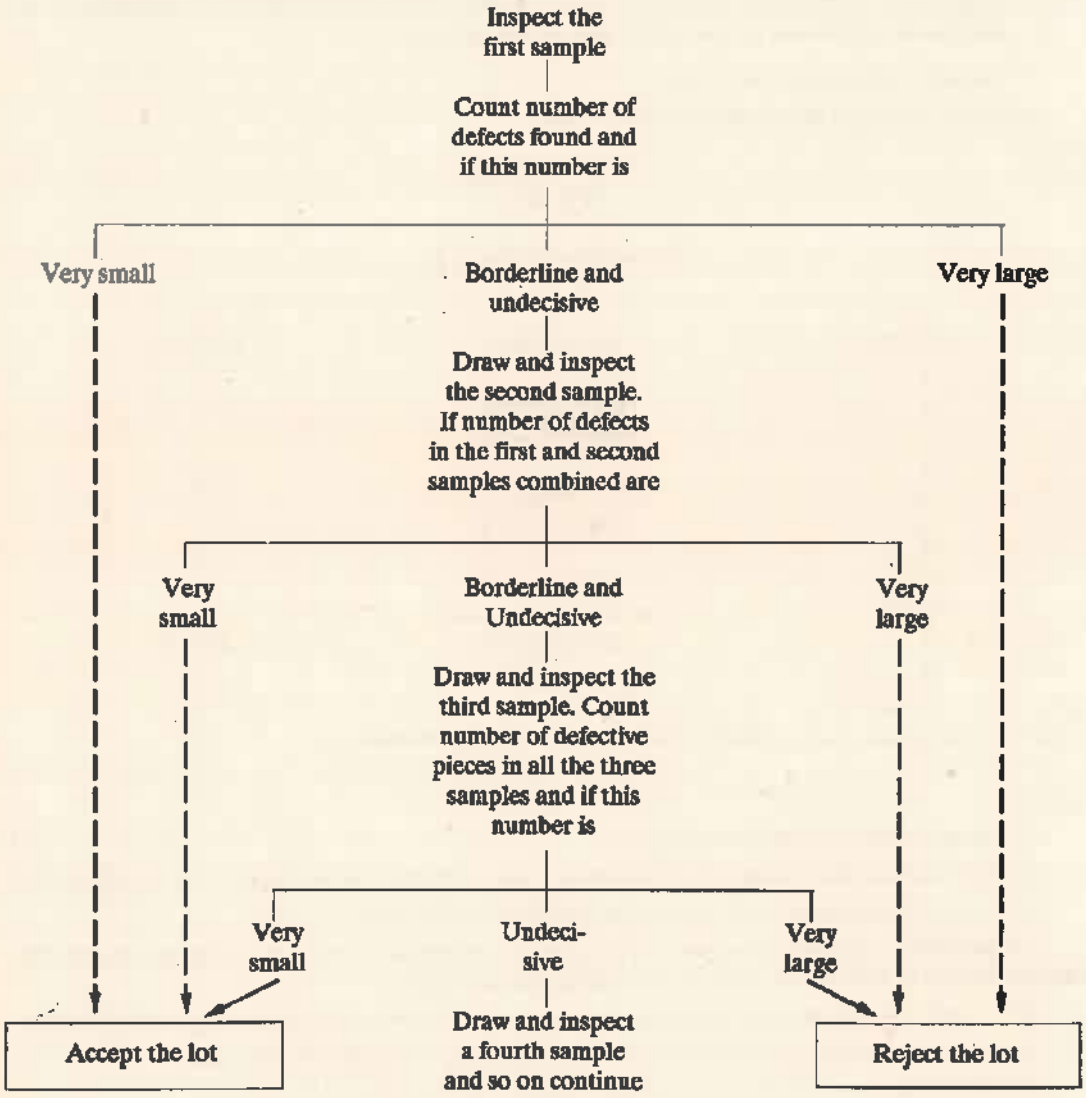
(*c*) Sequential sampling plan

- *Types of,*

1. Multiple sampling plan, and
2. Item by item analysis.

1. Multiple sampling plan

- A multiple sampling plan accepts or rejects a lot upon the results obtained from several samples (of component parts drawn from a lot).
- *Multiple sampling plan procedure*



- *Characteristics of multiple sampling plan*

(*i*) A multiple sampling plan involves smaller first samples than single or double sampling plans.

(*ii*) A multiple sampling plan is comparatively difficult to design and explain, and expensive to

administer.

(*iii*) It involves a higher overhead cost as compared to single and double sampling plans.

(*iv*) It involves more record keeping.

(*v*) In theory, multiple sampling may often permit lower total inspection than double sampling for a given degree of protection because of smaller sample sizes required.

(*vi*) New methods, which simplify multiple sampling, such as *automatic sampling boxes* may result in greatly improved efficiency in administering multiple sampling plans.

(*d*) Sequential sampling plan (Item by item analysis)

- It is a plan in which sample size is increased by one piece (or part) at a time till the sample becomes large enough and contains sufficient number of defective pieces to decide intelligently whether to accept the lot or to reject it.
- It is easy to design, but more expensive to administer than a comparable multisampling plan, since more steps are needed to take a decision.
- Since sample size is increased by one at a time, sample results are analysed much faster than in a single or double sampling plan.
- Sampling costs are least.
- Overhead cost is maximum.
- It is seldom used in lot acceptance control but is important because multiple sampling is based on it.

8.21. CONTROL CHARTS AND THEIR APPLICATIONS

Introduction. Control Charts are based on statistical sampling theory, according to which an adequate sized sample drawn, at random, from a lot represents the lot.

All processes whether semi-automatic or automatic are susceptible to variations which in turn result in changes in the dimensions of the products. These variations, as explained earlier, occur due to either chance causes or due to certain factors to which we can assign the causes for such variations. Variation in the diameter of spindles being manufactured on lathe may be either due to tool wear, non-homogeneity of bar stock, changes in machine settings, etc.

The purpose of control chart is to detect these changes in dimensions and indicate if the component parts being manufactured are within the specified tolerance or not.

Definition and Concept. Control chart is a (day-to-day) graphical presentation of the collected information. The information pertains to the measured or otherwise judged quality characteristics of the items or the samples. A control chart detects variations in the processing and warns if there is any departure from the specified tolerance limits. A control chart primarily is a diagnostic technique. It is dynamic in nature, *i.e.*, it is kept current and up-to-date as per the changes in processing conditions. It depicts whether there is any change in the characteristics of items since the start of the production run. Successively revised and plotted control chart immediately tells the undesired variations and it helps a lot in exploring the cause and eliminating manufacturing troubles.

Assume a turret was set to produce 1000 spindles of 2 cm diameter. After they were made, their diameters were measured and plotted as below (*See* Fig. 8.14).

Certain measured diameter values lie quite close to the desired dimension (*i.e.*, 2.0 cm), which is also known as mean diameter or mean value, whereas other diameter values are quite far from the mean value. Because of the fact that variations are inherent in all processes and therefore in product dimensions (and which is also evident from Fig. 8.14 as very few spindles have exactly 2.0 cm diameter), it becomes

necessary to accept all those pieces which fall under a set of specified tolerance limits or control limits ; otherwise, sticking to single mean value will result in huge scrap percentage. As soon as the control limits are incorporated in Fig. 8.14 – as upper and lower tolerance limits, Fig. 8.14 forms a control chart. These limits can be 1σ, 2σ, or 3σ, depending upon whether the confidence level is 68.27%, 95.45%, or 99.73%. Normally 3σ limits are taken for plotting control charts, and $(3\sigma+3\sigma)$ *i.e.*, 6σ spread is known as the *basic spread*. Besides 3σ control limits certain control charts also show *warning limits* spaced at 4σ spread. Warning limits inform the manufacturer—when the items or samples are approaching the danger level so that he can take an action before the process goes out of control.

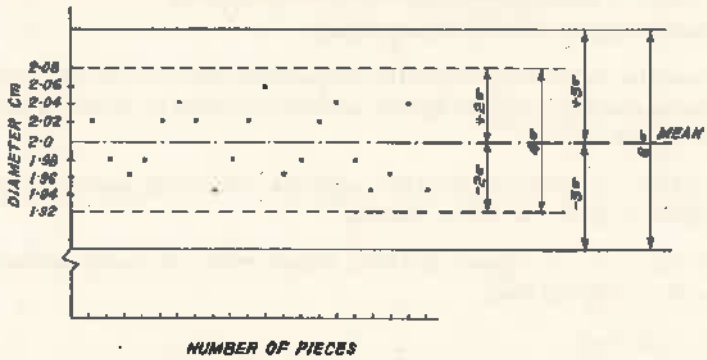


Fig. 8.14. Plotting of spindle diameters—leading to a control chart.

Control Charts—Purpose and Advantages

1. A Control Chart indicates whether the process is in control or out of control.

2. It determines process variability and detects unusual variations taking place in a process.

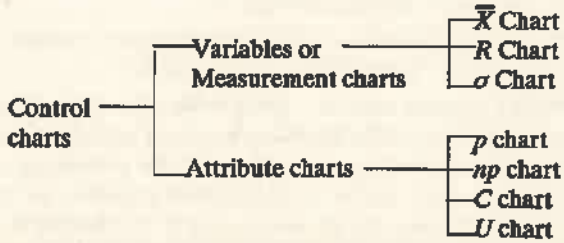
3. It ensures product quality level.

4. It warns in time, and if the process is rectified at that time, scrap or percentage rejection can be reduced.

5. It provides information about the selection of process and setting of tolerance limits.

6. Control charts build up the reputation of the organization through customer's satisfaction.

Types of Control Charts



Like sampling plans, control charts are also based on Attributes or Variables. In other words, quality can be controlled either through actual measurements (of dimensions, weight, strength, etc.) or through attributes (as yes or no criteria), for example by using go and no go gauge and without caring for the actual dimensions of a part. The concept of attributes and variables has been discussed under sampling inspection. *A comparison of variables and attribute charts is given below :*

1. Variables charts involve the measurement of the job dimensions and an item is accepted or rejected if its dimensions are within or beyond the fixed tolerance limits ; whereas an attribute chart only differentiates between a defective item and a non-defective item without going into the measurement of

its dimensions.

2. Variables charts are more detailed and contain more information as compared to attribute charts.

3. Attribute charts, being based upon go and no go data (which is less effective as compared to measured values) require comparatively bigger sample size.

4. Variables charts are relatively expensive because of the greater cost of collecting measured data.

5. Attributes charts are the only way to control quality in those cases where measurement of quality characteristics is either not possible or it is very complicated and costly to do so—as in the case of checking colour or finish of a product, or determining whether a casting contains cracks or not. In such cases the answer is either Yes or No.

Commonly used charts, like $\overline{X}$ and R charts for process control, p chart for analysing fraction defectives and C chart for controlling number of defects per piece, will be discussed below :

(*a*) $\overline{X}$ Chart

1. It shows changes in process average and is affected by changes in process variability.

2. It is a chart for the measure of central tendency.

3. It shows erratic or cyclic shifts in the process.

4. It detects steady progress changes, like tool wear.

5. It is the most commonly used variables chart.

6. When used along with R chart :

(*i*) it tells when to leave the process alone and when to chase and go for the causes leading to variation ;

(*ii*) it secures information in establishing or modifying processes, specifications or inspection procedures ; and

(*iii*) it controls the quality of incoming material.

7. $\overline{X}$ and R charts when used together form a powerful instrument for diagnosing quality problems.

(*b*) R-Chart

1. It controls general variability of the process and is affected by changes in process variability.

2. It is a chart for measure of spread.

3. It is generally used along with an $\overline{X}$-chart.

Plotting of $\overline{X}$ and R Charts. A good number of samples of items coming out of the machine are collected at random at different intervals of times and their quality characteristics (say diameter or length etc.) are measured.

For each sample, the mean value and range is found out. For example, if a sample contains 5 items, whose diameters are d_1, d_2, d_3, d_4 and d_5, the sample average,

$\overline{X} = d_1 + d_2 + d_3 + d_4 + d_5/5$ and range,

R = maximum diameter − minimum diameter.

A number of samples are selected and their average values and range are tabulated. The following example will explain the procedure to plot $\overline{X}$ and R charts.

Example 8.10.

Sample No. (sample size-5)	$\bar{X}$	R
1	7.0	2
2	7.5	3
3	8.0	2
4	10.0	2
5	9.5	3
6	11.0	4
7	11.5	3
8	4.0	2
9	3.5	3
10	4.0	2
	$\Sigma \bar{X} = 76$	$\Sigma R = 26$

$\bar{\bar{X}} = \Sigma \bar{X}$/No. of samples

$\bar{R} = \Sigma R$/No. of samples

Therefore, $\bar{\bar{X}} = \frac{76}{10} = 7.6$

and $\bar{R} = \frac{26}{10} = 2.6$

For $\bar{X}$ chart ;

Upper control limit (UCL) $= \bar{\bar{X}} + A_2\bar{R}$

Lower control limit (LCL) $= \bar{\bar{X}} - A_2\bar{R}$

For R chart :

Upper control limit (UCL) $= D_4\bar{R}$

Lower control limit (LCL) $= D_3\bar{R}$

The values of various factors (like A_2, D_4 and D_3), based on Normal Distribution can be found from the following table :

TABLE 8.3

Sample size (No. of items in a sample)	A_2 *Limit average*	D_3 *Range lower limit*	D_4 *Range upper limit*
2	1.88	0	3.27
3	1.02	0	2.57
4	0.73	0	2.28
5	0.58	0	2.11
6	0.48	0	2.00
8	0.37	0.14	1.86
10	0.31	0.22	1.78
12	0.27	0.28	1.72

Values of A_2, D_3 and D_4 for sample sizes 7, 9 and 11 can be (approximately) determined by taking the mean value of sample sizes 6 & 8, 8 & 10 and 10 & 12 respectively.

Sample size in this problem is 5, therefore,

$A_2 = 0.58$, $D_3 = 0$ and $D_4 = 2.11$

Thus, for $\bar{X}$ chart :

$$UCL = 7.6 + (0.58 \times 2.6)$$
$$= 7.6 + 1.51 = 9.11$$
$$LCL = 7.6 - (0.58 \times 2.6)$$
$$= 6.09.$$

and for R chart :

$$UCL = 2.11 \times 2.6 = 5.48$$
$$LCL = D_3 \times \bar{R} = 0 \times \bar{R} = 0.$$

These control limits are marked on the graph paper on either side of the mean value (line). $\bar{X}$ and R values are plotted on the graph and joined (Fig. 8.15), thus resulting the control chart.

From the $\bar{X}$ chart, it appears that the process became completely out of control from 4th sample onwards.

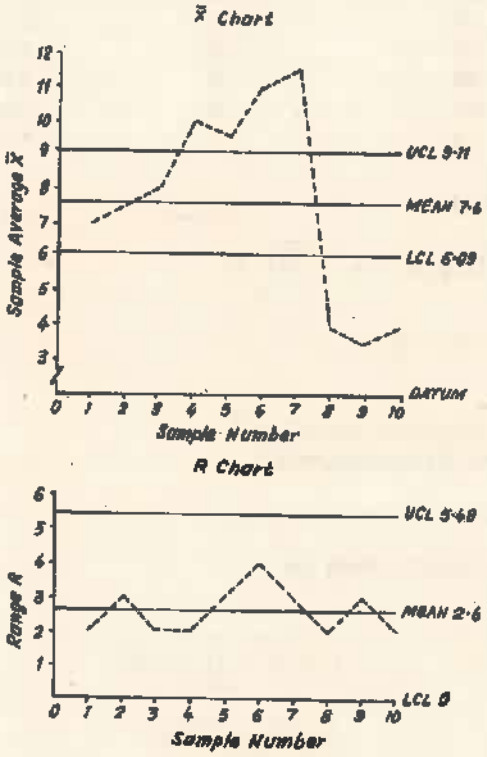


Fig. 8.15. $\bar{X}$ and R charts.

(c) p-Chart

1. It can be a fraction defective chart or % defective chart (100 p).

2. Each item is classified as good (non-defective) or bad (defective).

3. This chart is used to control the general quality of the component parts and it checks if the fluctuations in product quality (level) are due to chance cause alone.

4. It can be used even if sample size is variable (*i.e.*, different for all samples), but calculating control limits for each sample is rather cumbersome.

p-chart is plotted by calculating, first, the fraction defective and then the control limits. The process is said to be in control if fraction defective values fall within the control limits. In case the process is out of control an investigation to hunt for the cause becomes necessary.

The following example will explain the procedure of calculating and plotting a *p*-chart :

Example 8.11. (Refer to Ex. 8.15 also)

Date		*Number of pieces inspected (a)*	*Number of defective pieces found (b)*	*Fraction defective p=(b)/(a)*	*% defective 100 p*
November	4	300	25	0.0834	8.34
November	5	300	30	0.1000	10.00
November	6	300	35	0.1167	11.67
November	7	300	40	0.1333	13.33
November	8	300	45	0.1500	15.00
November	10	300	35	0.1167	11.67
November	11	300	40	0.1333	13.33
November	12	300	30	0.1000	10.00
November	13	300	20	0.0666	6.66
November	14	300	50	0.1666	16.66
Total number of days	= 10	3000	350		

$$\text{Upper control limit, UCL} = \bar{p} + 3.\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$\text{Lower control limit, LCL} = \bar{p} - 3.\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

where

$$\bar{p} = \frac{\text{Total number of defective pieces found}}{\text{Total number of pieces inspected}}$$

$$\bar{p} = \frac{350}{3000} = 0.1167$$

and n = number of pieces inspected every day

= 300

$$\text{Therefore, } \sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = \sqrt{\frac{0.1167 \times (1-0.1167)}{300}}$$

$$= \sqrt{\frac{0.1167 \times 0.8333}{300}}$$

$$= 0.01852$$

$$\text{and} \quad 3.\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = 0.01852 \times 3 = 0.05556$$

Thus, UCL = 0.1167 + 0.05556 = 0.17226 = 0.1723 (Approx.)

LCL = 0.1167 − 0.05556 = 0.06114 = 0.0611 (Approx.)

Mean, UCL and LCL are drawn on the graph paper, fraction defective values are marked and joined. It can be visualized (from Fig. 8.16) that all the points lie within the control limits and hence the process

is completely under control.

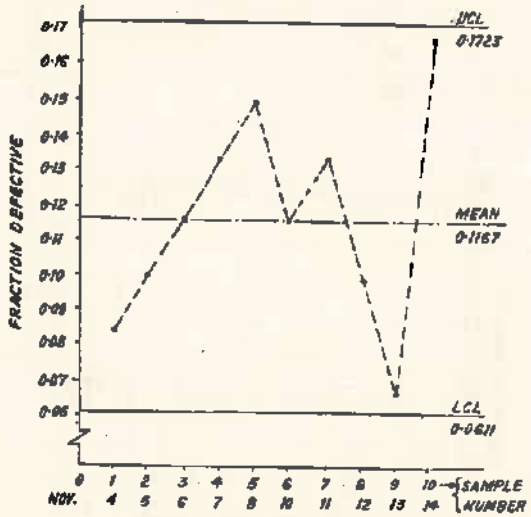


Fig. 8.16. *p*-Chart.

(*d*) ***C*-Chart**

1. It is the control chart in which number of defects in a piece or a sample are plotted.

2. It controls number of defects observed per unit or per sample.

3. Sample size is constant.

4. The chart is used where average number of defects are much less than the number of defects which would occur otherwise if everything possible goes wrong.

5. Whereas, *p*-chart considers the number of defective pieces in a given sample, *C*-chart takes into account the number of defects in each defective piece or in a given sample. A defective piece may contain more than one defect, for example a cast part may have blow holes and surface cracks at the same line.

6. The *C*-chart is preferred for large and complex parts. Such parts being few and limited, however, restrict the field of use for *C*-chart (as compared to *p*-chart).

C-chart is plotted in the same manner as *p*-chart except that the control limits are based on Poisson Distribution which describes more appropriately the distribution of defects.

The following example will explain the procedure for plotting *C*-chart.

Example 8.12.

Ten castings were inspected in order to locate defects in them. Every casting was found to contain certain number of defects as given below. It is required to plot a *C*-chart and draw the conclusions.

Castings	*No. of defects found on inspection (c)*
1	2
2	4
3	1
4	5
5	5
6	6

	7	3
	8	4
	9	0
	10	7
Total	10	37

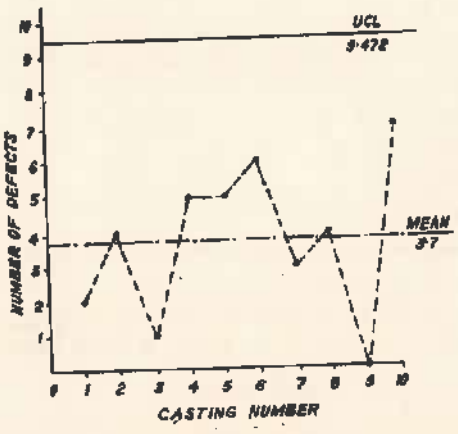


Fig. 8.17. *C*-Chart.

Therefore, $\bar{C} = \frac{37}{10} = 3.7$

$$UCL = \bar{C} + 3\sqrt{\bar{C}}$$

$$LCL = \bar{C} - 3\sqrt{\bar{C}}$$

or $$UCL = 3.7 + 3\sqrt{3.7}$$

$$= 9.472$$

$$LCL = 3.7 - 3\sqrt{3.7}$$

$$= -2.072 = \text{Zero.}$$

Value of $\bar{C}$, control limits and number of defects per casting are plotted on the graph paper, Fig. 8.17. It is concluded that since all the values of C lie within the control limits, the process is under control. (Lower control limit is negative and thus has been taken as being zero).

Applications of Control Chart. Control charts find applications in controlling the quality characteristics of the following :

1. Final assemblies (Attribute charts).
2. Manufactured components (shafts, spindles, balls, pins, holes, slots, etc.), (Variables charts).
3. Bullets and shells (Attribute charts).
4. Soldered joints (Attribute charts).
5. Castings and cloth lengths (Attribute, *C*-charts).
6. Defects in components made of glass (*C*-charts).
7. For studying tool wear (Variables charts).

8. Punch press works, forming, spot welding, etc., (Attribute charts).

9. Incoming material (Attribute or Variables charts).

10. Large and complex products like bomber engines, turbines, etc., (*C*-charts).

8.22. LIFE TESTING

Introduction. The life of a part is one of its quality criteria. For example, life of a spark plug or of a radio tube or of the crankshaft of an I.C. Engine, gives an idea of its quality. A good quality product is considered to have longer life.

The life of a component may be defined as the time period during which the part retains its quality characteristics. For example, the cylinder block of an I.C. Engine may not burst but if it wears out or develops ovality or taper, it is assumed that the life of the cylinder block is over. No matter afterwards the cylinder may be rebored and it may work with the next size piston for another life cycle.

Life tests are carried out in order to access the working life of a product, its capabilities and hence to form an idea of its quality level.

Life Tests. Life tests are carried out in different manners under various conditions :

(*a*) **Tests under Actual Working Conditions.** To subject a component to its actual working conditions for full duration for life test (*e.g.*, testing an engine of an aircraft for 30,000 to 60,000 hours), if not impossible, is quite laborious, cumbersome, time consuming and just impracticable. Moreover such full duration tests do not lend any help in controlling a manufacturing process.

(*b*) **Tests under Intensive Conditions.** Consider an electric toaster, which works for say 1 hour every day. If it were to be life tested under actual working conditions, it would be energised for only one hour per day and it will be noticed that after how many days the heating element fails. But, while testing under intensive conditions the idle times between two energising operations of the toaster are eliminated. It is worked continuously at rated specifications (*i.e.*, voltage, etc.) and thus the life can be estimated in a much shorter duration of time. However, the toaster may be deenergised for some period during intensive testing in order to study the effect of alternate heating and cooling on the material of heating element.

(*c*) **Tests under Accelerated Conditions.** These tests are conducted under severe operating conditions to quicken the product failure or break-down. For example, an electric circuit may be exposed to high voltages or high currents, a lathe may be subjected to severe vibrations and chatter, a refrigerator performance may be checked under high ambient temperature conditions, etc., etc.

Statistical technique can be used to plan and analyse the data of life (destructive) tests by sampling techniques and control charts. Sometimes, all the sample pieces need not be destructively tested, rather the results can be concluded from the time of first and middle failure. However, only through destructive testing the potential capability of a product can be determined. Sometimes management may not like to destroy their good products, but destructive testing is essential to reveal to the designer the weakest component of the chain. In development testing, a designer should get the component fabricated exactly under those conditions and specifications with which it will be manufactured, once tested okay. He should incorporate even the minute design changes in the sample fabricated for testing.

Dr. Davidson developed a table which shows, for a life test, the relationship between the sample size, probability and percent of units which will fail before their shortest life. According to that table if one wants to be 75% sure (probability) that not more than 10% of the components would fail before their shortest life of X-hours, he should conduct life tests on only 28 components.

Dr. Weibull evolved Probe Testing and with this—it is possible to plan tests and get maximum information as can be had from pure statistical techniques, but by conducting comparatively lesser number of tests.

8.23. RELIABILITY AND RELIABILITY PREDICTION

Definition and Concept. The study of reliability is important because it is related to the quality of

a product. Generally, components having low reliability are of poor quality but extra high quality does not always make a product of higher reliability. A poorly designed component even having very good material, surface finish and tolerances may have low reliability.

The *reliability* of a product is the Mathematical Probability that the product will perform its mission successfully and function for the required duration of time satisfactorily under predecided operating conditions.

In manufacturing almost all products and especially those, involving human lives like aircrafts, submarines, nuclear plants, it is highly essential to know and to be sure about the reliability of the individual parts and of the whole structure as a single entity.

The reliability prediction involves a quantitative evaluation of the existing and proposed product designs. It leads to a much better end product.

Reliability for a given time T and M (the mean time between failures, MTBF) is given by

$RT = e^{-T/M}$ for an individual part ... (1)

and for the system

$$R_{(S)T} = R_{a(T)} \times R_{b(T)} \times R_{c(T)} \times \ldots\ldots \times R_{z(T)} \quad \ldots (2)$$

where R_a, R_b ..... are the reliabilities of part A, part B, etc.

Steps in Reliability Calculation

Step-1. Find from the previous use of the product the number of parts and part failure rates.

Step-2. Design overall reliability of the product considering stress levels and information of step-1.

Step-3. Finally design and evaluate overall reliability using information of first two steps and environmental conditions, cycling effects, special maintenance, system complexity, etc.

Step-4. Obtain the test results of the system. Calculate MTBF as explained in the following example.

Example 8.13. To test the design of a typical circuitry of a weapon system.

Mean time between failure = 1600 Hrs.

Name of the parts	*Number used (n)*	*Failure rate per part (λ) (%/1000 Hrs.)*	*Total part failure rate (nλ) (%/1000 Hrs.)*
V	30	0.40	12.0
W	20	0.35	7.0
X	40	0.24	9.6
Y	50	0.12	6.0
Z	70	0.20	14.0
			48.6

$$\text{Mean time between failure} = \frac{1}{\text{failure rate}}$$

$$= \frac{1}{n.\lambda} = \frac{1 \times 100 \times 1000}{48.6}$$

$$= 2058 \text{ Hours};$$

against the requirements of only 1600 hours. Thus the (modified) design is perfectly reliable and hence acceptable.

Similar calculations can be made on the basis of the usage data supplied by the customers.

Reliability Increasing Techniques. Product reliability can be increased by using following techniques :

(*a*) Through simplification of the design, that is, by decreasing the number of component parts for a system and believing in Vital Few. It is clear from equation (2) that the reliability of a system is obtained by multiplying the reliabilities of the various parts.

If a product has 5 parts, each with reliability 0.9 then the total probability is $0.9\times0.9\times0.9\times0.9\times0.9=0.59$ whereas, if there would have been only three parts the probability of the system would be $0.9\times0.9\times0.9=0.73$.

(*b*) *By having redundancy built into the system.* Redundant components are provided in the system to take over, as soon as the actual component stops functioning. *Example* : Using a four engine aircraft which otherwise flies on three engines ; the fourth engine being redundant.

(*c*) *Principle of differential screening.* From a batch, screen, select and separate those components which exhibit high reliability, medium reliability and low reliability and use these components in products requiring only that much reliability. For example, highly reliable components may be used in military signalling devices and those of medium reliability in commercial applications.

(*d*) *Principle of truncation of distribution tails.* Referring to Fig. 8.8 the components which fall under 1σ limits are not likely to fail easily as those under 3σ limits.

(*e*) Reliability can be increased by avoiding those component parts which cannot stand maximum strength and stress requirements in their intended applications.

(*f*) *Principle of burn in screening.* It involves short term environmental tests which are conducted under severe stress conditions for eliminating parts having low reliability.

8.24. MONTE-CARLO SIMULATION

Monte-Carlo method is a simulation technique which is generally employed when the mathematical formulae become complex or the problem is such that it cannot be shaped reliably into mathematical form. Monte-Carlo method is not a sophisticated technique, rather it has empirical approach and bases itself on the rules of probability. Monte-Carlo method tries to simulate the real situation with reasonably predictable variations. The method makes use of cardboard tabs, random tables, etc. The tabs bear some relevant numbers on them, one tab at a time is drawn, its number is noted and then it is replaced before once again a tab is drawn from the bag or box (containing the tabs). This procedure is repeated until the desired solution for the problem is reached. The method can analyse business and other problems in which events occur with assigned probabilities.

The Monte-Carlo method may find *applications* as follows :

(*a*) To simulate the functioning of the complaint counter,

(*b*) Queuing problem,

(*c*) To estimate optimum spare parts for storage purposes,

(*d*) To find the best sequence for scheduling job batch orders,

(*e*) To estimate equipment and other machinery to take care of peak loads, and

(*f*) Replacement problems.

The following example will explain the procedure to solve a typical (problem) application of Monte-Carlo method.

Example 8.14. *ABC* company has 10 fork lift trucks at present. It is interested to know that how many more trucks it is likely to have to buy during the next five years (60 months) to maintain its fleet of 10 trucks.

From the past history the following information has been obtained which is expected to hold true for future also.

Time (months) (a)	*Percent of fork lift trucks which will become of no use in Time (a);* (b)	*Tabs* (c)
12	5	1
16	15	3
20	20	4
24	25	5
28	30	6
32	5	1

Solution. Column (*b*) values are in multiples of 5. It is the 'percent' of fork lift trucks which will become of no use in certain specified months.

First of all $\frac{1}{5\%} = \frac{100}{5} = 20$ little thick paper tabs are prepared.

Column (*c*) has been prepared from column (*b*) after dividing each value of column (*b*) by 5.

Considering columns (*c*) and (*a*), 20 tabs are marked as follows :

1 Tab bears the number 12,

3 Tabs bear the number 16, 4-20, 5-24, 6-28 and 1 tab-32.

The next step is to make the following table :

Fork lift truck No.	*Number of months after which the truck becomes of no use*				
	(a)	(b)	(c)	(d)	(e)
1	32	20	52	24	76
2	20	20	40	24	64
3	16	28	44	28	72
4	28	20	48	20	68
5	16	16	32	28	60
6	20	28	48	20	68
7	20	24	44	28	72
8	28	20	48	16	54
9	24	24	48	20	68
10	28	16	44	24	68

All the 20 tabs are put in a bag and at random one tab is drawn and the number written on it (say it is 32) is marked against truck 1. The tab is put in the bag and at random again another tab is drawn and its number (say 20) is marked against truck 2 and so on it is repeated till the first column (*a*) gets completed. It is inferred from column (*a*) that truck No. 1 will last for 32 months, truck 2 for 20 months and so on.

Each truck will be replaced after its life time, *i.e.,* truck 1 after 32 months, truck 2 after 20 months and so on. By the same procedure as above the life of the new trucks (which have replaced old ones) will next be estimated. Draw the tabs at random one by one from the bag and put values against the trucks under column (*b*).

Add columns (*a*) and (*b*) and put these figures under column (*c*). It is found that even after this set of replacement of trucks, no truck is in a position to reach its target of 60 months (*i.e.,* 5 years). Therefore these trucks are again replaced ; one by one tabs are drawn and the expected lives of next replacements are written under column (*d*). Columns (*c*) and (*d*) are then added and written as column (*e*) which shows that all the trucks will last 60 months, (*i.e.,* 5 years) or beyond.

Therefore to keep 10 trucks going all the time for 60 months, 20 replacement trucks [10 of column (*b*)+10 of column (*d*)] will be needed and thus the company is likely to have to buy 20 *more* trucks during the next five years to maintain its fleet of 10 trucks.

The following problems may be tried for practice :

Problem 8.1. *XYZ* company owns 40 trailers and is interested to know how many more trailers it is likely to buy in the next five years to maintain its fleet. From past experience it is found that the following lengths of life for this type of equipment hold good and they are expected to hold true in future also. Use Monte-Carlo method to find the number of trailers the company is likely to buy in next five years.

Months of use before replacement	*Number of cases*
12	3
15	7
18	12
21	18
24	26
27	7
30	5
33	3

Problem 8.2. The Brinell hardness of a population of piston rings is distributed normally with a standard deviation of 4.5 BHN. The upper specification for hardness is 180 BHN. Determine the value that the arithmetic mean of this population of hardness values must take in order to assure that not more than 5% of the piston rings will be above the upper hardness specification.

Problem 8.3. A component is produced in large quantities on a certain automatic lathe. One of the critical diameters is specified as 115 ± 1.25 mm. A 5% random check on the measurement of the said dimension indicate the following variation

Dimension (mm)	114	114.25	114.5	114.75	115	115.25	115.5	115.75	116
Frequency	1	8	54	123	248	115	44	6	1

Estimate the mean and standard deviation for the sample check. Show that the variation in the dimension for the whole batch would generally be expected to fall within the prescribed limits.

Problem 8.4. Determine the control limits for $\overline{X}$ and R charts if $\Sigma X = 357.50$, $\Sigma R = 9.90$.

Number of subgroups=25. It is given that A_2=0.18, D_3=0.41, and D_4=1.59.

[**Ans.** $\overline{X}$ chart 14.372, 14.228 R chart 0.629, 0.162]

Problem 8.5. The following table shows the number of defects per group in 25 successive groups of 5 relay units each.

Group No.	*Number of defectives per group*	*Group No.*	*Number of defectives per group*
1	77	2	64
3	75	4	93
5	45	6	61
7	49	8	65
9	45	10	77
11	59	12	54
13	41	14	87
15	40	16	22
17	92	18	89

19	55	20	25
21	54	22	22
23	49	24	33
25	20		

From this data set up a *C*-chart for use in the next period. Do these data come from a controlled process ? Give reasons in support of your answer.

Example 8.15. Using the data given in example 8.11 calculate the control limits for 100*p* and *np* charts and plot them.

Solution.

(*a*) **100p Chart**

$$\bar{p}_1 = \frac{\Sigma np}{\Sigma n} \times 100 = \frac{350}{3000} \times 100 = 11.67$$

$$\begin{matrix} UCL \\ LCL \end{matrix} = \bar{p}_1 \pm 3\sqrt{\frac{\bar{p}_1(100-\bar{p}_1)}{n}}$$

$$= 11.67 \pm 3\sqrt{\frac{11.67\,(100-11.67)}{300}}$$

$\therefore$ $UCL = 17.23$

and $LCL = 6.11$

(*b*) **np Chart**

$$n\bar{p} = 300 \times 0.1167 = 35.01$$

$$\begin{matrix} UCL \\ LCL \end{matrix} = n\bar{p} \pm 3\sqrt{n\bar{p}\,(1-\bar{p})}$$

$$= 35.01 \pm 3\sqrt{35.01\,(1-0.1167)}$$

$\therefore$ $UCL = 51.69$

and $LCL = 18.33$

Readers can plot 100*p* and *np* control charts from the control limits calculated above.

8.25. THE ZERO DEFECT CONCEPT

Definition

– The Zero Defect concept is a formula for a management programme which seeks the voluntary participation of workpeople in undertaking personel responsibility for the quality of the task in hand.

It is an approach to the problem of securing a high level of error-free work performance.

Evolution

– The Zero Defect concept originated in 1961 by Philip Crosby, then quality manager for the Martin Company of Orlando, Florida, and later developed into a phased strategy by Jim Halpin, Martin's quality director, the concept was first applied to a missile production programme for the U.S. Government.

Despite a marginally feasible delivery date (8-weeks only), Martin guaranteed to produce a defect-free missile on schedule, basing their confidence on a decision to make a complete departure from the *normal* procedures of inspection and test.

Where these stages would usually add to production time, Martin's technique was to establish a running production-line inspection by operatives who were individually pledged to achieve the necessary quality standard at the first manufacturing or assembly operation.

– In fact, the slogan used to *motivate* employees throughout the critical period was *Do it right the first time*.

Principle

– We as individuals have a duel standard ; one for our work and one for ourselves.

We are conditioned to believe that error is inevitable ; thus we not only accept error, we anticipate it. It does not bother us to make a few errors in our work, whether we are designing circuits, soldering joints, typing letters . . . but in our personal life we do not expect to bring less amount (every now and then) when we cash our pay-cheque ; nor do we enter a wrong house periodically by mistake. We, as individuals, do not tolerate these things. Z.D. concept was founded on principles such as these, by Martin.

Implementing a Z.D. programme

– The steps described below contribute to the implementation of a Z.D. programme :

(a) Personal challenge

– The employees should be challenged to attempt error-free performance.

– The employees are requested to voluntarily sign a *pledge-card*—a printed promise that he will strive to observe the highest standards of quality and performance.

– A pledge-card may be like this :

... 'I freely pledge myself to make a constant conscious effort to do my job right the first time, recognising that my individual contribution is a vital part .... etc.'

(b) Identification of error-cause

– The problems which obstruct the Z.D. aim should be identified, defect sources revealed and their causes rectified.

– The purpose of this phase is to provide employees with a background of knowledge, and on the basis of this, to encourage them to remain alert to (and report) potential sources of defect. Obviously, the necessary channels of communication between employees and supervisor are opened.

(c) Inspection

– The inspection should be a continuous and self-initiated process.

– The employee is given to understand clearly his personal responsibility for the quality of his own work. He is taught the specific quality points he is expected to monitor, and encouraged to report promptly any out-of-control conditions so that the necessary corrective action can be taken. Training for this role may include the use of a Z.D. *job break-down sheet*. This is presented in two columns, *one* showing the logical sequence of operations, the *other* showing critical factors which determine whether the job is being carried out without defect.

– Once again tremendous importance is attached to individual contributions to the Z.D. activity and *Defect Cause Removal* programmes are incorporated in the general pattern.

– *Defect Cause Removal* is a system through which each individual can contribute to the total Z.D. programme. All employees are eligible to submit a Defect Cause Removal proposal/recommendation.

The Defect Cause Removal Proposal is submitted, in the first instance, by the originator to his immediate superior. It states the location and nature of the defect and whether it is *actual* or *potential*.

The originator is asked additionally, to describe the existing situation which causes or threatens to cause, the defect observed, or foreseen. This should be done simply, and with sufficient clarity to enable the supervisor to identify the method, device, part, operation, equipment and area involved without difficulty.

It he is able, and so wishes, the originator may state his *recommendations* for correcting or eliminating the cause of the defect. 'Remember : you do not have to do this'. Identification of the defect cause is half the battle; someone else (whether the supervisor or any other person nominated by Z.D. Program Administrator) will endeavour to supply a satisfactory removal solution.

In every case, it is considered essential that the originator should receive an acknowledgement of his proposal and an assurance that he will be advised of the steps taken to deal with it.

(d) Motivation

– The management should provide continuous motivation by arousing and sustaining employees interest in the Z.D. programme, through the use of attention-getting techniques.

– Techniques and tools used in this phase are those of the Advertising industry—*i.e.*, by leaflets, meetings, special employee bulletins, pledge cards, displays of reject work accompanied by notice of contract cancellations etc.

– Other techniques/devices are Recognition certificates, plaques and Awards, etc.

– Equally significant can be the contribution made by the company training department, where the basic Z.D. precepts may be directed at apprentices, new employees and operatives undergoing retraining in the use of new machines and equipment etc.

8.26. QUALITY CIRCLE (Q.C.)

Concept of Q.C.

Quality circle is a small group of employees (8-10) working at one place, who come forward *voluntarily* and discuss their *work related problems* once in a week (say) for one hour. Workers meet as a group and utilise their inherent ability to think for themselves for identifying the constraints being faced by them and pooling their wisdom for final solutions that would improve their work life in general and contribute towards better results for the organisation.

Characteristics of Q.C.

(*a*) It is a *philosophy* as against technique.

(1) It harmonises the work.

(2) It removes barrier of mistrust.

(3) It makes workplace meaningful.

(4) It shows concern for the total person.

(*b*) It is voluntary.
(*c*) It is participative.
(*d*) It is group activity.
(*e*) It has management's support.
(*f*) It involves task performance.
(*g*) It is not a forum to discuss demands or grievances.
(*h*) It is not a forum for management to unload all their problems.
(*i*) It is not a substitute for joint-plant councils or work committees.
(*j*) It is not a panacea for all ills.

Objectives of Q.C.

(1) To make use of brain power of employees also in addition to their hand and feet.
(2) To improve mutual trust between management and employees/unions.
(3) To promote (group) participative culture which is the essence of quality circle concept.
(4) To improve quality of the organisation.

Benefits from Q.C.

1. Improvement in *quality*.
2. Increase in *productivity*.
3. Better *house-keeping*.
4. *Cost reduction*
5. Increased *safety*.
6. Working without tension.
7. Better *communication*.
8. Effective *team work*.
9. Better *human-relations*.
10. Greater sense of *belongingness*.
11. Better mutual *trust*.
12. Development of *participative* culture.

Starting a Quality Circle

Step-1. Explain to employees—what is quality circle and what possibly can be achieved by it.

Step-2. Form a quality circle of (*i*) about 8-10 employees (*ii*) working at the same area, (*iii*) having the same wavelength and (*iv*) who are interested to join the quality circle voluntarily.

Step-3. (*a*) *First meeting*

(*i*) Choose team leader and deputy leader.
(*ii*) Doubts of employees, if any, will be removed in this meeting.

(*b*) *Second meeting*

(*i*) List all problems.
(*ii*) Identify the problem to be taken first.
(*iii*) Conduct brain-storming session.
(*iv*) Leader keeps on recording the minutes.

(*c*) *Third meeting and onwards*

(*i*) Problem analysis by members.
(*ii*) Study of cause and effect relations. For example, if two machines are looked after by one worker what good or bad will happen.
(*iii*) Solutions recommended.

9*

Work Study

9.1. DEFINITION AND CONCEPT

Work study, as defined by British Standard Institution, is a generic term for those techniques particularly 'Method Study' and 'Work Measurement' which are used in the examination of human work in all its contexts and which lead systematically to the investigation of all the factors which effect the efficiency of the situation being reviewed, in order to seek improvements.

Actually, work study investigates the work done in an organisation and it aims at finding the best and most efficient way of using available resources, *i.e.*, men, material, money and machinery. Every organisation tries to achieve best quality production in the minimum possible time. The time required to manufacture an item depends upon the manufacturing procedure; and one phase of work study known as Method study aims at finding the best possible manufacturing procedure which involves, least time and does not cause fatigue to the workers. In brief, method study or motion study aims at finding the best way of doing a job. *Method Study* may be defined as the systematic investigation (*i.e.*, recording and critical examination) of the existing method of doing a job in order to develop and install an easy, rapid, efficient, effective and less fatiguing procedure for doing the same job and at lower costs. This is generally achieved by eliminating unnecessary motions involved in a certain procedure or by changing the sequence of operation or the process itself.

Once the method study has developed an improved procedure for doing a job, the work Measurement or Time Study will find the time allowed to complete the job by that procedure. *Work Measurement* may be defined as the application of different techniques to measure and establish the time required to complete the job by a qualified worker at a defined level of performance. The time necessary to complete a job is determined from number of observations.

9.2. NEED FOR WORK STUDY

Principles of work study used to be employed even long ago, in order to explore improvements, when industry was simple and involved lesser problems; of course a systematic procedure was not there. Today the industries with all their complexities and modernization naturally demand a more systematic approach like the work study in its present form. Work study finds applications in,

1. Industries (Production operations, research and development),
2. Marketing, sales and distribution,
3. Offices, stores and warehouses,
4. Material handling,
5. Design,
6. Building and other constructions,
7. Transport,
8. Hospital,
9. Army, and
10. Agriculture, etc.

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* For details refer the book "Work Study" by Dr. O. P. Khanna.

9.3. ADVANTAGES OF WORK STUDY

(*a*) Uniform and improved production flow,

(*b*) Higher productive efficiency,

(*c*) Reduced manufacturing costs,

(*d*) Fast and accurate delivery dates,

(*e*) Better employee-employer relations,

(*f*) Better service to customers,

(*g*) Job security and job satisfaction to workers,

(*h*) Better working and other conditions, and

(*i*) Higher wages to workers.

9.4. OBJECTIVES OF (OR ADVANTAGES OBTAINED THROUGH) METHOD STUDY

(1) Improved working processes and standardized procedures,

(2) Better work place layout; neat and clean environments and working conditions,

(3) Less fatigue to operators,

(4) Better product quality,

(5) Effective utilization of men, materials and machinery,

(6) Efficient and fast material handling,

(7) Reduced health hazards,

(8) Efficient planning of the section, and

(9) Streamlined working procedures.

9.5. OBJECTIVES OF (OR ADVANTAGES ACHIEVED THROUGH) WORK MEASUREMENT

Work measurement :

(1) determines the time required to do a job; thus it compares alternative methods and establishes the fastest method ;

(2) decides man power required for a job ; it helps in man power economy ;

(3) decides equipment requirements ;

(4) provides information for effective production planning and maintenance procedures ;

(5) aids in calculating exact delivery dates ;

(6) decides realistic labour budgeting and provides a basis for standard costing system ;

(7) provides a basis for fair and sound incentive schemes; and

(8) results in effective labour control.

Irrespective of the advantages mentioned above, the introduction of work study has always been looked by the supervisors, workers or union with suspicion. They probably feel insecure and think that work study will result in reduction in their salaries. Even otherwise a sudden change is never appreciated, therefore, workers and union should be taken into confidence and properly convinced before introducing work study.

9.6. METHOD STUDY PROCEDURE

The various steps involved are :

(1) ***Select*** the work worth studying and define the objectives to be achieved. An objective may be to reduce the manufacturing cost, or to reduce bottlenecks or to reduce fatigue incurred by the workers in order to increase their efficiency.

(2) ***Record*** all the relevant informations pertaining to the existing method (if any) in details and in the form of a chart to obtain a more clear picture about the same. Recording can be done with the help of following aids :

(*a*) *Process Charts* :

(*i*) Outline process chart,

(*ii*) Flow process chart ; Man type, Material type and Equipment type,

(*iii*) Two handed process chart, and

(*iv*) Multiple activity chart.

(*b*) *Diagrams* :

(*i*) Flow diagram,

(*ii*) String diagram,

(*iii*) Cyclegraph, and

(*iv*) Chronocyclegraph

(*c*) *Motion and Film Analysis (Micromotion and Memomotion Studies)* :

(*i*) Simo chart.

(*d*) *Models, etc.*

(3) Examine the recorded events critically and in sequence. ***Critical examination*** involves answer to a number of questions. An activity can be eliminated, simplified or combined with another. The basic questions are,

Purpose. What is done ?

Person. Who does it ?

Place. Where it is done ?

Means. How is it done ?

Sequence. When is it done ?

The above-mentioned five basic questions, individually are further subjected to enquiries like,

Why. Why is it necessary, why he does it, why it is done there, why is it done by that method and why is it done at that time ?

Alternative Ways of Doing. What else could be done, who else could do it, where else it could be done, how else it could be done and when else it could be done.

Best Method of Doing. What should be done, who should do it, where it should be done, how it should be done, and when it should be done.

(4) ***Develop*** the best method as resulted from critical examination and record it. The developed method should be,

(*i*) Practical and feasible,

(*ii*) Safe and effective,

(*iii*) Economical, and

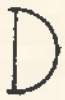
(*iv*) Acceptable to design, production control, quality control and sales departments.

(5) ***Install*** the (best) developed method or the improved method. Installation involves three phases, namely-planning, arranging and implementing. During first two stages the programme of installation (phase-wise) and a time table, are planned and the necessary arrangements of resources, equipments, tools and instructions to workers, over-time, etc., are made. The implementation or actual installation involves the introduction of developed method as standard practice. Problems associated with the developed method should be carefully studied and remedied, if necessary. Installation phase is complete as soon as the new method starts working smoothly and satisfactorily and gives encouraging results (like saving in time, scrap reduction, etc.)

(6) ***Maintain*** the new method, *i.e.*, ensure the proper functioning of the installed method by periodic checks and verifications. The purpose of checks and reviews is to find if the method being practised is the same or it has deviated from the authorised one. Reasons for deviation if any should be explored and the necessary changes may be made in the procedure being practised so that it reverts to the authorised one. Views of the workers, supervisors and other persons related with the authorised method can be of much help in exploring further improvements.

9.7. PROCESS CHARTS SYMBOLS

Charts are generally represented by symbols because symbols produce a better picture and quick understanding of the facts. Process charts use the following five basic symbols to record different types of events.

Event	*Symbol*	*Description*
1. *Operation*		Operation represents an action; it is a step in the procedure. An operation involves a change in the location or condition of a product. Example : cutting a bar on a power hacksaw or driving a nail in wood.
2. *Storage*		Storage represents a stage when a finished good or raw material awaits an action or when an item has been retained for quite some time for reference purposes. Storage shows an authorized control over an item. Example : Milling cutters lying in tool store or refrigerators in a stock room.
3. *Delay or Temporary Storage*		Delay occurs when something stops the process and a product waits for the next event. It is a temporary halt in the process. Example : power failure, waiting for the lift or a traffic jam.
4. *Transport*		Transport indicates the movement of an item from one location to another. The item may be material, equipment, an operator or his hands only. Example : Oil flowing through a penstock, aeroplane flying from one city to another, mild steel rods being sent from stores to Machine shop, etc.
5. *Inspection*		Inspection is an act of checking for correctness of the quantity or the quality of the items. Inspection is not normally expected to change the shape or other characteristics of an item. Example : gauging a piston pin or checking the hardness of a carburized mild steel piece.

In addition to the basic symbols discussed above, there are symbols for combined activities also and they are given below. The important event has the outer symbol.

6. *Operation-cum-transportation*		Example : Articles are being painted as they are transported by the chain conveyor.
7. *Inspection-cum-operation*		Example : A powder milk tin is being weighed (inspection) as it is filled. Both the events occur simultaneously and are controlled automatically.

9.8. FLOW PROCESS CHARTS

Introduction. A chart may be a diagram, a picture or a graph which gives an overall view of the situation, say a process. It helps visualising various possibilities of alteration or improvement.

A chart representing a process may be called a *Process Chart*. A process chart records graphically or diagrammatically, in sequence, the operations connected with a process. The chart portrays the process with the help of a set of (process chart) symbols and aids in better understanding and examining the process with a purpose to improve the same.

Process charts are of three types :

(a) Outline process chart, (Refer article 6.14)

(b) Flow process chart, and

(c) Two handed process chart.

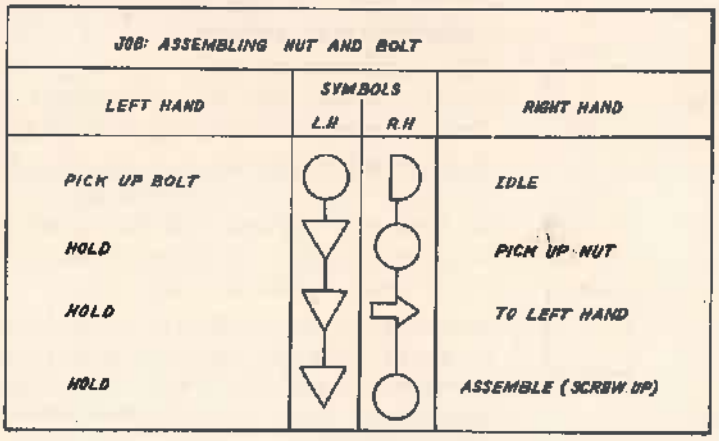
An *Outline Process Chart* surveys and records an overall picture of the process and states only main events sequence-wise. It considers only (main) operations and inspections. Actually an outline process chart is the beginning of a detailed analysis.

A *Two Handed Process Chart* records the activities of the left hand and the right hand (of an operator) as related to each other. The activities of the two hands can be synchronized by providing a time scale on the chart. Figure 9.1 shows a two-handed process chart which is also known as operator activity chart. Such a chart is generally used for repetitive works of short duration.

A *Flow Process Chart* is a detailed version of outline process chart and it records all the events. It,

(1) sets out sequence of flow (of a procedure or product) ;

(2) records all the events in sequence using process chart symbols ;



Summary :

L.H		R.H	
○	1	○	2
▽	3	▽	-
⇨	-	⇨	1
D	-	D	1

Fig. 9.1. Two-handed process chart.

(3) marks distances travelled and time taken for completing an activity; and

(4) mentions other important (or key) points, if any.

There are three types of flow process charts, namely:

(*a*) Flow process chart (Man) (Fig. 9.3),

(*b*) Flow process chart (Equipment), and

(*c*) Flow process chart (Material) (Fig. 9.2).

Man Type Flow Process Chart records the activities of an operator, *i.e.,* what an operator does.

Equipment Type Process Chart records the manner in which the equipment is used and *Material Type Process Chart* records what happens to the material, *i.e.,* the changes the material undergoes in location or condition.

Activity	*Operations*	*Distance moved (metres)*	*Time (minutes)*	*Remarks if any*
Castings lying in foundry store.	1	–	–	–
Moved to gas cutting machine.	1	10	3	By trolley
Wait, cutting machine being set.	1	–	5	–
Risers cut.	1	–	20	–
Wait for trolley.	2	–	10	–
Moved to machine shop.	2	20	6	By trolley
Inspected before machining.	1	–	15	–

Fig. 9.2. A portion of the flow process chart (Material type) showing flow of product.

Figure 9.2 shows a portion of the material type flow process chart.

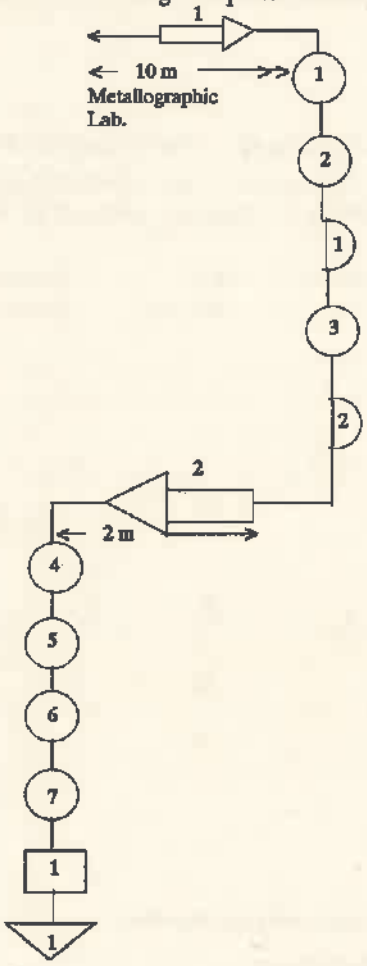
A flow process chart can be plotted in another manner also. Figure 9.3 shows an example of man type flow process chart plotted otherwise.

9.9. FLOW DIAGRAM

In a manufacturing shop, overhauling or a repair shop or in any other department there are movements of men and materials from one location to another. Though, process charts indicate the sequence of events, they do not illustrate the movements of men, material, etc., while the work is being accomplished. The number of movements if minimized, result in a lot of saving both in cost as well as efforts required to do a job. The path of movement (*i.e.,* the movement between two locations and the number of times a movement is repeated) can be better visualised by drawing a diagram; it may be a string diagram or a flow diagram. A string diagram is preferred over a flow diagram, if paths of movements are very much involved (congested) and difficult to trace on a flow diagram. A flow diagram is more suitable for simple cases.

A *Flow Diagram* is a drawing or a diagram which is drawn to scale. It shows the relative position of production machinery, jigs, fixtures, gangway, etc., and marks the paths followed by men (workers) and materials.

Job. Polishing the specimen for metallographic study.



Start polishing machine.

Sprinkle the solution of polishing compound on the rotating table.

Hold the specimen in hand.

Place the specimen gently on the rotating table and polish it.

Wait for a few seconds.

Take away the specimen to wash basin.

Wash the specimen.

Etch the specimen.

Wash the specimen again.

Dry it.

Check under a microscope.

Keep the specimen in the container.

Fig. 9.3. Man type flow process chart.

Steps in drawing a flow diagram:

(1) Draw to scale the plan of the work area.

(2) Mark the relative positions of machine tools, benches, store, racks, inspection booths, etc.

(3) From the different observations, draw the actual (path) movements of the material or the worker on the diagram and indicate the direction of movement. Different movements can be marked in different colours (for better understanding). Process symbols may also be added on to the diagram.

Figure 9.4 shows a simple flow diagram, in which, raw material from the store moves to station *A* where an operation is performed, the semi-finished product is sent to place *B* where another operation

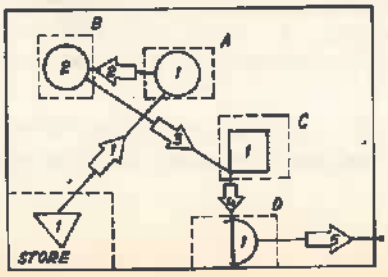


Fig. 9.4. A flow diagram.

is carried out, then it moves to place *C* for inspection, is further sent to bench *D* where it halts for a short while and ultimately goes out of the factory.

9.10. STRING DIAGRAM

Introduction. When the paths are many and repetitive, a flow diagram becomes congested and it is neither easy to trace it nor to understand. Under such conditions a string diagram is preferred.

String Diagram is a model or a scale plan of the shop, in which every machine or equipment is marked and a peg or pin is struck by or in the area representing a facility. A continuous coloured thread or string traces the path taken up by the materials or workers while performing a particular operation.

Construction :

(*i*) Draw the scale-layout of the shop (working) area and mark various features, such as machinery, work benches, store, etc.

(*ii*) Mount this scaled drawing on a soft board and strike pins or pegs at all the places which form the path of the workers and materials. More pegs may be struck in between the facilities to trace more or less, the actual path of men and materials.

(*iii*) A continuous coloured unstretchable string, taken from the first to the last peg, is wound to mark the path followed by workers or materials.

As many as 15 times, a thread can be taken round each peg easily and yet it will not be difficult to comprehend the various movements. The thread when measured gives approximately the total distance travelled by a worker or the material. Figure 9.5 shows a string diagram.

Uses. A string diagram picturises the movements. It,

(*i*) is very useful in dealing with complex movements and plant layout and design problem,

(*ii*) indicates clearly, back tracking, congestion, bottlenecks, and over and under utilised paths on the shop floor,

(*iii*) measures the distances involved and points out whether a work station is suitably located,

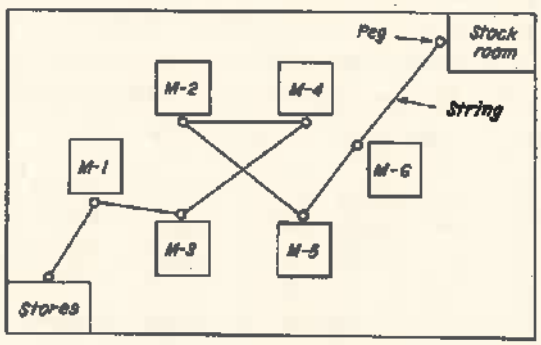


Fig. 9.5. String diagram (M-1 machine-1).

(*iv*) traces existing path of movements for necessary modifications if any,

(*v*) is preferred when movements are not regular as regards their frequency and distance travelled,

(*vi*) shows the pattern of movements and thus helps in deciding the most economical routes to do a particular operation,

(*vii*) is *advantageous* in studying the movements of

(*a*) an individual operator handling a number of machines,

(*b*) a group or gang moving from one machine or work bench to another, and

(*c*) workers/materials in an assembly or repair shop.

Drawbacks. If the workers or materials move in some irregular or curvilinear path, it is not possible to trace exactly the same on the string diagram and thus no estimate can be made regarding the total distance travelled by the workers or the materials.

9.11. MULTIPLE ACTIVITY CHART

(1) Definition. Where a number of workers work in a group or an individual operator handles two or more machines, their activities have to be co-ordinated for achieving proper results. A multiple activity chart records simultaneously the activities of all the workers and machines on a common time scale and thus shows inter-relations between them.

(2) Purpose.

(*i*) To detect idle times being enforced on machines and workers,

(*ii*) To optimise work distribution between workers and machines,

(*iii*) To decide number of workers in a group,

(*iv*) To balance the work teams,

(*v*) To examine the interdependency of activities, and

(*vi*) Ultimately, to develop an improved method of accomplishing a task and to have an effective labour cost control.

(3) Construction.

(*i*) A separate vertical bar or column is there to represent each subject (which may be a machine or an operator).

(*ii*) A common time scale is provided for all the subjects.

(*iii*) Activities of each subject in relation to those of the others are marked in the respective columns.

(*iv*) Previously conducted time studies provide the time values for each activity.

(*v*) A brief description of each activity is marked on the chart.

(*vi*) Working and idle times are marked differently on the chart.

Figure 9.6 shows a Man Machine Chart which is a specialized form of Multiple Activity Chart.

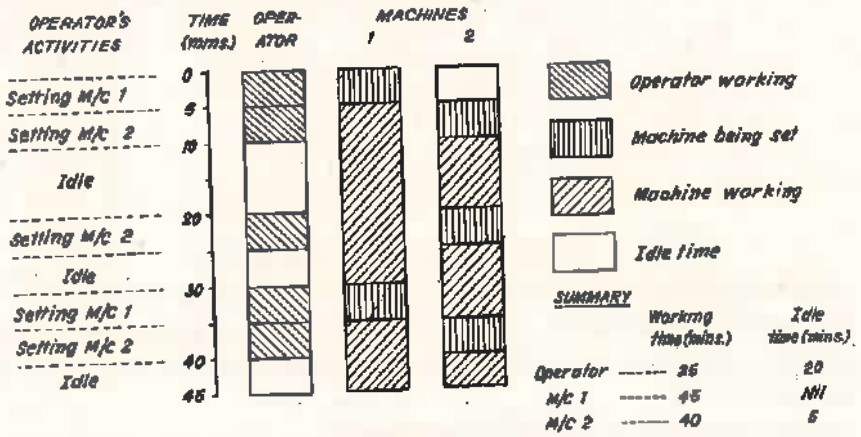


Fig. 9.6. Man Machine Chart.

(4) Analysis. After constructing the chart, it is tried to,

(*i*) rearrange the work cycle to minimize men or machine idle times,

(*ii*) simplify the operations,

(*iii*) combine or eliminate some of the elements etc.

(5) Applications. A multiple activity chart finds applications in

(*i*) plant repair and maintenance,

(*ii*) construction jobs, and

(*iii*) planning team work.

(6) Gang Process Chart :

- Gang process chart is another type of multiple activity chart which portrays the relationship of the activities carried out by different members of a group (or gang) with respect to one another while doing a job such as riveting. The aim (of the chart) is to reduce idle and ineffective time and to improve the efficiency of the gang operations.
- A gang process chart looks like a man-machine chart with the difference that instead of one operator, there are a number of operators or workers.

9.12. OPERATION ANALYSIS

Operation Analysis is a detailed study of different operations involved in doing a work. Operation analysis becomes necessary in order to investigate the shortcomings of the existing method and to develop an improved procedure. Operation analysis suggests, whether some elements, should be eliminated or combined or their sequence should be altered in order to obtain effective utilization of existing man-power and machinery with the minimum fatigue incurred by the workers. The analysis mainly considers the movements of the limbs and aims at finding a simpler and economical method of doing the job.

Before the procedural steps of a task are analyzed and the motions (of an operator) are studied or eliminated, an operation chart is constructed. Figure 9.7 shows an operation chart of the existing method of assembling nuts and bolts. As a next step, the different motions involved are subjected to specific and detailed questioning with a view to eliminate unnecessary motions, and to arrange the remaining motions in a better sequence. Principles of motion economy as discussed under section 9.14 serve as a very good guide in developing a better and improved method.

The chart (Fig. 9.7) of the existing method is tested as per the rules of motion economy and the following points are noted:

(1) The distribution of work between the two hands is not balanced. Right hand is overloaded.

(2) The two hands do not follow opposite motions.

(3) Gravity has not been utilized for delivering the material to its destination, etc.

Besides assessing the present method as per the principles of motion economy, it is also subjected to following questions (whichever are applicable) with regard to

(*a*) *Worker.*

1. Is he mentally and physically fit?
2. Does he incur unnecessary fatigue?
3. Does he need training to improve?
4. Does he get suitable salary?

(*b*) *Set-up.* 1. Are tools and other equipments readily available?

2. Can the set-up be modified or can the number of set-ups be decreased?

(*c*) *Material.* 1. Is material of the proper specifications, *i.e.*, composition, diameter, width, thickness or weight?

Operation : Nut & Bolt assembly.

Name of the worker.....

Location.....

Method : Present/Proposed



Left Hand Description	*Symbols*	*Right Hand Description*
Idle		Goes to bin-1
		Grasps a bolt
		Carries to left hand
Grasps and holds the bolt		Releases to left hand
		Goes to bin-2
		Grasps a nut
		Carries to left hand
		Screws nut on the bolt
Releases nut-bolt assembly		Grasps the assembly
Idle		Transfers assembly to bin-3

Fig. 9.7. Operation chart for the present method of assembling nuts and bolts.

2. Can it be substituted by a less costly material?
3. Can scrap be minimized?

(*d*) *Material handling.*

1. Can materials be transferred in big (unit) lots, thereby reducing the number of handlings?
2. Is it possible to avoid back tracking of the material?
3. Can the distances, by which the material is moved, be cut short?

(*e*) *Operations.*

1. Can some operations be eliminated?
2. Can some operations be made automatic?
3. How, resequencing of the operations will effect?
4. Is it possible to combine some operations?

(*f*) *Tools and Fixtures.* 1. Are they available in good condition?
2. Are they suitably located and prepositioned?
3. Is it advantageous to modify existing jigs and fixtures for better productivity?

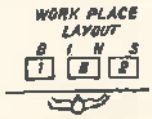
(g) *Working Conditions.* 1. Is light and ventilation adequate?

2. Are the operations and working conditions safe?

3. Are facilities of wash rooms, etc., available?

Considering the existing method in the light of motion economy principles and questions mentioned above, a proposed method for the same task is as follows (Fig. 9.8).

Operation : Nut and Bolt Assembly
Name of the worker.....
.....
Location.....
Method : Present/Proposed



(3) It is a cavity in the work table, under which runs a conveyor to take each assembly at its destination.

Left hand description	*Symbols*	*Right hand description*
Goes to bin-1		Goes to bin-2
Grasps a bolt		Grasps a nut
Brings over the cavity or space cut in the work table (3)		Brings over cavity-3
Holds and grasps the bolt.		Screws the nut
Releases the assembly to drop on a conveyor through cavity-3.		Releases the assembly to drop on a conveyor through cavity-3.

Fig.9.8. Operation chart for the proposed method of assembling nuts and bolts.

9.13. ANALYSIS OF MOTION

The motions or movements of the limbs of a worker play a major part in the fabrication or manufacture of the products. By carefully observing a worker while he is doing an operation, a number of movements made by him which appear to be unnecessary and unproductive can be identified and eliminated.

Analysis of an operation, when carried out in terms of individual motions of a worker is known as *motion analysis.*

The purpose of motion analysis is to design an improved method which eliminates unnecessary motions and employs human efforts more productively. In doing so the principles of motion economy prove to be very helpful.

Steps involved in Motion Analysis are :

(*a*) Select the operation to be studied.

(*b*) List and chart various motions performed by the operator.

(*c*) Identify the productive and idle motions.

(*d*) Eliminate the unnecessary and non-productive motions.

(*e*) Redesign the existing operating procedure by employing minimum number of motions in the most appropriate sequence and in accordance with the principles of motion economy.

(*f*) Impart necessary instructions to the worker so that he develops proper habit cycle.

(*g*) Check once again the procedure in the light of step (*e*) above.

(*h*) The procedure may be standardized.

9.14. MOTION ECONOMY, PRINCIPLES OF

A set of rules were designed by Gilbreth in order to develop better methods. A better method of doing a job is one which consumes minimum of time and energy in performing limb (hand, foot, leg, arm, etc.) motions in order to complete the task and this is possible only, by economising the use of motions.

The rules of human motions as presented by Gilbreth were rearranged and amplified by Barnes, Lowry, Maynard, and others. The various rules are as follows :

1. Rules Concerning Human Body

(*a*) Both hands should be used for productive work.

(*b*) Both the hands should start and finish their motions at the same time.

(*c*) Except for the rest period, the two hands should not be idle at one time.

(*d*) Motions of hands or arms should be symmetrical, simultaneous and opposite.

(*e*) Motions should be simple and involve minimum number of limbs (of course depending upon the type of work). The purpose is to perform the work in the shortest duration of time and with minimum of fatigue.

(*f*) It is very desirable for a worker to employ momentum to assist himself where the same (momentum) is not to be overcome or conquered by his own muscular efforts.

(*g*) Motions should be smooth and continuous ; they should not involve frequent stops and sharp directional changes.

(*h*) Ballastic movements (*i.e.*, as used in driving a nail) wherever feasible should be preferred over controlled ones because they are easy, fast and more accurate.

(*i*) A worker may use mechanical aids to assist him to overcome muscular effort.

(*j*) Work movements should be rhythmical and automatic, if possible.

2. Rules Concerning Work Place Layout and Material Handling

(*a*) There should be a definite, fixed and easily accessible location for materials and tools.

(*b*) As far as possible, materials, tools and other mechanical devices should be kept close to the work place.

(*c*) Gravity should preferably be employed for delivering materials at the work place.

(*d*) An assembled or final product should preferably be dropped on a conveyor (or chute) near the work place, so that gravity and not the operator delivers the job at the required place. Hands should normally not be employed for non-productive work.

(*e*) Tools and materials should preferably be located in the order or sequence in which they will be required for use. It reduces mental strain (on the operator) and the process becomes more or less mechanical.

(*f*) Good illumination is necessary for proper seeing, fast operating and reducing accidents.

(*g*) In order to impart rest to some of his limbs, an operator may sometimes sit or stand while working. This necessitates a relationship between his chair height and the height of the table or work place.

(*h*) In order to reduce fatigue, the seating arrangement of the worker should be comfortable and adjustable.

(*i*) All heavy parts should be lifted by mechanical devices.

3. Rules Concerning Tools and Equipment Design

(*a*) Jigs, fixtures and foot operated devices should be employed to reduce the work load on the hands.

(*b*) Wherever possible, those tools should be used which can perform more than one operations. This saves a lot of time, otherwise wasted in searching and picking a number of tools. A tool shown in Fig. 9.9 can carry out three operations, namely (*i*) hammering, (*ii*) drawing out nails, (*iii*) screw driving.

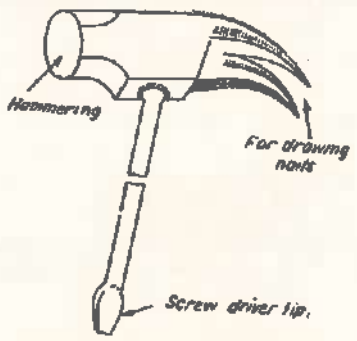


Fig. 9.9. A multipurpose tool.

(c) Preferably, tools and materials should be preplaced and located near the work place. It saves the time otherwise wasted in searching and bringing the tools for doing job.

(d) There should be maximum surface contact between the tool (handle) and the hand. It helps proper application of hand force and minimizes fatigue.

(e) Where the work is carried out by fingers (as in typing) the load distribution on-to-each finger should be as per the normal capacity of the finger.

4. Rules Concerning Time Conservation

(*a*) Even temporary ceasing of work, by a man or machine should not be encouraged.

(*b*) Machine should not run idle. It is not desirable that (the lathe chuck holding) the job is rotating but no cut is being taken.

(*c*) Two or more jobs should be worked upon at the same time or two or more operations should be carried out on a job simultaneously. For example, a drill and a turning tool may simultaneously operate on a part being manufactured on a turret lathe.

(*d*) Number of motions involved in completing a job should be minimized.

9.15. DESIGN OF WORK PLACE LAYOUT

Design Considerations

(1) Materials and tools should be available at their predetermined places and close to the worker.

(2) Tools and materials should preferably be located in the order in which they will be used.

(3) Wherever possible gravity should be employed for, the raw material to reach the operator, and finished product to be delivered at its destination. However, it should not be too automatic to become monotonous and boring for the operator. Under such conditions suitable breaks and rest periods should be provided.

(4) The operator should have comfortable posture. The height of his seat should position the worker such that the work table is about 50 mm below the elbow level of the operator.

(5) A worker should have his choice to sit or stand freely during work ; that means it should be possible to work both while sitting or standing. A flat foot rest should be provided for the sitting workers.

Sitting is less tiring as compared to standing. Seat should not be very long and may have an angle of four degrees. The back of the seat should not restrict the arm movements (essential) during work.

(6) Worker should be able to operate levers and handles without changing body position.

(7) The work place should have enough illumination, proper conditions of heat, cold and humidity, and reduced dust, noise, etc.

Suggested Work Place Layout. Figure 9.10 shows a work place layout with different areas and typical dimensions.

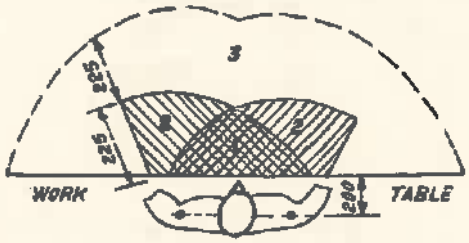


Fig. 9.10. Work place layout showing different areas and typical dimensions (mm).

1. *Actual Working Area.* It is most convenient area for working.

2. *Normal Working Area.* It is within the easy reach of the operator.

3. *Maximum Working Area.* It is accessible with full arm stretch.

Figure. 9.11 shows work place layout for assembling small component parts. *A*-1 is the actual working area and the place of assembly (*POA*) where four component parts *P*-1, *P*-2, *P*-3 and *P*-4 are assembled together. Bins containing *P*-1, *P*-2, *P*-3, *P*-4 and commonly employed tools (CET) (like screw driver, plier, etc.) lie in the normal working area *A*-2. Occasionally required tools (ORT) (hammers, etc.) lie in the maximum working area *A*-3. After the assembly has been made at *POA*, it is dropped into the cut portion in the work table-*PDA* (place for dropping assemblies)-from where the assembly is delivered at its destination with the help of a conveyor. This work place arrangement satisfies most of the principles of motion economy.

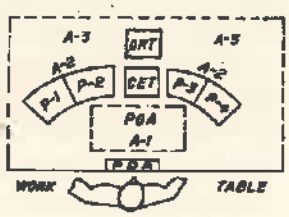


Fig. 9.11. Work place layout for an assembly job.

9.16. THERBLIGS

Therbligs were suggested by Gilbreth. Therbligs are used to describe the basic elements of movements or fundamental hand motions of the work cycle. Every therblig is represented by a symbol, a definite colour and with a word or two to-record the same. For example, thereblig Grasp has symbol U, red colour and is denoted by the word G. A simo chart employs therbligs which are of microscopic nature, whereas a process chart uses symbols like operation, inspection, transportation, etc., which are macroscopic. A single operation may consist of many therbligs ; for example,

Macroscopic motion	*Microscopic motion (therbligs)*
1. Operation of picking away a screw driver.	1. Reach hand for screw driver (transport empty). 2. Grasp the same (Grasp). 3. Take away the screw driver (transport loaded).

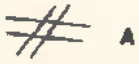
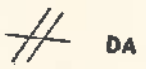
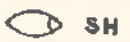
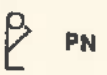
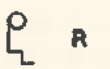
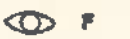
Though it looks cumbersome to deal with and to chart microscopic motions, yet they possess decided advantages over macroscopic motions.

1. As explained above, one macroscopic motion may contain a number of microscopic motions. At times, it may not be possible to eliminate completely a macromotion but an unnecessary micromotion can definitely be avoided.

2. Since microsystem is very detailed, it is simpler to understand what precisely the worker is doing.

3. Therblig colours make the charts more meaningful.

Various *Therbligs* along with their definition, symbols and colours are given below :

Sl. No.	*Therblig*	*Symbol*	*Colour*	*Definition*
1.	Assemble	 A	Violet	Putting objects together.
2.	Disassemble	 DA	Light violet	Separating different parts of an assembled unit.
3.	Avoidable delay	 AD	Lemon yellow	A delay within operator's control.
4.	Unavoidable delay	 UD	Yellow	A delay on which operator has no control.
5.	Transport loaded	 TL	Green	Moving an article from one place to another.
6.	Transport empty	 TE	Olive green	Moving (a body member, say hand) empty.
7.	Search	 SH	Black	Hunting for an object.
8.	Plan	 PN	Brown	Mental reaction before action.
9.	Rest	 R	Orange	An allowance, idleness or pause to overcome fatigue incurred during previous work.
10.	Position	 P	Blue	Turning to line up, orient or change position.
11.	Find	 F	Grey	Mental reaction at end of search.

Sl. No.	*Therblig*	*Symbol*	*Colour*	*Definition*
12.	Inspect	 I	Burnt ochre	Examining an object for its quality.
13.	Preposition	 PP	Pale blue	Locating an article in pre-determined position so that it is ready for use.
14.	Grasp	 G	Red	Taking hold of something.
15.	Use	 U	Purple	Manipulating or causing a tool to do its function.
16.	Hold	 H	Gold ochre	Retention (after grasp).
17.	Select	ST	Light grey	Choosing one object from amongst many.
18.	Release load	 RL	Carmine red	Releasing an object.

9.17. S.I.M.O. (SIMULTANEOUS-MOTION-CYCLE) CHART

Definition and Concept. It is an extremely detailed left-and right-hand operation chart. It shows on a common time scale the simultaneous minute movements (therbligs) performed by the two hands of an operator. Besides hands, the movements of other limbs of an operator may also be recorded. The time scale is represented in winks (1/2000 of a minute).

S.I.M.O. chart is generally *used* for micromotion analysis of (*a*) short cycle repetitive jobs, (*b*) High order skill jobs, and finds applications in jobs like component assembly, packaging, repetitive use of jigs and fixtures, inspection, etc.

A simo chart shows relationship between the different limbs of an operator ; for example, at any instant it can be found what the one hand is doing with respect to the other, in terms of therbligs. In addition to these relationships, a simo chart also records the duration of micromotions.

Construction

(1) Using a 16-mm movie camera a number of short and repetitive work cycles are filmed (at 16 frames per second) as the worker performs the job. For recording time, a timing device (wink counter) is placed in the field of view.

(2) The film thus obtained is viewed and the most efficiently performed one whole cycle is selected for analysis. (A cycle involves complete series of motions from beginning to the end for completing a unit of work).

(3) A special projector is employed to study the work cycle recorded on the film. The work study Engineer analyses the film, frame by frame, studying one frame at a time, and concentrating first on the left-hand and then on right-hand movements.

(4) The data noted in step-3 is recorded in the form of a therblig chart. The durations of actual movements are also read from the wink counter.

(5) A simo chart (Fig. 9.12) is then drawn for further study and analysis.

(6) This simo chart of the existing method is subjected to a questioning procedure based on the principles of motion economy; the purpose is to develop a better and improved procedure for doing a job.

(7) A new *Simo* chart is then prepared for the new method.

(8) The new method is then checked as regards the advantages claimed for the same.

SIMO CHART

Operation..... Date.....

Name of the worker..... Film No.....

Component, Name..... Operation No.....

Method:Present/Proposed

Left hand description	*Symbol*	*Time (winks)*	*Symbol*	*Right hand description*
Grasp chisel	*G*	0	*G*	Grasp hammer
		10		
To job	*TL*	20	*TL*	To job
Position	*P*	30	*AD*	Idle
		40		
Hold	*H*	50	*U*	Use

Fig. 9.12 Simo Chart

A simo chart is *advantageous* because it permits very accurate and detailed analysis. The work cycle from the film can be studied at ease, peacefully and away from the disturbing surroundings of the actual work place. However, the technique is limited because of the high cost of filming and analysis.

9.18. STOP WATCH PROCEDURE FOR COLLECTING TIME STUDY DATA

Procedural Steps. The various steps involved are as follows :

1. Establish the quality to be achieved in the product. Strike a balance between a low and very high quality. Low quality means more rejection and scrap and very high quality marks uneconomical production.

2. Identify the operations to be timed.

3. Obtain the improved procedure from the method study department.

4. Collect the necessary equipments (refer page 9-20) and ensure their accuracy.

5. Select the worker to be observed.

6. Take the worker as well as supervisor into confidence and explain to them the objectives of the project.

7. Explain to the worker the improved working procedure and the use of tools, jigs, fixtures and other attachments.

8. Break the operation into small elements and write them on the proper form.

An *element* may be defined as a distinct part of an operation or working procedure. The element, being a small entity makes it convenient to be observed, measured and analysed. The different *objectives* of element breakdown are as follows.

(*i*) To separate productive and unproductive activities or effective and idle times,

(*ii*) To get complete and accurate information,

(*iii*) To access accurately operator's performance,

(*iv*) To produce detailed work specification,

(*v*) To select the best method by comparing the work elements of two or more given methods, and

(*vi*) To collect information to compile standard data.

9. Separate constant (time) elements from variable (time) elements. (Machine elements and manual elements are the examples of constant time and variable time elements)

10. Determine the number of observations to be timed for each element, (refer page 9-47). .

11. Conduct the observations (of timing the elements) and record them on the time study form (Fig. 9.15).

Measurement of time can be done by any one of the three, *i.e.*, non-fly back, fly back or split hand techniques. In continuous timing method a non-fly back type of stop watch is employed. It is started as the first element begins and the reading is taken as the first element ends and the second element begins. Stop watch hands move continuously and the reading is noted again as second element ends and third begins and so on. At the end of the specified number of elements, the time for each element is found as follows :

Element No.	*Total time read at any instant (minutes)*	*Actual time for an element (minutes)*
1	20	20
2	40	40-20=20
3	70	70-40=30
4	100	100-70=30
		and so on.

12. Rate also the performance of the worker during step (11).

13. Repeat steps (11) and (12) for taking more than one observations.

14. Compute observed time from the measure of central tendency.

15. Calculate normal time from observed time by using performance rating factor.

16. Add process allowance, rest and personal allowances, and special allowances to the normal time in order to obtain Standard time or Allowed time. Policy allowances are in addition to standard time. (Fig. 9.13).

Standard Time may be defined as the amount of time required to complete a unit of work, (*a*) under existing working conditions, (*b*) using the specified method and machinery, (*c*) by an operator, able to the work in a proper manner, and (*d*) at a standard pace.



OT : Observed time.
PRF : Performance rating factor.
NT : Normal time.
PA : Process allowances
RPA : Rest and personal allowances.
SA : Special allowances.
POA : Policy allowances.

Fig. 9.13. Conversion of observed time to standard time.

Stop watch study is *employed* :

(*a*) for checking time standards obtained by other methods ;

(*b*) for timing repetitive operations employed in manufacturing different jobs ;

(*c*) where it becomes necessary to break down an activity (involving motions of head, leg, foot, trunk, etc.) in detail and study.

Stop Watch Time Study Equipment. Stop watch is one of the principle timing devices employed for measuring the time taken by an operator to complete the job. Besides stop watch, motion picture cameras and time recording machines have also been used.

Stop watch is an accurate time measuring equipment (watch) which can run continuously for one hour or half an hour normally and records time by its small hand. One revolution of the big hand of the watch (Fig. 9.14) records one minute and the scale covering one minute may be calibrated in intervals of 1/300th of a minute or 1/100th of a minute.

A stop watch may be of the following *types* :

1. Non-fly back,
2. Fly back, and
3. Split hand or split second type.

Non-fly back stop watch is preferred for continuous timing. First pressing of the winding knob starts the watch and long hand begins moving. If winding knob is pressed second time, the long hand stops and with third pressing, hands return to zero position.

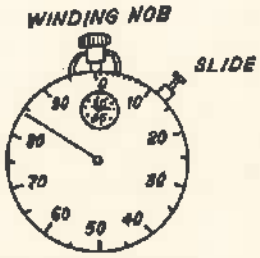


Fig. 9.14. Stop Watch

If two elements are to be timed and the second element is immediately after the first, the non-fly back system does not work well because it involves stopping the watch at the end of first element, pressing the knob to bring hands back to zero, and again pressing the knob to start the hands ; which consume quite some time and hence the second element cannot be timed accurately. Such cases require the use of fly back or split hand type of watch.

In *fly back* system, the watch is started and stopped with the help of the slide (Fg. 9.14). Pressing the winding knob brings the hands back to zero, but they do not stop, start immediately moving forward again. To stop the hands at any point, slide is used. This stop watch is preferred for taking fly back (or snap back) timing or continuous timing observations.

Split hand type of watch gives greater accuracy in reading when two elements are to be timed and one immediately follows the other. As one element finishes, pressing the winding knob makes one hand to stop (so that an observor can read time accurately) while the other keeps moving. After the reading has been taken, a second pressing on the knob restarts the (stopped) hand and the two hands go together.

Besides a stop watch, the other equipments needed for time study are, time study form (Fig. 9.15), time study board, steel rule or measuring tape, tachometer, micrometer, pencil, slide rule or calculator, etc.

PERFORMANCE RATING. Rating means gauging and comparing the pace rate or the performance of a worker against a standard performance level set by the time study engineer. The standard performance level is different for different jobs. The (performance) rating factor is used to convert observed time into normal time.

$$\text{Normal time} = \text{Observed time} \times \frac{\text{Performance level of the worker}}{\text{Standard performance level expected}}$$

Time Study Form

Product..... Time Study Engineer .....
Operation No..... Date.....
Operation description.....
No. of cycles.....5.....
Standard time found.....

Element description	*Observed time (Stop watch reading)*					*Averaged observed time*	*Rating factor*	*Normal time*	*Allowances*	*Standard time*
	1	*2*	*3*	*4*	*5*					

Fig. 9.15. Time study form.

A rating factor or the levelling factor is a factor by which the observed time (*i.e.*, the actual time taken by the worker to perform a job) is multiplied in order to adjust for differences in operator's performances. Performance rating becomes necessary in order to differentiate between the performances of two or more operators. Secondly, it can also show day-to-day variations in the level of performance of the same worker.

The rating can be,

(*a*) *Standard-rating*. It is the average rate of pace at which a qualified worker will naturally work if he is motivated to apply himself to his work.

(*b*) *Normal rating*. It is the average rate or pace at which a qualified worker will naturally work even if he has no specific motivation to apply himself to his work.

Various rating techniques are as follows :

(1) Speed rating,
(2) Skill and effort rating,
(3) Westing-house system of rating,
(4) Synthetic rating,
(5) Objective rating, and
(6) Physiological evaluation of performance level.

1. Speed rating. Speed of the movements of a worker is the only factor in speed rating. Rating personnel observes the speed of the movements of the worker against a standard expected pace or speed and notes the relationship between them as a rating factor. Rating can be applied to different elements.

$$\text{Normal time} = \text{Observed time} \times \frac{\text{Worker's speed}}{\text{Speed expected from the worker}}$$

2. Skill and effort rating. This rating system was suggested by C.E. Bedaux in 1916. The units of work are expressed as B's. If a worker acquires 60 B's in one hour, it would be standard performance. While timing the elements the operator is rated for the speed of his movements and his skill. An efficent worker earns points in excess of 60 B's and a poor worker-below 60 B's. B-points for a job can be calculated by adding the same (*i.e.*, B-points) for each element involved in the job. B-points for an element are equal to :

$$\frac{\left(\begin{matrix}\text{Observed time}\\ \text{in minutes}\end{matrix}\right) \times \left(\begin{matrix}\text{B-points earned}\\ \text{by the worker}\end{matrix}\right) \times (\text{Relaxation factor})}{60}$$

Relaxation factor depends upon the nature of the work and may vary from 1 to 3 for light to very heavy duty works or jobs.

3. Westing-house system of rating. It is based upon four factors, which are further divided into subfactors and have numerical values attached with them. The various factors are,

(*i*) *Skill*	Superskill,	Excellent,	Good,
	(+0.15)	(+0.11)	(+0.08)
	Average	Fair	Poor,
	(0.00)	(-0.05)	(-0.16)*

Similarly other three factors named below are subgrouped and each subgroup has a numerical value.

(*ii*) Effort,

(*iii*) Conditions (of temperature, noise, smoke, fumes, etc.), and

(*iv*) Consistency,

A worker is rated on the basis of the above four factors. The following example will clarify the system.

Example 9.1. Let the observed time for an operation be 0.6 minutes and a worker while being observed, is estimated as follows :

Excellent skill	+0.11
Good effort	+0.02
Good conditions	+0.02
Fair consistency	−0.02
Algebraic sum	+0.13

which indicates that the worker is 13% above average, or his pace rate is 113%. If a worker gets negative numerical figure he is considered below average. The rating factor in this case is 1.13 and thus normal time for the operation=0.6x1.13 = 0.678 minutes.

4. Synthetic rating. In this system the speed or the pace rate of an operator is evaluated with the help of predetermined motion time standards (PMTS). Various elements are timed in the usual way and their values are compared with the time values as existing in predetermined motion time standards. P.M.T.S. are compiled as a result of large number of observations on each movement (and generally) through micromotion (*i.e.*, frame by frame) analysis. Such studies are carried out for a wide variety of jobs with male and female workers under different working conditions.

$$\text{Rating factor} = \frac{\text{Time value extracted from PMTS}}{\text{Observed time}}$$

* numerical values.

5. **Objective rating.** This system involves, first, rating the speed of the worker against a standard pace, independent of job difficulty and then adding an allowance depending upon the job difficulty. The job difficulty is decided from the following

(*a*) The amount of body used,

(*b*) Foot movements involved,

(*c*) Eye-hand co-ordination (if any),

(*d*) Weight moved or lifted, and

(*e*) Handling requirements, etc.

6. **Physiological Evaluation of performance level.** Performance level of a worker can also be estimated physiologically, because heart beat rate increases with the muscular activities and amount of oxygen consumed by a worker increases with the severity of physical labour.

ALLOWANCES. Allowances are added to the normal time in order to arrive at standard time. Various allowances and for the reasons for which they are provided, are as follows :

1. **Process Allowances.** They are meant to compensate workers for the enforced idleness due to the character or nature of a process or an operation. If the idlness would not have been enforced, the workers would have earned more. Such idlness is unavoidable when a worker handles a machine which works automatically for a part of the total working time or where a number of workers perform independent operations on the same job and it is not possible to completely balance the production line.

A worker generally feels discouraged if unluckily the idle time becomes a major portion of the total cycle time because even if he works at a fast pace rate during the non-idle time, he can hardly boost his low earnings.

2. **Personal and Rest Allowances.** A worker cannot work continuously like a machine and hence such allowances are provided to him in order to satisfy his personal needs (like visiting toilet, etc.) and to recover from the physiological and psychological effects of energy spent while performing an operation under existing working conditions. Rest allowance is a relaxation allowance to a worker to overcome fatigue incurred during working. Excessive fatigue affects badly the performance of a worker. Fatigue is the result of unhealthy working conditions, physical exertion, inconvenient postures, concentration, etc. Relaxation allowances may vary from 12% to 20% (or even more) of the normal time from light to heavy works.

	Description	*Allowance*	*Remarks*
(*a*)	Personal allowances	5%	-
(*b*)	Basic fatigue allowance	4%	-
(*c*)	Abnormal posture	0 to 15%	Depending upon the severity
(*d*)	Visual concentration	0 to 10%	-do-
(*e*)	Bad light	1 to 5%	-do-
(*f*)	Atmospheric conditions (lack of ventilation, bad smell, fumes, dust, smoke, etc.)	1 to 10%	-do-
(*g*)	Noise (normal, low or loud, continuous or frequent)	0 to 10%	Depending upon the severity

	Description	*Allowance*	*Remarks*
(*h*)	Special protective dress (as in welding, metal casting, etc.)	0 to 20%	Depending upon the severity
(*i*)	Heat (Normal to above (85°F)	0 to 20%	-do-
(*j*)	Tediousness	0 to 5%	-do-
(*k*)	Mental strain	1 to 8%	-do-

3. **Special Allowances.** They may be temporary or permanent and are given for activites which are not generally the part of work cycle but are considered essential for performing the work satisfactorily. special allowances can be classifiied as,

(*a*) *Periodic activity allowance,* which is for the activites to be carried out periodically during work cycle, for example, setting up of a planer, regrinding a lathe tool etc.

(*b*) *Interference Allowance.* Machine interference allowances are provided when a worker is looking after two or more machines and one or more of them stop (at random or cyclically) while he is attending to another (machine). The result, of machine stoppages or machine interference, is loss in production or total output. Thus, for no fault of his own, the worker suffers because of low output. Interference allowance compensates this aspects. Machine stoppage may be cyclic or random and thus 'cycle interference allowances' or 'random interference allowances' are specfied. Cycle interference allowances are generally given to a worker handling more than one automatic machines which have different automatic cycle times. If the worker is attending machine *B* and the automatic cycle time of machine *A* is over, naturally machine *A* will stop and the worker is not in a position to attend the same until he makes machine *B* to start. 'Random interference allowances' are given on machines which stop or have to be stopped due to certain causes occuring at random (*e.g.,* when a yarn breaks in winding).

9.19. STANDARD DATA

Definition and Concept of Standard Data. Standard data is a catalogue of 'normal time' values for different elements of jobs or for minute movements involved in different jobs. This catalogue is prepared by compiling the timings of a number of standard elements.

The *necessity* of preparing such a time catalogue or standard data arose because (in an industry), generally, similar elements or motions are involved in many jobs. (As an example, drilling holes is a common feature of many machine shop jobs). If time study is to be conducted for every new job, it is naturally wasteful to retime those elements of the new job which are in common with the previously timed jobs. In such cases it is always economical to use the previously timed and compiled data, called *Standard Data*. Once the standard data is ready, one requires to list the job elements or the minute motions of an operation, read their times from the standard data catalogue and add them up. The total time thus obtained is an estimate of normal time for a job which can be converted into standard time by adding proper allowances.

Types of Standard Data. Two types of standard data are used and each is calculated by a different method.

(1) *Standard data (Macrodata)* is based upon elements of a job, is also known as 'Element Standard Data' and is compiled for a representative group of elements by macroscopic methods. It is for families of jobs and gives normal time for various elements of jobs. The time values are procured from the actual stop watch (or other) measurements of the tasks (within the job family) carried out previously. This type of data is restricted to particular operations such as machining on lathe, etc. Operations are broken down into elements ; which are then, timed to get a system of data showing normal element time for any and all jobs (completed on that lathe but) having different sizes, materials, feed, speed, depths of cut, and method of holding the job, etc. Thus compiled large data helps considerably in timing a new job, without going

into any more time study. This shortens considerably the amount of time and labour needed to find the standard time for a new job.

(2) *Universal standard data (Microdata)* is based upon minute movements (*i.e.*, therbligs-reach, carry, hold, etc.) involved in an operation and is compiled by microscopic methods. The methods, lie on the principle that all jobs consist of very little movements called therbligs or in other words, all jobs can be broken into therbligs. Microdata compiles normal time for a work cycle or a task by analysing the fundamental types of motions (therbligs). This analysis is carried out by frame to frame study of the film of the work cycle recorded by movie camera (Micromotion Analysis). M-T-M (Method-Time-Measurment) and Work factor system are examples of universal standard data.

Macrodata deals with (big) elements and microdata with (minute) motions. Macrodata is collected by time study (say stop watch study) whereas microdata is the result of micromotion study and analysis ; but both lead to normal time for a work cycle.

Developing the Standard Data. The steps involved in developing standard data are given below :

(1) Decide the range of applicabilty of the standard data.

(2) Break the jobs into elements. There are three types of elements, namely constant elements, variable elements and machine elements (refer Section 9.18).

(3) Obtain or conduct time studies for wide varieties of jobs/job families under different sets of parameters and conditions.

The conditions and characteristics of job, method and equipments, with which time study values are obtained, should be same for the jobs for which this standard data is to be used.

(4) Summarize time studies using a summary form.

(5) Separate constant elements from variable elements.

(6) Using statistical methods calculate the average standard time for constant elements.

(7) Explore the job characteristics leading to variability in elements. A graph can be plotted between normal time value of each element and the dimension of variable (say size of item) and a smooth curve can be fitted (Fig. 9.16).

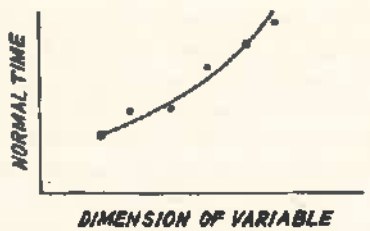


Fig. 9.16. Dimension of Variable.

(8) Compile the standard data, and

(9) Test the data for its correctness and accuracy.

Comparison of Standard Data with Individual Time Studies. Whether a new job should be timed by a new detailed time study or by adding time values taken from standard data, it depends upon a number of considerations. Conducting a time study for every job may be more economical than compiling a large standard data if the number of jobs involved are a few. But, if the number of jobs to be handled are large, decidedly going for compiling the standard data is economical and advantageous in following respects :

1. Standard data eliminates the need for large number of time studies.

2. Standard data being collected from a large number of observations is naturally more reliable. It possesses greater accuracy and scope of coverage.

3. Being more accurate, it gives a better estimate of production times.

4. Production schedules for incoming jobs can be better planned.

5. Standard data finds universal application.

Use of Standard Data. Standard data is used for the following :

(1) To estimate standard time for new jobs of repetitive of non-repetitive nature, quickly and economically,

(2) For estimating production times for pricing inquires made by customers or for quotation purposes,

(3) In job design, process planning and scheduling,

(4) To measure productive labour for cost checks,

(5) For balancing production operations,

(6) As a realistic basis for incentive plans,

(7) For constructing time formulae,

(8) To calculate the number of automatic machines which an operator can handle effectively.

(9) To find percentage efficiency of manual operations,

(10) In machine (or other) shops where similar jobs are manufactured in different sizes.

(11) To find standards for short runs of custom order products, *i.e.,* for production runs too small to employ time study,

(12) Repair and maintenance,

(13) Building construction,

(14) Machining and assembly,

(15) Typing and clerical jobs,

(16) Filing,

(17) Warehousing,

(18) Packaging, and

(19) Planning team work activities as in garment making industries.

9.20. ANALYTICAL ESTIMATING

Introduction. Setting the time standards for long and non-repetitive operations by Stop Watch Method are uneconomical.

Analytical Estimating technique determines the time values for such jobs either by using the synthetic data or on the basis of the past experience of the estimator when no synthetic or standard data is available. In order to produce accurate results the estimator must have suffcient experience of estimating, motion study, time study and the use of synthetised time standards.

BS 3138 : 1969 defined *Analytical Estimating* as a Work Measurement technique being a development of estimating, whereby the time required to carry out elements of a job at a defined level of performance is estimated partly from knowledge and practical experience of the elements concerned and partly from synthetic data.

Procedure. The various procedural steps involved in Analytical Estimating are :

(*a*) Find out job details which include job dimensions, standard procedure and especially the job conditions, *i.e.,* poor illumination, high temperatures, hazardous environments, availability of special

jigs, fixtures or toolings, condition of materials or other parts to be operated upon, etc.

(*b*) Break the job into constituent elements.

(*c*) Select time values for as many elements possible from the library of element time values (*i.e.*, synthetic data).

(*d*) To the remaining elements for which no synthetic data is available, usually the estimator gives suitable time values from his past knowledge and experience.

(*e*) Add (*c*) and (*d*) and this is the total basic time at a 100% rating.

(*f*) Add to (*e*) an appropriate Blanket Relaxation Allowance. In analytical estimating, Relaxation Allowance is not added to individual elements, rather a blanket, R.A., depending upon the type of job and job conditions, is predecided as a percentage (10-20%) of the total basic time and is added to the total basic time.

(*g*) Any additional allowances if applicable may be added to (*f*) in order to arrive at Standard Time for the given job or task.

Advantages

(*i*) It possesses almost the same advantages as enjoyed by synthesis technique of Work Measurement.

(*ii*) It aids in planning and scheduling.

(*iii*) It provides a basis for rate fixing for non-repetitive works in industries.

(*iv*) It improves labour control.

Drawback. Since analytical estimating relies upon the judgement of the estimator, the time values obtained are not as accurate and reliable as estimated by other work measurement techniques.

Uses or Applications. Analytical estimating is used,

(*i*) for non-repetitive jobs, jobs involving long cycle times and the jobs having elements of variable nature. Stop watch time study or building synthetic data, for timing such jobs does not prove to be economical.

(*ii*) in Repair and Maintenance work,
Tool rooms,
Engineering construction,
Job production,
One time large projects, and
Office routines, etc.

Difference between Synthesis, P.M.T.S. and Analytical Estimating. Synthesis, P.M.T.S, or Analytical Estimating, all these techniques estimate the standard time of a job without themselves measuring the time, *i.e.*, these techniques do not employ a time measuring equipment like stop watch, etc.

(*i*) Synthesis builds up the total time for a job by adding the times for different elements of the job. The element time values are taken from a catalogue (of elements times) built from a firm's own past time studies on other jobs having the concerned elements. Time values for all the elements of a job to be timed can be found from the previously collected time data, (Synthetic Data).

(*ii*) P.M.T.S. is similar to synthesis but differs as regards the characteristics of the job elements. P.M.T.S. deals with more basic elements of duration 0.1 second or less whereas the element time in case of synthesis may be of 3 to 4 seconds of duration.

Like Synthesis, P.M.T.S. also relies upon manuals or time catalogues for building the total time for a job.

(*iii*) Analytical Estimating differs from P.M.T.S. as regards the duration of elements. It is similar to synthesis.

Analytical Estimating differs from synthesis in the sense that it estimates time of non-repetitive and long operation jobs, for whose all job elements, past time data may not be available with the firm. Hence the time for the new job has to be determined, by timing some elements on the basis of synthetic data available and the remaining elements are given a time by the estimator from his past experience of timing different jobs.

9.21. PREDETERMINED MOTION TIME SYSTEM (PMTS) OR ELEMENTAL MOTION TIME SYSTEM OR BASIC MOTION TIME SYSTEM

Introduction. In section 9.19, the Standard Data has been classified as *Macro Data and Micro Data*. An element in Macro data, *e.g.*, pick up the screw driver may have its timed value of several seconds whereas in Micro data the elements of the job are basic human motions wth duration 0.1 second or even less. This section will deal with *M-T-M and Work Factor Systems* (*i.e.*, PMTS) which are known as Micro data. Micro data is based upon much smaller division of motions (*i.e.*, therbligs) as compared to Macro data.

BS 3138 : 1969 *defines* PMTS as a work measurement technique whereby times established for basic human motions (classified according to the nature of the motion and the conditions under which it is made) are used to build up the time for a job at a defined level of performance.

Technique :

(*i*) The technique to build PMTS data does not measure element time by a stop watch and thus it avoids the inaccuracies being introduced owing to the element of human judgement.

(*ii*) It is assumed that all manual tasks in industries are made up of certain basic human movements (like reach, move, disengage etc.) which are common to almost all jobs.

(*iii*) The average time taken by the (normal) industrial workers to perform a basic movement is practically constant.

With the above facts in mind, the various steps involved in collecting PMTS data are as follows :

(*a*) Select large number of workers doing varieties of jobs under normal working condtions in industries.

(*b*) Record the job operations on a movie film. (Micromotion study).

(*c*) Analyse the film, note down the time taken to complete each element and compile the data in the form of a table or chart.

The jobs selected are such that they involve most of the common basic motions and are worked under different set of conditions by workers having different ages and other characteristics.

Once the tables for various basic motions are ready, the normal time for any new job can be determined by breaking the job into its basic movements, noting time for each motion from the tables and adding up the time values for all the basic motions involved in the job.

Standard time may be obtained by adding proper allowances.

Objects and Uses of PMTS. Predetermined motion time system finds the following uses :

(*i*) It is very useful in Method Analysis.

(*ii*) It helps modifying and improving work methods before starting the work on the job.

(*iii*) It sets time standards for different jobs.

(*iv*) It assists in constructing time formulae.

(*v*) It aids in the prebalancing of the manufacturing lines.

(*vi*) It provides a basis for wage plans and labour cost estimation.

(*vii*) It facilitates training of the workers and supervisor.

(*viii*) It s used for timing those short and repetitive motions which cannot be measured by stop watch.

Advantages of PMTS. Predetermined motion time system possesses the following advantages :

(*i*) It eliminates inaccuracies associated with stop watch time study.

(*ii*) It is superior to stop watch time study when applied to short cycle highly repetitive operations.

(*iii*) Time standard for a job can be arrived at without going to the place of work.

(*iv*) Unlike stop watch study, no rating factor is employed.

(*v*) PMTS data, since it is the result of very large number of observations, is more reliable and accurate as compared to stop watch time study data.

(*vi*) The time and cost associated with finding the standard time for a job is considerably reduced.

(*vii*) Alternative methods are compared easily.

(*viii*) PMTS helps in tool and product design.

Drawbacks :

(*i*) PMTS can deal only with manual motions of an operation.

(*ii*) All categories of motions have not been considered while collecting PMTS data.

Applications of PMTS. Predetermined motion time system is usefully employed for the following types of jobs :.

(*a*) Machining work,

(*b*) Maintenance work,

(*c*) Assembly jobs,

(*d*) Servicing, and

(*e*) Office work.

9.22. METHOD-TIME-MEASUREMENT (M-T-M) :

Introduction. This system was developed by Method-Time-Measurement Association and it got recognition in 1948. Unlike work factor system, M-T-M does not require any modification of the basic time values. Moreover the basic human movements in this system are analysed in more detail. M-T-M measures time in terms of TMUs (Time-Measurement-Units) and 1 TMU=0.0006 minutes.

M-T-M analyses an industrial job into the basic human movements required to do the same. From the tables of these basic motions (Table I to IX), depending upon the kind of motion, and conditions under which it is made, predetermined time values are given to each motion. When all such times are added up, it provides the normal time for the job. Standard time can be found by adding suitable allowances.

According to M-T-M the various classification of motions are :

(*i*) Reach-R,

(*ii*) Move-M,

(*iii*) Turn and Apply Pressure-T and AP,

(*iv*) Grasp-G,

(*v*) Position-P,

(*vi*) Release-RL,

(*vii*) Disengage-D,

(*viii*) Eye travel time and eye focus time-ET and EF.

(*ix*) Body, Leg and Foot Motions, and

(*x*) Simultaneous Motions.

A table is provided for each motion. Depending upon different characteristics of a motion, the time can be read from the table.

TABLE-I

Reach-R

Distance moved inches	Time TMU				Hand in motion		Case and Description
	A	B	C or D	E	A	B	
3/4 or less	2	2	2	2	1.6	1.6	A.....
2	4	4	5.9	3.8	3.5	2.7	B.....
.	.	.	.	.	.	.	C.....
.	.	.	.	.	.	.	D.....
.	.	.	.	.	.	.	E.....

In *Reach* the hand moves to destination and has a predefined objective. Time for *Reach* depends upon :

(*i*) the distance moved,

(*ii*) nature of destination,

(*iii*) type of reach, (*i.e.*, whether hands move/accelerate/decelerate at the begining/end of reach or not).

There are five cases for the motion *Reach* ;

A. Reach to an object in other hand or to an object in fixed location.

B. Reach to single object in location which may vary a little from cycle to cycle.

C. Reach to object jumbled with other objects in a group. It involves search and select.

D. Reach to a very small object or reach to an object where accurate grasp is required.

E. Reach to indefinite location to get hand in position for body balance.

TABLE-II

Move-M

Distance moved inches	Time TMU				Weight Allowances			Case and Description
	A	B	C	Hand in motion B	Wt. (lb). up to	Factor	Constant TMU	
1	2.5	2.9	3.4	2.3	2.5	1.00	0	A.....
3	4.9	5.7	6.7	3.6	7.5	1.06	2.2	B.....
.	.	.	.	.	.	.	.	
.	.	.	.	.	.	.	.	
.	.	.	.	.	.	.	.	C.....

Move involves transporting an object to a definite location. Time for *Move* is influenced by,

(*i*) Nature of location or destination,

(*ii*) Distance moved,

(*iii*) Weight factor (or resistance), and

(*iv*) Type of move.

There are three cases for the basic motion *Move*.

A. Move object to other hand or against stop.

B. Move object to approximate or indefinite location.

C. Move object to exact location.

TABLE III

Turn and Apply Pressure—T and AP

Weight (lbs.)	Time TMU for degrees turned									
	30	45	60	75	90	105	120	135	150	180
Small (0–2) lbs.	2.8	3.5	4.1	4.8	5.4	6.1	6.8	7.4	8.1	9.4
Medium (2.1–10)	...	...	...	...	...	...	...	...	...	...
Large (10.1–35)	...	...	...	...	...	...	...	...	...	...

Apply pressure case 1 16.2 TMU

Apply pressure case 2 10.6 TMU

Turn indicates the rotation of the hand about the axis of forearm.

The time for *Turn* depends upon the degrees turned and the weght factor. Weight factor classifies *Turn* into three types namely Small, Medium and Large (refer Table-III)

TABLE-IV

Grasp-G

Case	Time TMU	Description
1A	2.0	Pick up Grasp
1B	...	.....
1C1	...	
1C2	...	
1C3	...	
2	5.6	Regrasp
3	5.6	Transfer Grasp
4A	...	Jumbled objects
4B	...	.....
4C	...	.....
5	0	Contact

Apply Pressure means the application of pressure to,

(i) squeeze an object say a lever,

(ii) overcome resistance–It requires more force than (*i*).

Grasp means taking hold of an object. Motions like Search and Select precede Grasp. The time for *Grasp* depends upon the description or type of the grasp motion.

TABLE-V

Position-P

(Distance moved to engage 1" or less)

Class of Fit		Symmetry	Easy to handle	Difficult to handle
1. Loose	No pressure required	S	5.6	11.2
		SS	9.1	14.7
		NS	10.4	16.0
2. Close	Light pressure required	S	.	.
		SS	.	.
		NS	.	.
3. Exact	Heavy pressure required	S	.	.
		SS	.	.
		NS	.	.

Position means turning to line up, orient, or change position

The time for *Position* depends upon

(a) Class of fit — Loose, Close, Exact

(b) Symmetry — S-Symmetrical, SS-Semi-symmetrical, NS-Non-symmetrical

(c) Ease of handling — Easy to handle, Difficult to handle

TABLE VI

Release-RL

Case	Time TMU	Description
1	2.0	Normal release– Releasing object by opening fingers
2	0	Contact release

Release means liberating an object.

TABLE VII

Disengage D

Class of fit	Easy to handle	Difficult to handle
1. Loose	4.0	5.7
2. Close	7.5	11.8
3. Tight	...	...

Disengage means to disjoin the two objects. The time for the motion *Disengage* depends upon

(*a*) Class of fit — Loose, Close, Tight

(*b*) Ease of handling — Easy to handle, Difficult to handle

TABLE VIII

Eye Travel and Eye Focus-ET and EF

Eye travel time (not more than 20 TMU)

$$= 15.2 \times \left(\frac{\text{[Distance between points from and to which the eye travels]}}{\text{[Perpendicular distance from the eye to the line of travel]}} \right)$$

Eye focus time = 7.3 TMU

TABLE IX

Body, Leg and Foot-Motions

Description	Symbol	Distance	Time TMU
Foot Motion	FM	Up to 4"	8.5
Leg or Foreleg Motion	LM	Up to 6"	7.1
Side-step	–	–	–
Bend on one knee Kneel on floor	–	–	–
Sit Stand Turn body	–	–	–
Walk	W-FT W-P	Per Foot Per Pace	5.3 15.0

9.23. WORK FACTOR

Introduction. Work Factor System got developed in Philadelphia in the year 1934. The two main names associated with Work Factor System were those of J. H. Quick and W. J. Shea.

Like M-T-M, Work Factor System,

(*i*) also relies on manuals containing time values for different elements (i.e., leg, trunk, foot, etc.) predetermined from high speed films of a large number of Industrial Operations.

Unlike M-T-M, Work Factor System,

(*i*) is more accurate,

(*ii*) has a simple and easy procedure,

(*iii*) in addition to other aspects, it takes into account Mental Process Times,

(*iv*) considers some non-productive times also,

(*v*) has its standards for an experienced skilled worker whereas M-T-M standards are based upon the performance of an average operator. Because of this reason, for the same job, Work Factor System gives a smaller time as compared to M-T-M.

(*vi*) has 1 Time Unit=0.0001 minutes.

Classfication. Work Factor System has a number of sets of data. For example :

1. Detailed Work Factor

(*a*) As the name suggests, it is detailed for fine analysis.

(*b*) It is preferred for high accuracy and consistency of results.

(*c*) It is used for cost reduction, method improvement and setting time standards.

(*d*) It cannot be applied (used) by an untrained personnel.

2. Simplified Work Factor

(*a*) It involves broader elements and provides quicker results.

(*b*) It is not so precise as the Detailed Work Factor.

(*c*) The error in the results obtained by this system may be of the order of 0.5%.

(*d*) It may be used for timing-machining, maintenance and material handling operations.

(*e*) Like Detailed Work Factor, it is also employed for estimating cost of different operations.

3. Abbreviated Work Factor

(*a*) It is the further abbreviation of the Work Factors explained above.

(*b*) It provides still quicker analysis.

(*c*) It is not so precise as the Detailed or Simplified Work Factor.

(*d*) The standard time estimated by this system is more than that found out by Detailed or Simplified Work Factor.

(*e*) Unlike the two Work Factors explained above, the Abbreviated Work Factor possesses all the data in one sheet.

(*f*) It finds applications in construction work, maintenance and material handling operations.

4. Ready Work Factor

(*a*) As compared to all other Work Factor Systems, it is easy to learn and to administer.

(*b*) It is meant for persons (belonging to other departments like accounts, etc.) which do not have much experience of Work Study.

The Detailed Work Factor is Discussed Below :

Principle. Detailed Work Factor considers some basic motions whose time in turn is modified by the elements of difficulty, (*i.e.*, the time increases in some proportion as the number of difficulties increase). As it will be explained below, weight, change of direction, etc., each factor is called a Work Factor. The more the number of Work Factors (up to 4 only) the more is the time taken for a motion.

The Detailed Work Factor considers the following :

(*i*) **Elements of Work :**

(*a*) Assemble,

(*b*) Dissemble,

(*c*) Grasp,

(*d*) Mental Process,

(*e*) Preposition,

(*f*) Release,

(*g*) Transport, and

(*h*) Use.

(*a*) *Assemble.* Putting objects together.

(*b*) *Dissemble.* Separating different parts of a body.

(*c*) *Grasp.* Taking hold of something.

(*d*) *Mental Process.* In mental process, the senses receive a stimulus and react accordingly. Sort, inspect, recollect etc., involve mental process.

(*e*) *Preposition.* Locating an article in predetermined position so that it is ready for use.

(*f*) *Release.* Releasing or letting go an object.

(*g*) *Transport.* Moving an article or hand from one place to another.

(*h*) *Use.* Manipulating or causing a tool to do its function.

(*ii*) **Variables of Distance.** Distances moved from 1 to 40 inches and the related times are given in Work Factor Tables.

(*iii*) **Weights or Resistance (W).** Weights associated with the motions or the resistance experienced by a limb in performing a motion are duly accounted for in Work Factor. Besides other variables, the amount of weight (in lbs.) associated with a motion (for a male or female worker) specifies the number of Work Factors (refer W.F. Tables).

A Work Factor means an element of difficulty. An operation having 4 Work Factors associated with it implies that it is more difficult than the operation with 1 Work Factor only and thus the time associated with the former is also more [refer Table I].

W. F. Tables also show that for each body member for a particular distance moved there are five values of times-one basic time value and the remaining four values of times depending upon the number of Work Factors associated with the motion. The basic time value is for the minimum difficulty.

(*iv*) **Degree of Control.** The degrees of control as connected with manual work are :

(*a*) Steering or Directional Control (S).

(*b*) Change of Direction (U).

(*c*) Precaution or care (P).

(*d*) Manner of Terminating the Motion (D-Definite stop).

These categories when combined with weight classifications decide the number of Work Factors (difficulties) associated with a body motion.

(*v*) Body members-They are :

(*a*) Arm (*A*), (*b*) Leg (*L*),
(*c*) Trunk (*T*), (*d*) Finger-Hand (*F, H*),
(*e*) Foot (*FT*), (*f*) Forearm swivel (*FS*).

W. F. Tables (*i*) to (*vi*) provide time values for motions connected with them.

Procedure. The various steps involved in finding the operation time are as follows :

TABLE-WF (WORK FACTOR)

1 Time Unit = 0.0001 Minutes

(*i*) ARM-Measured at Knuckles

Distance moved inches	Basic Time value	Work Factors			
		1	2	3	4
1	18	26	34	40	46
2	20	29	37	44	50
⋮					
12	46	65	85 *	102	117
⋮					
35	76	103	128	151	171
40	81	109	135	159	179
Weight (lbs) Male	2	7	13	20	Up
Weight (lbs) Female	1	3.5	6.5	10	Up

(*a*) Analyse the job in detail into individual motions,
(*b*) Determine the number of work factors associated with each motion.
(*c*) Find the time for each motion from the tables provided,
(*d*) Add times for all the motions, and
(*e*) Add the appropriate allowances to arrive at the standard time.

(*ii*) LEG-Measured at Ankle

Distance moved inches	Basic Time value	Work Factors			
		1	2	3	4
1	21	30	39	46	53
2	23	33	42	51	58
⋮					
35	87	118	147	173	197
40	93	126	155	182	206
Weight (lbs) Male	8	42	UP	–	–
Weight (lbs) Female	4	21	UP	–	–

* Basic Time Value modified after considering work factor (an element of difficulty).

(*iii*) **Trunk-Measured at Shoulder**

	Distance moved inches	Basic Time value	Work Factors			
			1	2	3	4
	1	26	38	49	58	67
	2	29	42	53	64	73
	⋮					
	19	82	113	145	176	206
	20	84	116	148	179	209
Weight (lbs)	Male	11	58	UP	–	–
	Female	5.5	29	UP	–	–

(*iv*) **Finger-Hand Measured at Finger Tip**

	Distance moved inches	Basic Time value	Work Factors			
			1	2	3	4
	1	16	23	29	35	40
	2	17	25	32	38	44
	⋮					
	4	23	33	42	50	58
Weight (lbs)	Male	2/3	2.5	4	UP	–
	Female	1/3	1.25	2	UP	–

(*v*) **Foot-Measured at Toe**

	Distance moved inches	Basic Time value	Work Factors			
			1	2	3	4
	1	20	29	37	44	51
	4	29	41	53	64	73
Weight (lbs)	Male	5	22	UP	–	–
	Female	2.5	11	UP	–	–

(*vi*) Forearm Swivel-Measured at Knuckles

Distance moved inches		Basic Time value	Work Factors			
			1	2	3	4
45°		17	22	28	32	37
180°		31	40	49	57	65
Torque	Male	3	13	UP	–	–
(lbs)	Female	1.5	6.5	UP	–	–

(*vii*) Walking Time (30 in. Pace)

Type	1	2	Over 2
General	Analyse from	260	120+80/Pace
Restricted	Table	380	120+100/Pace

(*viii*) Visual Inspection

Focus	20
Inspect	...
React	20
Head turn	45°.....

Advantages. Besides those listed earlier work factor possesses one more major advantage that-since the job is analysed in detail, bad methods prevailing in the activity are uncovered automatically.

Applications. Work factor finds applications in :

(*i*) Industries makinig small, light hand assemblies, and

(*ii*) Electronic industry.

Example 9.2. Using the Detailed Work Factor, find the time required in picking up a shaft of 2 inch diameter, weighing 7 lbs. from a distance of 12 inches and then placing its one end inside the bush bearing (clearance fit). Assume a male worker.

Solution

(1) Reach to grasp the shaft. For this motion the Analysis is A12WD.

(*a*) *A* 12 means Arm motion of 12 inches.

(*b*) *W* is there because a weight of 7 lbs. and up and less than 13 lbs. adds 1 Work Factor. [Table (*i*)].

(*c*) *D* indicates a definite stop for the arm and therefore introduces 1 Work Factor.

From Tables-*WF-ARM*(*A*) (*i*) for 12 inches distance and 2 Work Factors the Time Units are 85 ...(*i*)

(2) Grasp the shaft. For this motion, the analysis is *F* 2. For Finger motion of 2 inches and a weight of 7 lbs. from Table (*iv*), the time units are 38. ...(*ii*)

(3) Move shaft by a distance of 12 inches and then place into the bearing. For this motion, the Analysis is *A* 12 *WSD*; *W* is because of 7 lbs. of weight, *S*-due to steering of shaft end to the bearing and *D*-because shaft (or arm) will come to definite stop over the bearing.

Referring Table (*i*) *ARM*, the time units for a distance of 12 inches and three Work Factors, are 102. ...(*iii*)

Therefore total time units $= (i) + (ii) + (iii)$

$= 85 + 38 + 102 = 225$

Since 1 time unit = 0.0001 minutes, thus the total time for the existing work.

$= 0.0001 \times 225 = 0.0225$ minutes

9.24. ACTIVITY SAMPLING, RATIO-DELAY STUDY OR WORK SAMPLING

Introduction. L.H.C. Tippett developed *Activity Sampling* in Britain in 1934 for the British Cotton Industry Research Board. R. L. Morrow used this technique in America round about 1945 and named it *Ratio Delay Study*. In 1952, C. L. Brisley renamed the technique as *Work Sampling* and today it is one of the very common techniques of Work Measurement.

Activity sampling as defined by B.S. 3138 : 1969, is a technique in which a large number of observations are made over a period of time of one or a group of machines, processes, or workers. Each observation records what is happening at that instant and the percent of observations recorded for a particular activity or delay is a measure of the percentage of time during which that activity or delay occurs.

Work Sampling can tell what percentage of the working day, a person spends how, *i.e.*, for how much time he works, what time he expends for his personal needs and for how long he remains idle.

Activities of very long duration (such as to find the actual working time of an operator in one shift of eight hours) cannot be economically timed with the help of stop watch time study. In such cases, the most appropriate technique of Work Measurement is Work Sampling which takes only 1/20th of the time required for stop watch study and gives the results within an accuracy of ± 2%.

Theory/Principle. Work sampling relies upon Statistical Theory of Sampling and Probability Theory. Normal Frequency Distribution and Confidence Level are associated very much with Work Sampling.

Statistical theory of sampling explains that adequate random samples of observations spread over a sufficient period of time can construct an accurate picture of the actual situation in the system. Approximately 500 observations produce fairly reliable results and the results obtained through observations 3000 or more are very accurate.

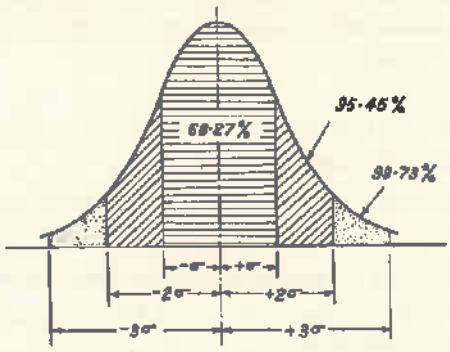


Fig. 9.17. Normal distribution curve and confidence level.

Normal frequency distribution (Fig. 9.17) portrays graphically the probability of occurrence of a chance event. Moreover, it gives important relationship between the number of standard deviations and the area under the curve representing the confidence level of an occurrence.

Standard deviation (σ)	Confidence level (%)
1	68.27
1.96	95.00
2	95.45
3	99.73

A confidence level of 95.45% signifies that the Work Study Engineer is sure that 95.45% of the times, the random observation will represent the true facts.

If the Work Study Engineer takes 25 rounds of the Machine Shop in a day, observes an operator 'x' and finds that

15 times he was working on the machine,

4 times he was setting up or cleaning the machine,

3 times he was not doing anything.

3 times he had gone for his personal needs ; it shows that the worker spends 60% of his time in actually working over the machines and for 12% of the total time he is idle, etc., etc. These facts can be confirmed or refuted by conducting more number of observations.

Procedure

(*a*) Define the problem, *i.e.,* determine the main objectives and define each activity to be measured.

(*b*) Make sure that all the persons connected with the study (*i.e.,* workers and supervisor) understand the objectives of the study.

(*c*) State the desired accuracy limits for the ultimate results.

(*d*) Conduct a Pilot Study to

(*i*) estimate the approximate percentage occurrence of the activity (*i.e., p*).

(*ii*) estimate the required number of observations for the desired accuracy set, and

(*iii*) ensure that workers have become habituated to the visits of the work study engineer.

(*e*) Design the actual study.

(*f*) Using the data obtained from Pilot Study (*d*)(*i*), above, *i.e.,* value of *p*, calculate the number of observations to be made.

***Example* 9.3.** Pilot Study showed the percentage of occurrence of an activity as 50%. Determine the number of observations for 95% confidence level and an accuracy of ±2%.

Solution

$$N = \frac{4p(100-p)}{L^2}$$

where N is the number of observations

p is % of occurence

L is limits of accuracy.

Therefore $N = \frac{4\times 50(100-50)}{2^2} = 2500.$

(a) Other methods for finding number of observations are :

(1) Rule of 1000.
(2) Rule of thumb tables.
(3) Alignment charts (Fig. 9.18)
(4) Use of Random number tables.

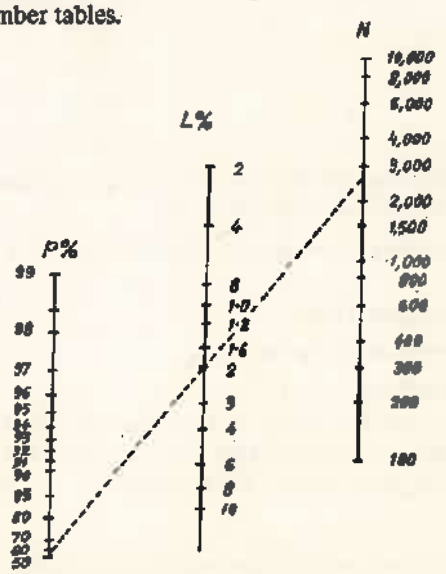


Fig. 9.18. Alignment Chart.

Study Number..... Observer.....
Sheet..... Date.....

Visit No.	Time of Visit	Operator No.				
		1	2	3	4	5
1	8.05	A	B	A	A	C
2	8.15	C	C	A	D	A
3	8.30	D	B	C	C	A
4	9.00	B	A	A	A	A
.....						
25	15.00	A	A	E	A	C

Observations : A Working
B Not working
C Getting instructions
D Waiting for tool/material
E Talking to co-workers
F Gone some where

Fig. 9.19. Work Sampling : Observation Sheet.

A random number table may look like:

850632	320974	100458	394501	430842
134859	462587	634052	639684	983886
462421	657288	379762	334985	726402

The number 850632 may imply 8.50 o'clock and 6.32 o'clock for taking an observation. A number which does not give time value in a particular shift hours may be left.

(5) Use of Punched Cards.

(*b*) Decide the number of days for study and select the shifts for the same.

(*c*) Decide the time interval between observations and the path to be followed for recording the same.

(*d*) Design the observation record sheet (Fig. 9.19)

(*e*) Make the observations and note down the information.

(*f*) Plot the data collected every day on the control chart. The observed data falling outside the control (3σ) limits on any day indicates an abnormal situation on that day and it may be caused out.

(*g*) Check the accuracy of data or the actual limit of error at the conclusion of the study.

Example 9.4. 2500 observations were conducted and it was found that the activity under study occurred 1200 times; determine the limits of accuracy and limits of error.

Solution :

$$p = \frac{1200}{2500} \times 100 = 48\%$$

Since $$N = \frac{4p(100-p)}{L^2}$$

Therefore $$L = \sqrt{\frac{4p(100-p)}{N}} = \sqrt{\frac{4 \times 48(100-48)}{2500}}$$

$$= 4\%$$

Limits of error = 48 ± 4%, *i.e.*, in between 52% and 44%.

(–) Construct a final report, state conclusions and make recommendations, if any.

Example 9.5. A work sampling study was conducted for 100 hours in the machine shop in order to estimate the standard time. The total number of observations recorded were 2500. No working activity could be noticed for 400 observations. The ratio between manual and machine elements was 2 : 1. Average rating factor was estimated as 1.15 and the total number of articles produced during the study period were 6000.

Rest and personal allowances may be taken as 12% of the normal time.

Solution :

$$\text{Proportion of working time} = \frac{2100}{2500} \times 100 = 84\%$$

$$\text{Time taken to make one article} = 100 \times \left(\frac{84}{100}\right) \times \frac{60}{6000} \text{ minutes}$$

$$= 0.84 \text{ minutes}$$

Out of 0.84 minutes, the time devoted by

$$\text{manual labour} = 0.84 \times \frac{2}{3} = 0.56 \text{ minutes}$$

and Machine time $= 0.84 \times \frac{1}{3} = 0.28$ minutes

Normal time per article = Observed time×Rating+Machine time.
= 0.56×1.15+0.28
= 0.924 minutes.

Standard time per article = Normal time+Allowances
= 0.924+0.924×12/100
= 1.0348 minutes.

Advantages

(*i*) It involves much less cost as compared to stop watch time study.

(*ii*) It can be carried out with little training.

(*iii*) It can time long operations which are almost impractical to be measured (*i.e.*, timed) by stop watch time study.

(*iv*) It is very advantageous for timing group activities.

(*v*) It does not need any timing device like stop watch or microchronometer, etc.

(*vi*) Even if the study gets interrupted in between, it does not introduce any error in the results.

(*vii*) Observations can be made within the desired accuracy.

(*viii*) Large number of observations extended over days/weeks damp down the influence of day-to-day fluctuations on the results.

(*ix*) It can increase efficiency by uncovering the sources of delay.

Limitations

(*i*) It is uneconomical both as regards time and money to study activities of short duration by Work Sampling.

(*ii*) It is also uneconomical in case one worker or one machine is to be studied.

(*iii*) It does not break, the job into elements and thus does not provide element details.

(*iv*) It does not assist in improving work method.

(*v*) It normally does not account for the speed at which an operator is working.

(*vi*) Workers may not understand the principles of work sampling and hence may not trust it.

(*vii*) Observations, neither random nor sufficient in number may produce inaccurate results.

Applications/Uses

(*i*) To determine working time and idle time of men and machines.

(*ii*) To time long duration activities which are regular/irregular, frequent/infrequent.

(*iii*) To estimate the time for which material handling equipments are actually operating in a day.

(*iv*) To estimate allowances for unavoidable delay.

(*v*) In describing resource utilisation patterns.

(*vi*) For the purpose of cost control and accounting.

(*vii*) In estimating the percentage utility of the inspectors and time standards for indirect labour.

(*viii*) In stores, hospitals, warehousing, offices, farm work, repair and maintenance work, textile industry, machine shops, etc.

(*ix*) It is preferred when the cost of using other work measurement techniques for timing a job appears to be great.

9.25. SYNTHESIS OF WORK STUDY DATA

Work study data or in other words time study values of elements obtained from direct time studies, conducted on various jobs having different parameters and under different conditions are synthesized in order to obtain 'Synthetic Times' or 'Basic Data' or 'Standard Data'.

The 'Standard Data', its development and uses have been discussed in detail in Section 9.19.

Before describing the procedure for synthesis of work study data, it is better to understand the meaning of synthesis. *Synthesis* is a work measurement technique to build up normal time for a new job (at a defined level of performance) by adding element times collected from previously held time studies on similar jobs having same elements as possessed by the new job.

The following steps are involved in synthesis :

(1) Collect all the possible details about the job, for example, material, dimensions, method, conditions, etc. The collected details should be reliable.

(2) Break the job into constituent elements. The size of the elements should be decided critically. A smaller element will have much wider range of usefulness and applicability but the time study Engineer will naturally take longer time to compile the standard time for the job.

Three types of elements, namely machine elements, constant elements, and variable elements may be there, in a job.

Machine Elements. They are controlled by the characteristics of the process such as feed, speed, depth of the cut, amount of metal to be removed, etc.

Constant Elements. They are identical from job to job; for example, mounting a cutter on the milling machine arbor or holding a lathe tool in the tool post.

Variable Elements. They are similar in nature from job to job but vary in difficulty and the time required to complete them, because different jobs may possess different dimensions, shapes, and weights. Variable elements may be those, involving hand work or others, influenced by the changes in metal machinability, quality, tolerances, etc.

Constant, variable or machine elements in each job, may be repeated the same number of time, different number of times or they may or may not be present in various jobs.

Constant elements are easy to deal with. Only sufficient number of observations are required to obtain a realistic time. Variable elements are quite problemous as compared to constant elements and need more skill and attention on the part of analyst. Good number of observations are must in order to establish a relationship (which may be a straight line or a curve) between the element characteristics and basic time for that element.

Machine elements are normally calculated from the information, of speed of job rotation, feed of the tool and the depth of cut, etc.

(3) As far as possible select the appropriate normal times for all the elements involved in the operation, from the synthetic data or the standard data.

(4) Estimate various allowances like, personal and rest allowances, process allowances and special allowances, for each element.

(5) Verify the analysis of elements for the selected job method and other conditions.

(6) Add various allowances to the normal time for each element and sum up all such times to fix the standard time for the new job.

9.26. USE OF TIME STUDY DATA IN WAGE INCENTIVE AND COLLECTIVE BARGAINING

This topic involves three meaningful words which need some elaboration. They are :

(*a*) *Time Study Data.* It contains the facts or the informations resulted from time study. Time values

for completing a job can be measured by a stop watch, a motion picture camera or a time study machine. Time study values when compiled together constitute, what is known as time study data. Time study data may be in the form of 'base time' (to which various allowances may be added depending upon the work situation or working conditions) or it may be 'standard time' (in which rating factors and various allowances have already been added).

(*b*) *Wage Incentives or Wage Incentive Schemes.* The purpose of incentive wages is to reward a more productive employee in proportion to his achievements of output or his own efforts. A good financial incentive scheme motivates workers to produce better and more. An incentive is reinforced if rewarded immediately after the performance. Incentives are given in addition to the guaranteed wages on base rates. Various commonly referred wage incentive plans are :

(*i*) Straight piece rate system with a guaranteed base wage,

(*ii*) Halsey plan,

(*iii*) Rowan plan,

(*iv*) Gantt plan,

(*v*) Emerson's plan,

(*vi*) 100% bonus plan,

(*vii*) Bedaux plan, and

(*viii*) Group plans.

(*c*) *Collective Bargaining.* Collective bargaining means negotiations between the workers and the management in order to discuss and decide about the benefits which workers want to achieve and the objectives which management wants to satisfy. Workers would like to have higher wages, job security, pension, better working conditions, etc., and management would prefer to have no strikes, better cooperation from the workers, high output and of better quality, care of equipment and machinery, high profits, etc.

Ultimately it is a compromise where both the parties arrive at. It is understood that the bargaining is done in good faith, *i.e.*, it is always with an intention to arrive at an agreement. The management is supposed to offer constructive counter proposals to the demands put forward by the workers. The collective bargaining negotiations end with all the findings, facts or agreements, being shaped as a written contract for a specified period of time and signed by the representatives of both the parties.

Time study data is the outcome of work study which is an important technique or a tool for managers to know, how ouput can be increased with the effective utilisation of the same available resources.

Time study data being compiled from a large number of properly conducted observations, forms the best and a rational and equitable basis for an incentive plan or for negotiating a collective bargaining. Since time study data is very straight-forward and has facts and figures associated with it, is therefore easy to use for an incentive plan and to convince the other party (workers or union) regarding the fairness, reliability and accuracy of such a plan and the associated work standards. On the basis of standard time, the jobs of various types and time durations can be specified in terms of the same and this further advocates the usefulness of time study data for an incentive plan. Moreover, collective bargaining contracts between workers and management become easier because work specification establishes accurately the job working conditions and the (new) method.

The purpose of using time study data for an incentive plan is to offer the worker a reward in addition to his base wage rate for reaching certain standard of output as specified by management. In other words it is an encouragement to a worker for his efforts to help manangement achieve its objectives.

The place where incentive schemes based on accurate time study data have been tried, encouraging results could be seen; productivity got raised significantly, workers became motivated, absenteeism and labour turn-over were minimized, and employee-employer relations got improved, etc. However, it was

realized that an incentive scheme in which an individual was rewarded for his own output, proved more effective than the one in which more than six (or so) persons worked together and shared equally the benefits of the incentive plan.

For a time study based incentive plan to be effective :

(1) it must be based upon accurate and just standard time values ;

(2) standards must be consistant ;

(3) sufficient difference must exist between the base wage and the wage at a reasonably attainable standard of performance ; and

(4) the standard of performance or the standard of output should neither be too tight nor too loose. Rather, it should be such that an average worker working at normal pace under the existing working conditions can achieve the required output. Tight standards create resentment in the minds of workers and result in employee-employer disputes. On the other hand, loose standards limit the output and in turn management may incur losses.

Calculation of reward to a worker :

In time study based incentive schemes the bonus or the reward is related to a factor known as *Operator Performance* which is

$$= \frac{\text{Units of work actually produced by worker}}{\text{Units of work which could be produced at standard performance}} \times 100$$

Suppose there is 8 hour duty and a job should take 30 minutes to complete (standard performance), but after 8 hours an operator is able to complete only 14 such jobs. Therefore the operator performance is,

$$\frac{14}{\frac{8\times60}{30}} \times 100 = \frac{14}{16} \times 100 = 87.5\%$$

Example 9.6.

Given :

Base wage rate : Rs. 4/hour.

Bonus at standard performance : 33.33%

Total items to complete : 50

Processing time for each item : 3 minutes.

Work completed in : 140 minutes.

To find : Bonus earned.

Solution.

Earning rate of the operator = Base wage rate per hour + (Bonus) (Wage rate)

$$= 4 + \frac{(33.33)}{100} 4 = \text{Rs. } 5.33$$

$$\text{Earning rate per minute} = \text{Rs.} \frac{5.33}{60} = \text{Rs. } 0.0888$$

Operator's actual earnings

= (No. of items to be made) × (time for one item) × (earning rate)

= 50 × 3 × 0.0888 = Rs. 13.32 ...(1)

Operator's earnings depending upon base wage rate

= (time taken to complete the work) × (Base wage rate)

$= \frac{140}{60}$ (Hrs) × Rs. 4/hour = Rs. 9.33 ...(2)

Therefore the bonus (or reward) earned by the Operator

= (1) − (2)

= Rs. 13.32 − Rs. 9.33

= Rs. 3.99 or Rs. 4.

Readers may try the following problem for the sake of practice.

Problem 9.1. Describe briefly the different techniques of 'rating' used in connection with work study of an operator's performance in a labour intensive industry.

The elemental time recorded on a time study sheet by snap-back method for a single manual work element indicates the following times in decimal minutes :

0.14, 0.15, 0.14 ,0.20, 0.15, 0.20, 0.18, 0.17, 0.19, 0.18, 0.14

0.17, 0.19, 0.13, 0.15, 0.17, 0.17, 0.19, 0.14, 0.17, 0.18, 0.16

0.14, 0.16, 0.13, 0.19, 0.14, 0.13, 0.14, 0.17, 0.12, 0.13, 0.14,

0.18, 0.14

The rating was judged as 80 on a 60 normal scale.

(*a*) Determine the normal time for the said work element.

(*b*) Determine the number of observations required to give a desired precision of ±5% with a confidence level of 95%.

[Hint (*b*) : Refer chapter on statistical quality control.

Draw frequency distribution chart ; then

$$\text{Number of observations} = N = \left[\frac{40 \sqrt{n\Sigma X^2 - (\Sigma X)^2}}{\Sigma X} \right]^2$$

(for ±5% and 95%)

Where $n = \Sigma f = 35$

$\Sigma X = \Sigma fx$

and $\Sigma X^2 = \Sigma fx^2$

9.27. COMPARISON OF WORK MEASUREMENT TECHNIQUES

Criteria	Work Sampling	Predetermined Time Standards	Stop Watch Timing	Employee Reporting	Historical
1. Speed. Time required to measure and establish standards	Average to fast	Slow to average	Average	Average	Fast
2. Training and Skill required: Technicians, Supervisors	Low to moderate	High	Moderate to high	Low	Low
3. Cost :Technician, employee time, equipment, etc.	Average	Fairly high	Average	Low	Minimal
4. Assistance in Methods Improvement	Low to moderate	High	Good	Very little	No
5. Accuracy: Subjective vs. objective, degree of distortion	Fair to good	Very high	Good to high	Fair	Low
6. Acceptability: Employee Supervisor	Fair	Good	Fair to good	Fair to good	Fair to good

7. Interruption of Work Operations	Moderate	Low	Fairly high	Fairly high	None
8. Applicability: For physical, clerical, professional work	Very good	Average	Average	Very good	Good
9. Savings: How quickly; how much	Average to high	High	Average to high	Fair to good	Fair
10. Usability: In scheduling production, evaluating performance	Average to high	High	High	Fair to good	Fair
11. Reporting Requirements: Difficulty of furnishing data	Average	Average	Average	Fair	Simple

Fig. 9.20.

9.28. ERGONOMICS

Definition

Ergons means 'Work' and *Nomos* means 'Natural Laws'. Ergonomics or its American equivalent 'Human Engineering' may be defined as the scientific study of the relationship between man and his working environments. Ergonomics implies 'Fitting the job to the worker'. Ergonomics combines the knowledge of a psychologist, physiologist, anatomist, engineer, anthropologist and a bio-metrician.

Objectives. The objectives of the study of ergonomics is to optimize the integration of man and machine in order to increase work rate and accuracy. It involves the design of,

(*i*) a work place befitting the needs and requirements of the worker,

(*ii*) equipment, machinery and controls in such a manner so as to minimize mental and physical strain on the worker thereby increasing the efficiency, and

(*iii*) a conducive environment for executing the task most effectively.

Both Work study and Ergonomics are complementary and try to fit the job to the workers; however, Ergonomics adequately takes care of factors governing physical and mental strains.

Applications. In practice, ergonomics has been applied to a number of areas as discussed below :

(*i*) Working environments,

(*ii*) The workplace, and

(*iii*) Other areas.

(*i*) Working Environments

(*a*) The environment aspect includes considerations regarding light, climatic conditions (*i.e.*, temperature, humidity and fresh air circulation), noise, bad odour, smoke, fumes, etc., which affect the health and efficiency of a worker.

(*b*) Day light should be reinforced with artificial lights, depending upon the nature of work.

(*c*) The environment should be well-ventilated and comfortable.

(*d*) Dust and fume collectors should preferably be attached with the equipments giving rise to them.

(*e*) Glares and reflections coming from glazed and polished surfaces should be avoided.

(*f*) For better perception, different parts or sub-systems of an equipment should be coloured suitably. Colours also add to the sense of pleasure.

(*g*) Excessive contrast, owing to colour or badly located windows, etc., should be eluded.

(*h*) Noise, no doubt distracts the attention (thoughts, mind) but if it is slow and continuous, workers become habituated to it. When the noise is high pitched, intermittent or sudden, it is more dangerous and needs to be dampened by isolating the place of noise and through the use of sound absorbing materials.

(*ii*) Work place layout

- The workplace is a space in a factory/machine which must accommodate an operator(s), who may be sitting or standing.
- Ideally, a workplace should be custom built for the use of one person whose dimensions are known. For general use, however, a compromise must be made to allow for the varying dimensions of humans. Therefore, a workplace should be so proportioned that it suits a chosen group of people.

  Adjustment may be provided (on seat heights for example) to help the situation.
- Fig. 9.21 shows suggested critical dimensions for a group of males using a seated workplace. These dimensions can be obtained quickly and easily and will be quite satisfactory for constructing a mock-up of the proposed design.

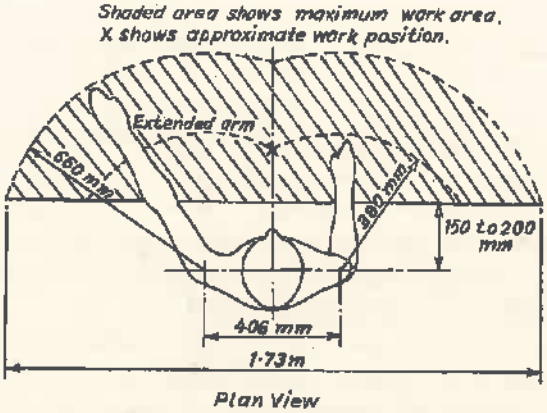


Fig. 9.21. Critical dimensions for seated male operator

The Fig. 9.21 shows the left hand covering the maximum working area and the right hand covering the normal working area.

Normal working area is the space within which a seated or standing worker can reach and use tools, materials and equipment when his elbows fall naturally by the side of the body.

Maximum working area is the space over which a seated or standing worker has to make full length arm movements (*i.e.*, from the shoulder) in order to reach and use tools, materials and equipment.

Assuming the work as some operation requiring equipment, any tools, bins, etc., they should be placed within the area shaded so that they can be seen and reached quickly and easily.

- Fig. 9.22 shows the situation with respect to bench heights and seat heights. In this view, the seat should be adjustable for height and rake. It is not usually convenient to have adjustable benches or work tops and the value of 712mm to 762mm is probably the best compromise dimension.
- Workplace layout, design of seat, arrangement of different equipment, tools and components should not cause discomfort to the worker.
- The seat should be such that the worker is able to adopt different postures, if necessary, for carrying out different operations.
- The height and back of the chair should be adjustable.
- A proper foot rest, arm rest and leg room should be provided. While working, an operator should feel himself natural and comfortable.

– Design and layout of display panels and instrument dials should result in accurate observations. They should preferably form a part of the workplace and the display should be easily readable by all. Also the display panel should be at right angles to the line of sight of the operator.

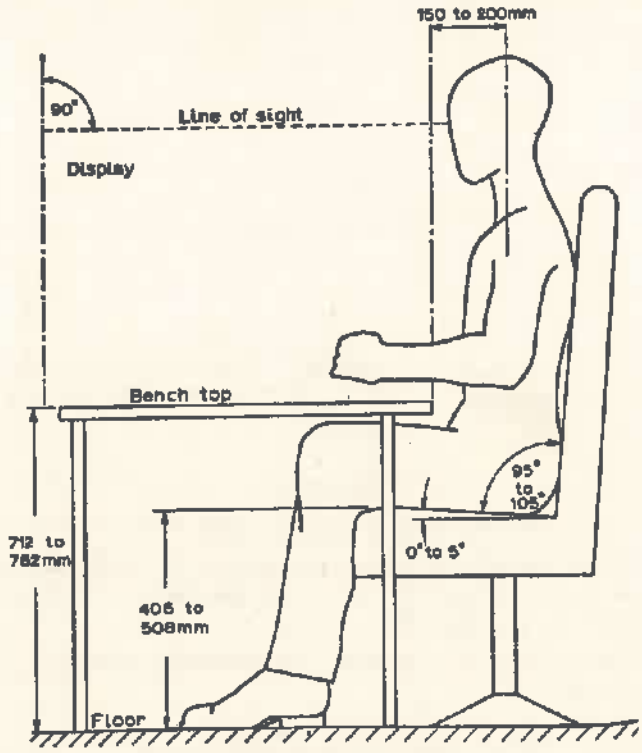


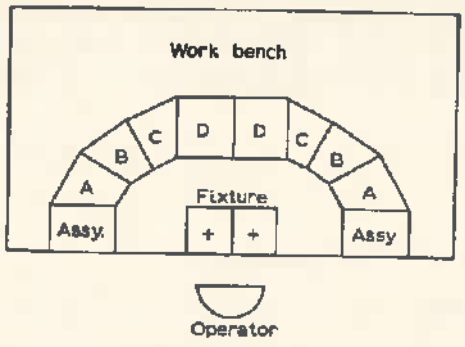
Fig. 9.22. Bench and seat heights

– An instrument with a pointer should be employed for check readings whereas for quantitative readings, digital type of instruments should be preferred.

– Design and location of various manual controls, knobs, wheels and levers should not cause excessive physical and mental strain to the worker. Levers and controls should be located close to the operator. Hand and foot controls, both, should be employed to advantage.

– All controls should preferably move in one direction for one kind of action. For example, upward movement of the levers should energise the subsystem and downward motion should deenergise and vice versa.

– In the case of tote boxes, bins, loose or portable tools, etc., there should be a definite place for their location within the working area. Hence the operator can develop habitual, confident movements when reaching for equipment often without any need for the eyes to direct the hands. The mental effort and strain are less. For the same reason, material and tools used at the workplace should always be located within the working area to permit the best sequence of operations (refer Fig. 9.23).



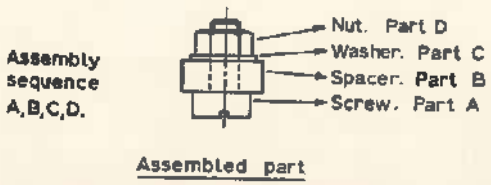


Fig. 9.23. Workplace layout for assembled part

The operation shown consists of assembling four parts A, B, C and D (two assemblies at a time) using both hands. As finished assemblies are placed in chutes, parts A are in the next bins as they are required first for the next assembly.

- Where possible, clear access should be given around industrial workplaces to allow for adequate supervision and inspection.
- It is clear that if ergonomic principles are observed in the design of workplaces, then the operator will be more efficient, less strained and tired and consequently less liable to have an accident.

(*iii*) **Other Areas.** Other areas include studies related to fatigue, losses caused due to fatigue, rest pauses, amount of energy consumed, shift work and age considerations.

10

Network Analysis

10.1. INTRODUCTION

Planning by network analysis, probably, got recognition in the year 1955 when dramatic reductions in time (about 70%) were experienced in connection with the overhaul of generating plant by Central Electricity Generating Board in Great Britain.

Network analysis is a system which plans projects both large and small by analysing the project activities. Projects are broken down to individual tasks or activities, which are arranged in logical sequence. It is also decided as which tasks will be performed simultaneously and which others sequentially. A network diagram is constructed, which presents visually the relationship between all the activities involved. Time, costs and other resources are allocated to different activities.

Network analysis helps designing, planning, coordinating, controlling and in decision making in order to accomplish the project economically in the minimum available time with the limited available resources.

Network techniques were developed from the Milestone chart and Bar chart. These conventional planning methods, because of their inherent limitations could not be utilized for planning large and complex projects. They had the following *Disadvantages:*

(*a*) A bar chart becomes too cumbersome while dealing with big and complex projects when the activities are to be considered in detail and their interaction or interdependencies are to be studied clearly.

(*b*) A bar chart does not point out as which tasks should be given priorities as regards the resources (*i.e.*, men, money, materials, and machinery).

(*c*) The effects of changes in schedule cannot be evaluated with the help of a bar chart.

(*d*) A bar chart neither satisfactorily tells the times at which the activities begin and end nor it indicates tolerances in activity timings.

(*e*) A bar chart does not show the continuing interrelationship of the activities, especially if the number of activities is large and they change in time scale and resources.

(*f*) A bar chart does not predict satisfactorily, well in advance the effects of inevitable snags and thus a corrective action cannot be taken in time.

(*g*) Bar charting is simply a scheduling operation, whereas network techniques plan as well as schedule.

(*h*) A bar chart does not normally indicate work progress, which is very essential.

10.2. NETWORK TECHNIQUES

A number of network techniques have been developed and a few of them are named below :

1. P.E.R.T. : Programme Evaluation and Review Technique.
2. C.P.M. : Critical Path Method.
3. R.A.M.S. : Resource Allocation and Multiproject Scheduling.
4. P.E.P. : Programme Evaluation Procedure.
5. C.O.P.A.C. : Critical Operating Production Allocation Control.

6.	M.A.P.	:	Manpower Allocation Procedure.
7.	R.P.S.M.	:	Resource Planning and Scheduling Method.
8.	L.C.S.	:	Least Cost Scheduling.
9.	M.O.S.S.	:	Multi-operation Scheduling System.
10.	P.C.S.	:	Project Control System.
11.	G.E.R.T.	:	Graphical Evaluation Review Technique.

The most commonly known and used Network Techniques are PERT and CPM; and they will be discussed in brief.

10.3. TERMS RELATED TO NETWORK PLANNING METHODS

(*a*) ***Event.*** An event is a specific instant of time which marks the start and the end of an activity. Event consumes neither time nor resources. It is represented by a circle and the event number is written within the circle (Fig. 10.1). Event and node are synonyms. Examples of events are--start the motor, loan approved, etc.

(*b*) ***Activity.*** Every project consists of a number of job operations or tasks which are called activities. An activity is an element of project and it may be a process, a material handling or material procurement cycle, etc. For example, 'Instal machinery', 'Arrange foreign exchange' are activities.

An activity is shown by an arrow and it begins and ends with an event. Unlike event, an activity consumes time and resources. An activity may be performed by an individual or a group of individuals. An activity is normally given a name like, *A, B, C*, etc., which is marked below the arrow and the estimated time to accomplish the activity is marked above the arrow (Fig. 10.1).

Activities are classified as :

(*i*) *Critical activities.* In a network diagram, critical activities are those which if consume more than their estimated time, the project will be delayed. An activity is called critical if its earliest start time plus the time taken by it is equal to the latest finishing time. A critical activity (*e.g., A, C* or *E*) is marked either by a thick arrow or as in Fig. 10.1, to distinguish it from a non-critical activity.

(*ii*) *Non-critical activities.* Such activities have provision (float or slack) so that, even if they consume a specified time over and above the estimated time, the project will not be delayed. In Fig. 10.1, activities *B* and *D* are non-critical activities.

(*iii*) *Dummy activities.* When two activities start at the same instant of time (like activities *C* and *D* in Fig. 10.1), the head events are joined by a dotted arrow and this is known as a dummy activity (activity *F* in Fig. 10.1). Dummy activity does not consume time. A dummy activity may be non-critical or critical. It becomes a critical activity when its earliest start time (EST) is same as its latest finishing time (LFT).

(*c*) ***Critical Path.*** It is that sequence of activities which decide the total project duration. Critical path is formed by critical activities. In Fig. 10.1, path 1-2-4-5 is the critical path. A critical path consumes maximum resources. It is the longest path and consumes maximum time. A critical path has zero float. The expected completion dates cannot be met, if even one critical activity is delayed. A dummy activity joining two critical activities is also a critical activity. A critical path reveals those activities which must be manipulated by some means or the other if the scheduled completion dates are to be met.

(*d*) ***Duration.*** Duration is the estimated or actual time required to complete a task or an activity.

(*e*) ***Total project time.*** It is the time which will be taken to complete a project and is found from the sequence of critical activities. In other words it is the duration of critical path.

(*f*) ***Earliest start time (EST).*** It is the earliest possible time at which an activity can start and is calculated by moving from first to last event in a network diagram (Fig. 10.1).

(*g*) ***Earliest finish time (EFT).*** It is the earliest possible time at which an activity can finish.

$EFT = EST +$ duration of that activity.

(*h*) ***Latest finish time (LFT).*** It is calculated by moving backward, *i.e.*, from last event to first event of the network diagram. It is the last event time of the head event.

(*i*) ***Latest start time (LST).*** It is the latest possible time by which an activity can start.

$LST = LFT$ – duration of that activity.

Example 10.1 explains the method of calculating *EST, EFT, LFT* and *LST*.

(*j*) ***Float or slack.*** Slack is with reference to an event and float is with respect to an activity. In other words, slack is used with PERT and float with CPM--but in general practice, they may be used interchangeably. It may be float or slack, it means spare time, a margin of extra time over and above its duration which a non-critical activity can consume without delaying the project. Float is the difference between the time available for completing an activity and the time necessary to complete the same.

(*i*) ***Total Float.*** It is the additional time which a non-critical activity can consume without increasing the project duration. However, total float may affect the floats in previous and subsequent activities.

Total float = (*LST* – *EST*) or (*LFT* – *EFT*) and it can be negative also.

(*ii*) ***Free Float.*** If all the non-critical activities start as early as possible, the surplus time is the free float. Free float if used, does not change the float in later activities. In other words if an activity is delayed by the free float period, the succeeding activity will not be delayed, in turn.

Free float = *EST* of tail event – *EST* of head event – activity duration.

(*iii*) ***Independent Float.*** The use of independent float of an activity does not change the float in other activities. Independent float can be used to advantage if one is interested to reduce the effort on a non-critical activity in order to apply the same (effort) on a critical activity thereby reducing the project duration. The independent float associated with an activity is not reduced by delaying previous operations whereas such a reduction can be noticed with free float.

Independent float = *EST* of tail (succeeding) event – *LFT* of head (preceding) event – activity duration.

Independent float, if it turns out to be negative, is taken as zero.

(*k*) ***Network diagram or Arrow diagram.*** Network diagram is the basic feature of network planning. It is a diagram (Fig. 10.1) which represents all the events and activities in sequence (in which they are required to be performed to complete the project), along with their interrelationships and interdependencies.

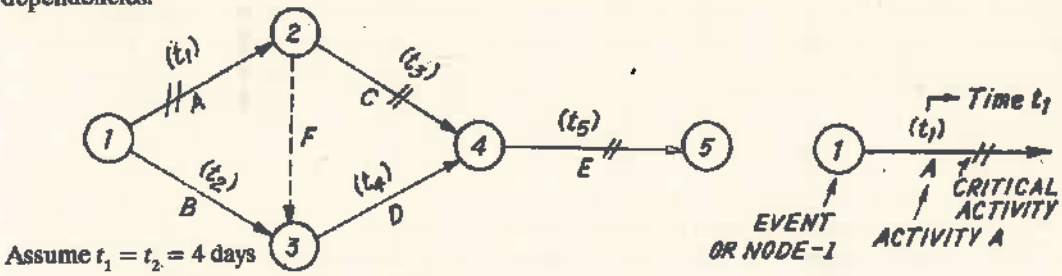


Fig. 10.1. Network (Arrow) diagram.

Arrow diagram is the visual presentation of the complete task (activities) by means of arrows. It is the most frequently used form of network diagram where every activity is represented by an arrow and the activity sequences are indicated by the direction of arrows. For example, Fig. 10.1 shows that activity *C* and *D* can start only after *A* and *B* are complete. Dotted arrow (dummy activity) shows that *A* and *B* finish at the same time (*i.e.*, $t_1 = t_2$) and *C* and *D* start at the same time. There are two paths to complete the project and they are 1-2-4-5 or 1-3-4-5.

In an arrow diagram, the length or the inclination of the arrow does not have any significance.

Arrow diagrams are very useful as they provide detailed information for making decisions in connection with large and complex projects.

Example 10.1. A small engineering project consists of 6 activities namely *A*, *B*, *C*, *D*, *E* and *F* with duration of 4, 6, 5, 4, 3 and 3 days respectively. Draw the network diagram and calculate *EST*, *LST*, *EFT*, *LFT* and floats. Mark the critical path and find total project duration.

Solution :

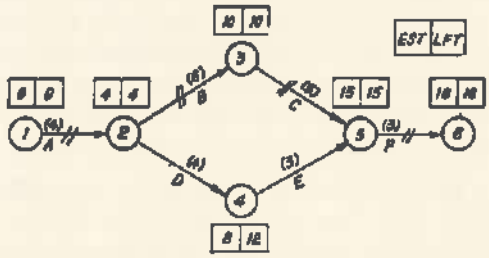


Fig. 10.2. Network diagram.

(1) *EST* is calculated by starting from event-1, *i.e.*, activity *A* and giving it a time 0 (*EST*).

Now *EST* of activity *B*=0+duration of activity *A*=4

EST of activity *C*=*EST* of activity B+duration of activity *B*=4+6=10 and so on.

EST of activity *F* can be found by following two paths, *i.e.*, 1-2-3-5 and 1-2-4-3. The path 1-2-3-5 gives 15th day whereas the path 1-2-4-5 estimates 11th day as *EST* of activity *F*.

TABLE 10.1

Activity	*Duration (days)*	*EST*	*LST*	*EFT*	*LFT*	*Total Float*	*Free Float*	*Independent Float*
A	4	0	0	4	4	0	0	0
B	6	4	4	10	10	0	0	0
C	5	10	10	15	15	0	0	0
D	4	4	8	8	12	4	0	0
E	3	8	12	11	15	4	4	0
F	3	15	15	18	18	0	0	0
Col. 1	Col. 2	Col. 3 from N.W. diagram	Col. 4 *LFT* −*D*	Col. 5 *EST* +*D*	Col. 6 from N.W. diagram	Col. 7 *LST*−*EST* or *LFT*−*EFT*		

Naturally the bigger value (15) is selected because until activity *C* is completed which ought to finish on 15th day, activity *F* cannot be started.

EST for other activities is calculated by proceeding similarly, in the forward direction from the first event to the last event.

(2) *LFT* is calculated in a similar manner as *EST* but by proceeding backward from the last event to

the first one. For example

LFT for activity $F=18$

LFT for activity C and $E=18-$duration of activity $F=15$

LFT for activity D = *LFT* for activity E–duration of activity E

$= 15-3=12$ and so on.

(3) *LST* for each activity is calculated from the relation,

LST=*LFT* of an activity–duration of that activity.

For example, *LST* of activity $D=12-4=8$.

(4) *EFT* for each activity is calculated from the relation

EFT=*EST* of an activity+duration of that activity.

For example, *EFT* of activity $D=4+4=8$.

(5) Total float=(*LST*–*EST*) or (*LFT*–*EFT*)

For example, total float for activity

$D=(8-4)$ or $(12-8)=4$.

(6) Free float=*EST* of tail event–*EST* of head event–activity duration.

For example, free float for activity D (Fig. 10.2)

$= 8-4-4=0$

(7) Independent float=*EST* of tail event–*LFT* of head event–activity duration.

For example, Independent float for activity D

$= 8-4-4=0$

(8) Critical path is one which consumes maximum time and it is 1-2-3-5-6. The total project duration, therefore, is

4+6+5+3=18 days.

10.4. PROGRAMME EVALUATION REVIEW TECHNIQUE (PERT)

Introduction. PERT was first used in 1957 as a method of planning and controlling the Polaris Missiles Programme by Booz, Allen and Hamilton together with U.S. Naval department. The aim was to finish the project two years in advance. PERT describes basic network technique which includes planning, monitoring and control of projects. PERT finds applications in planning and control of complex set of tasks, functions and relationships. It is a very important technique in the field of project Management. PERT is commonly employed for conducting the initial review of a project. PERT is a very useful device for planning the time and resources. It represents an important step in the development of managerial science. It points out potentially troublesome areas (which may disrupt programme objectives) against which a timely action can be taken to prevent their occurrences. PERT helps in decision making.

PERT, actually, developed as a research and development planning tool where activity timings could not be estimated with enough certainty. To some extent a similar situation occurs in design work also. PERT can be employed at those places where a project cannot be easily defined in terms of time or resources required. Of course, events can be readily defined which means it is known that, first, part *A* will be manufactured, only then subassembly *S* can be built and so on. PERT technique proves very much advantageous when used for non-repetitive type of projects, *R & D*, prototype production, defence projects, etc.

Because of the uncertainty of activity timings, PERT acquired the shape of a probabilistic model. It uses linear programming and probability concepts for planning and controlling activities. Probability concept helps in estimating activity timings ; and the maximization of (attainment of) the predefined

objectives is achieved through the Linear programming feature of PERT. The statistical probability feature of PERT foretells the probability of reaching the specified target dates. PERT is mainly concerned with events and is thus an event-oriented system.

The basic tool used in PERT technique is the network or flow plan. Network consists of a series of related events and activities. An important point is that, as a person plans the activities in his mind, so the flow plan (or diagram) evolves and, it even points out the gaps in the drawing. The network thus drawn shows, how various activities of a project depend on each other and that certain activities have to be completed before the others can start.

Techniques. The PERT planning technique consists of the following steps:

(1) The project is broken down into different activities systematically.

(2) Activities are arranged in logical sequence.

(3) The network diagram is drawn. Events and activities are numbered.

(4) Using three times estimate, the expected time for each activity is calculated.

(5) Standard deviation and variance for each activity are computed.

(6) Earliest starting times and latest finishing times are calculated.

(7) Expected time, earliest starting time, and latest finishing times are marked on the network diagram.

(8) Slack is calculated.

(9) Critical path(s) are identified and marked on the network diagram.

(10) Length of critical path or total project duration is found out.

(11) Lastly, the probability that the project will finish at due date is calculated.

Example 10.2 explains in detail the PERT planning technique.

Example 10.2 : A small engineering project consists of 9 activities. Three time estimates for each activity are given in Table 10.2.

(*a*) Calculate values of expected time (t_e), standard deviation (S_t) and variance (V_t) for each activity.

(*b*) Draw the network diagram and mark t_e on each activity.

(*c*) Calculate *EST* and *LFT* and mark them on the network diagram.

(*d*) Calculate total slack for each activity.

(*e*) Identify the critical path(s) and mark on the network diagram.

(*f*) Find the length of critical paths or the total project duration.

(*g*) Calculate variance of critical path.

(*h*) Calculate the probability that jobs on critical path will be finished by the due date of 38 days.

(*i*) Calculate the approximate probability that the jobs on the next most critical path will be completed by the due date of 38 days.

(*j*) Estimate the probability that the entire project will be completed by the due date of 38 days. Explain it.

(*k*) If the project due date changes to 35 days what is the probability of not meeting the due date.

(*l*) Find the due date which has a probability of 94.5% of being met.

Solution : The concept of expected time and the estimation of variability of activity times (which is necessary before solving the problem) is given below.

1. Estimation of Activity Time. For dealing with uncertainties associated with different activities, PERT approach computes expected time for each activity from the following three time estimates :

(*a*) *Optimistic time* (t_o). It is the shortest possible time in which an activity can be completed if everything goes exceptionally well.

(*b*) *Most likely time* (t_m). It is the time in which the activity is normally expected to complete under normal contingencies.

(*c*) *Pessimistic time* (t_p). It is the time which an activity will take to complete in case of difficulty, *i.e.*, if mostly the things go wrong. It is the longest of all the three time estimates.

The t_o, t_m and t_p are combined statistically to develop the expected time (t_e) for an activity. The fundamental assumption in PERT is that the three time estimates form the end points and mode of Beta distribution (Fig. 10.3). It is further assumed that t_p and t_o are about equally likely to occur whereas the probability of occurrence of t_m is 4 times that of t_p or t_o.

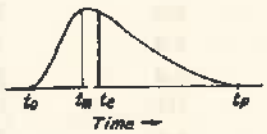


Fig.10.3. PERT time estimates–Beta distribution.

Therefore, t_e is given by,

$$t_e = \frac{t_o + (t_m \times 4) + t_p}{6} \quad ...(i)$$

(2) Estimation of Variability of Activity Times. The purpose is to find, how reliable–'t_e' as got from equation (1) is

Assume

Case I

$t_o = 5$

$t_m = 6$

$t_p = 7$

$t_e = \frac{5 + (6 \times 4) + 7}{6}$

$t_e = 6$

$t_e = t_m$

Case II

$t_o = 5$

$t_m = 10$

$t_p = 21$

$t_e = \frac{5 + (10 \times 4) + 21}{6}$

$t_e = 11$

t_e is not equal to t_m

This indicates that, if the time required for an activity shows high variability (Case II) and there is wide range of (21–5=16) three times estimates, the certainty and confidence to correctly anticipate the actual time from relation (1) decreases and thus the need to measure the variability in the time of an activity arises. Knowing the variability, the reliability of t_e values can be assessed. PERT, using statistical probability concept, employs standard deviation (S_t) and variance (V_t) as measures of variability. They are given by,

$$S_t = \left[\frac{t_p - t_o}{6}\right] \quad ...(2)$$

$$V_t = \left[\frac{t_p - t_o}{6}\right]^2 = (S_t)^2 \quad ...(3)$$

Thus for cases I and II above

$$(S_t)_1 = \left[\frac{7-5}{6}\right] = \frac{1}{6} \; ; \; (S_t)_2 = \frac{21-5}{6} = 2.66$$

$$(V_t)_1 = \left[\frac{1}{6}\right]^2 = \frac{1}{36} \; ; \; (V_t)_2 = 7.1$$

This supports the above concept.

Coming to the actual problem :

(*a*) the Table 10.2 gives the values of t_o, t_m and t_p for each activity. The values of t_e, S_t and V_t are calculated by using equations (1), (2), and (3) and have been added in the Table 10.2.

TABLE 10.2

DAYS

Activity	t_o	t_m	t_p	t_e	S_t	V_t
1-2	2	5	14	6	2	4
1-6	2	5	8	5	1	1
2-3	5	11	29	13	4	16
2-4	1	4	7	4	1	1
3-5	5	11	17	11	2	4
4-5	2	5	14	6	2	4
6-7	3	9	27	11	4	16
5-8	2	2	8	3	1	1
7-8	7	13	31	15	4	16

The network diagram is given below with T_e, *EST*, *LFT* and critical path marked on the same.

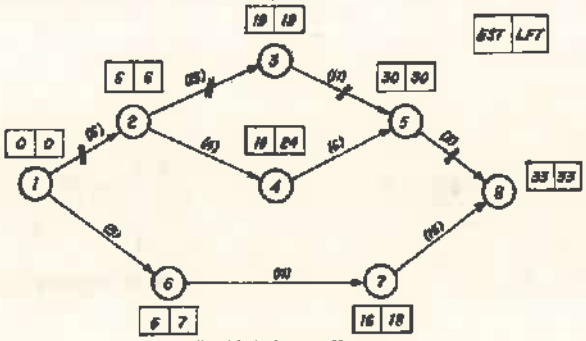


Fig. 10.4. Arrow diagram.

(d)

TABLE 10.3

Activity	EST	LST	Total slack LST−EST
1-2	0	0	0
1-6	0	2	2
2-3	6	6	0
2-4	6	20	14
3-5	19	19	0
4-5	10	24	14
6-7	5	7	2
5-8	30	30	0
7-8	16	18	2

(*e*) Critical path is 1-2-3-5-8 and it is marked on the network diagram.

(*f*) The length of the critical path or the total project duration (T_e) is sum of the duration of each critical activity, *i.e.*, 6+13+11+3=33 days.

(*g*) Variance of the critical path is sum of the variance of each critical activity, *i.e.*, 4+16+4+1=25.

(*h*) The probability that the project will meet the scheduled or the due date is calculated from the following relation

$$Z = \frac{D - T_e}{S_t} \quad \text{...(4)}$$

where T_e is the total project duration=33 days

S_t is the standard deviation

$= \sqrt{\text{Variance of the project}} = \sqrt{25} = 5$

D is the due or scheduled date (time)=38 days.

Z is the number of standard deviations by which D exceeds T_e.

Substituting different values in equation (4).

$Z = \frac{38 - 33}{5} = 1$; for the value of Z=1 the corresponding value of probability can be read from Table 10.4 and this is 0.841.

TABLE 10.4

Standard Normal Distribution

Z	*Probability of meeting due or scheduled date*	*Z*	*Probability of meeting due or scheduled date*
2.8	0.997	−0.2	0.421
2.6	0.995	−0.4	0.345
2.4	0.992	−0.6	0.274
2.2	0.986	−0.8	0.212
2.0	0.977	−1.0	0.159
1.8	0.964	−1.2	0.115
1.6	0.945	−1.4	0.081
1.4	0.919	−1.6	0.055
1.2	0.885	−1.8	0.036
1.0	0.841	−2.0	0.023
0.8	0.788	−2.2	0.014
0.6	0.726	−2.4	0.008
0.4	0.655	−2.6	0.005
0.2	0.579	−2.8	0.003
0.0	0.500		

(*i*) The next most critical path is 1-6-7-8, of 31 days duration.

Variance of the path = 1+16+16=33

Therefore, $S_t = \sqrt{33} = 5.74$

and $Z = \frac{D - T_e}{S_t} = \frac{38 - 31}{5.74} = 1.22$

From Table 10.4 for Z=1.22, the approximate probability of meeting due date is 0.888.

(*j*) To complete the project, there are three paths from first to last event,

(*a*) 1-2-3-5-8 (33 days)

(*b*) 1-2-4-5-8 (19 days)

(*c*) 1-6-7-8 (31 days)

Path (*b*) involves much less time, so its probability of completing in 38 days is very high.

Paths (*a*) and (*c*) are independent of each other and the probabilities of paths (*a*) and (*c*) to complete in due time of 38 days are 0.841 and 0.888 respectively. Therefore the probability of their both being completed in 38 days is = 0.841 x 0.888 = 0.7468.

(*k*) Again $Z = \dfrac{D - T_e}{S_t} = \dfrac{35 - 33}{5} = 0.4$

From Table 10.4 for $Z = 0.4$, the probability of meeting due date is 0.655; and hence the probability of not meeting the due date

$$= 1 - 0.655 = 0.345$$

(l) From Table 10.4, for the probability of 94.5% or 0.945, the value of $Z = 1.6$

and $Z = \dfrac{D - T_e}{S_t}$, therefore $1.6 = \dfrac{D - 33}{5}$

and thus $D = 41$ days.

10.5. CRITICAL PATH METHOD (CPM), CRITICAL PATH PLANNING (CPP), CRITICAL PATH ANALYSIS (CPA)

Introduction. The E.I. du Point de Nemours Company (USA) in the year 1958 while overhauling a chemical plant employed a technique called Critical Path Method to schedule and control the project and experienced a good amount of saving. Unlike PERT, CPM developed in civilian business and engineering industry where activity timings were relatively well known.

CPM is applicable to both large and small projects, taking from space programmes to wedding or horse shows. It is widely recognized and is the most versatile and potent management planning technique.

CPM is a technique, used for planning and controlling the most logical and economic sequence of operations for accomplishing a project. The project is analysed into different activities whose relationships, as in PERT, are shown on the network diagram. The network is then utilized for optimising the use of resources, progress and control.

Difference between PERT and CPM. The fundamental network of PERT and CPM are though identical, yet there are (certain) differences in details as mentioned below :

	PERT	*CPM*
(1)	A probabilistic model with uncertainty in activity duration. Expected time is calculated from t_o, t_m and t_p.	A deterministic model with well-known activity (single) times based upon past experience. It assumes that, the expected time is actually the time taken.
(2)	An event-oriented approach.	An activity-oriented system.
(3)	PERT terminology uses words like network diagram, events, and slack.	CPM terminology employs words like arrow diagram, nodes, and float.
(4)	The use of dummy activities is required for representing the proper sequencing.	The use of dummy activities is not necessary. The arrow diagram thus becomes slightly simpler.
(5)	PERT basically does not demarcate between critical and non-critical activities.	CPM marks critical activities.
(6)	PERT finds applications in projects where resources (men, materials and specially money) are always made available as and when required.	CPM is employed to those projects where minimum overall costs is of primary importance. There is better utilization of resources.

(7) Especially suitable in defence projects and R & D where activity times cannot be reliably predicted.

Suitable for problems in industrial setting, plant maintenance, civil construction projects, etc.

Technique. CPM employs the following steps for accomplishing a project planning.

(1) Break down the project into various activities systematically.

(2) Label all activities.

(3) Arrange all the activities in logical sequence.

(4) Construct the arrow diagram.

(5) Number all the nodes (events) and activities.

(6) Find the *time* for each activity.

(7) Mark the activity times on the arrow diagram.

(8) Calculate early and late, start and finishing times.

(9) Tabulate various times and mark EST and LFT on the arrow diagram.

(10) Calculate total float for each activity.

(11) Identify the critical activities and mark the critical path on the arrow diagram.

(12) Calculate the total project duration.

(13) If it is intended to reduce the total project duration, *crash* the critical activities of the *network*.

(14) *Optimise the cost*

(15) *Update the Network*

(16) *Smooth the network resources.*

Example 10.3 explains CPM technique in detail.

Example 10.3 : It is required to fabricate tanks for an electroplating shop. The activities involved are as follows :

(*a*) Order material for the tanks, (*b*) Await delivery of the material, (*c*) Collect tooling equipment for tank fabrication, (*d*) Fabricate the tanks, (*e*) Test the tanks against leakage, (*f*) Obtain precut rubber lining from the market, (*g*) Fix lining on the inside of the tanks, and (*h*) Paint the tanks from outside.

Using the activities listed above construct an arrow diagram for the fabrication of tanks and explain in detail the CPM-planning scheduling and control technique.

Solution : From the given data, the following arrow diagram has been constructed (Fig. 10.5)

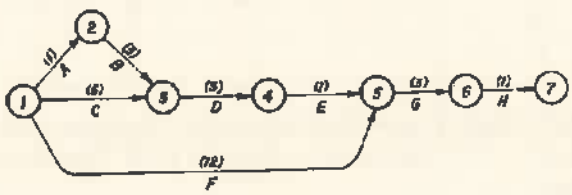


Fig. 10.5. Arrow diagram.

E. 10.3 (a). ESTIMATING ACTIVITY TIME (DURATION)

After the arrow diagram has been drawn and various activities marked on the same, the next step is to estimate time for each activity. The time estimate should be as realistic as possible and preferably based upon past experience, *i.e.*, time values can be taken from similar/same activities accomplished earlier. Estimation of duration is no problem for an experienced estimator, but for a new person if past data is not available, it is better to use PERT technique for estimating time. The estimator after consulting

others and from his own judgement finds three time estimates to calculate the expected time. After the project is over, the estimator must always be intimated about the actual time taken to complete the activities, which he estimated earlier. This feed-back information helps a lot in imparting experience to a new estimator and at the same time it is a record for future estimation.

Assume that the estimator, basing upon his past experience, gives the following time values to different activities.

Activity	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*
Duration (Days)	1	3	5	3	1	12	3	1

The duration is marked on the network diagram (Fig. 10.5).

E. 10.3 (b). PREPARATION OF ANALYSIS TABLE

EST and *LFT* are calculated (as explained earlier) and marked on the arrow diagram (Fig. 10.6).

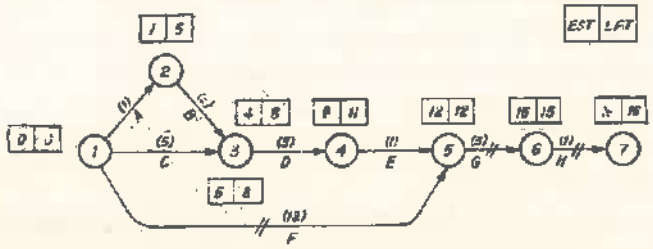


Fig. 10.6. Arrow diagram showing *EST* and *LFT*.

ANALSYSIS TABLE 10.3

Activity	*Duration*	*EST* (6–2)	*LST* (2+3)	*EFT*	*LFT*	*Total Time* (6–3)	*Total Float* (4–3)	*Remarks*
1	2	3	4	5	6	7	8	9
1-2(A)	1	0	4	1	5	5	4	
2-3(B)	3	1	5	4	8	7	4	
1-3(C)	5	0	3	5	8	8	3	
3-4(D)	3	5	8	8	11	6	3	
4-5(E)	1	8	11	9	12	4	3	
1-5(F)	12	0	0	12	12	12	0	Critical
5-6(G)	3	12	12	15	15	3	0	Critical
6-7(H)	1	15	15	16	16	1	0	Critical

The analysis Table 10.3 recognises the critical activities (*i.e.*, activities with zero float) which are marked on the arrow diagram (Fig. 10.6) and thus the critical path 1-5-6-7 is established. The total project duration is 12+3+1=16 days.

E. 10.3(c). CRASHING OF NETWORK

Many times it is felt that the project duration as estimated from normal arrow diagram is long and it is desired by management to accomplish the project in a shorter duration of time in order to secure progress payments or to avoid lateness penalties, etc. To do so various possibilities are explored. *Work study techniques* of systematic questioning (as in critical examination under method study) are employed to every (critical) activity to seek the possibilities of reducing their duration. The critical path activities

are classified as *Do* and *Ancillary* activities. Ancillary activities are those which support *Do* activities. For example, cutting of threads on a bar is *Do* activity whereas making the set up for cutting threads is an *Ancillary* activity. After identification, *Do* activities are subjected to systematic questioning technique embodying series of questions as regards purpose, place, sequence, person and means.

The second method is to *trade off* or transfer some resources from the activities having float to the critical activities, in order to reduce their duration. Trading off-redistributes the resources and accompanies changes in duration. The resources may be workforce, amount of equipment and machinery, money, (better and more suitable) materials, etc.

Even by using work study techniques, trade off and other possible methods, if efficiency does not improve and the project duration is not shortened, then the only alternative left is *network contraction or compression*. In other words, when all those techniques, which can reduce project duration at almost zero additional cost, fail, then network *contraction*, expediting or *crashing* of activities is resorted to. This system of improvement involves extra cost because extra money is spent on overtime engagement of workforce, purchase of additional machinery, use of better materials, skilled workers, etc. The cost increases, as more and more activities are crashed and in turn, of course the project duration decreases. One has to strike a balance between the extra money spent and the project time saved.

There are two types of activities—*critical* and *non-critical*. Crashing non-critical activities does not serve any purpose as they do not control the project duration and completing them (still) earlier does no benefit rather increases work-in-progress. Therefore, crashing is centred on critical activities only which can reduce project duration if completed earlier.

Crashing of critical activities is started, in a systematic manner, from that (critical) activity which has least cost-time slope, *i.e.*, which is cheapest to crash. Activities are crashed one after the other till the activity duration cannot be reduced further or the duration of original critical path gets shortened beyond a certain limit that another critical path comes into the picture. Under such circumstances if there are more than one critical paths, then, one activity in each of the critical paths is chosen for crashing by the same amount of time. The crashing continues to the point, whereafter further decrease in project duration is not possible, because, either the network reaches the compression limit set or the cost of crashing is more than the amount of saving in return.

The following terms need to be explained before (actually) crashing the network.

Normal Cost (N_C). It is the lowest cost of completing an activity in the minimum time, employing normal means, *i.e.*, not using overtime or other special resources.

Normal Time (N_T). It is the minimum time required to achieve the normal cost.

Crash Cost (C_O). It is the least cost of completing an activity by employing all possible means like overtime, additional machinery, proper materials, etc.

Crash Time (C_T). It is the absolute minimum time associated with the crash cost.

Cost-time slope or slope of activity cost line (Fig. 10.7),

$$S = \frac{C_C - N_C}{N_T - C_T}$$

Table 10.4 shows *estimated* normal and crash values of time and cost for each activity. Slope and the maximum compression for each activity has been calculated. Maximum compression is the difference between normal time and crash time.

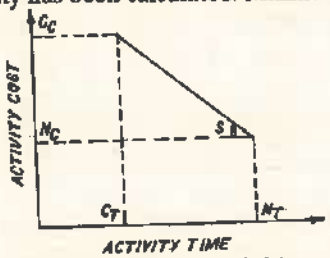


Fig. 10.7. Cost-time slope of an activity.

TABLE 10.4

Activity		*Normal*		*Crash*			
No.	*C/NC*	*Time (Days)* N_T	*Cost (Rs.)* N_C	*Time (days)* C_T	*Cost (Rs.)* C_c	*Slope rate Rs./day*	*Max. compression (days)*
1-2 (A)	NC (Non-Critical)	1	20	1	20	–	–
2-3 (B)	NC	3	70	2	120	50	1
1-3 (C)	NC	5	110	3	180	35	2
3-4 (D)	NC	3	80	2	140	60	1
4-5 (E)	NC	1	30	1	30	–	–
1-5 (F)	C (Critical)	12	250	9	370	40	3
5-6 (G)	C	3	90	2	160	70	1
6-7 (H)	C	1	20	1	20	–	–
Total	–	–	670	–	1040	–	–

In the critical path 1-5-6-7 (16 days) (Fig. 10.6) there are three critical activities.

1-5 @ Rs. 40/day

5-6 @ Rs. 70/day

and 6-7, which has zero maximum compression and hence cannot be crashed. Activity 1-5 is least expensive to crash and hence it is done so and a modified Table 10.5 of first compression is prepared.

TABLE 10.5
First Compression

Activity		*First Compression*		*Crash*			
No.	*C/NC*	*Time (Days)*	*Cost (Rs.)*	*Time (days)*	*Cost (Rs.)*	*Slope rate Rs./day*	*Max. compression (days)*
1-2 (A)	NC	1	20	1	20	–	–
2-3 (B)	NC	3	70	2	120	50	1
1-3 (C)	C	5	110	3	180	35	2
3-4 (D)	C	3	80	2	140	60	1
4-5 (E)	C	1	30	1	30	–	–
1-5 (F)	C	9	370	9	370	–	–
5-6 (G)	C	3	90	2	160	70	1
6-7 (H)	C	1	20	1	20	–	–
Total	–	–	790	–	1040	–	–

The arrow diagram constructed after first compression is given in Fig. 10.8.

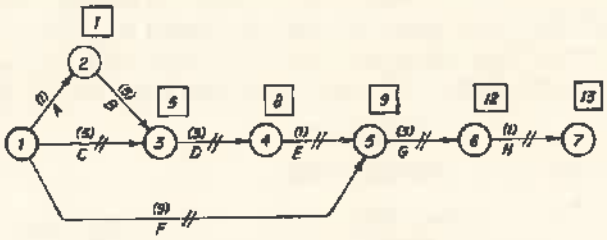


Fig. 10.8. Arrow diagram after first compression.

Now there are two critical paths that is 1-5-6-7 and 1-3-4-5-6-7, both giving a project duration of 13 days.

Activities like 1-3 and 3-4 though can be crashed by spending extra money but there will be no advantage because activity 1-5 has reached its compression limit (9 days) and therefore cannot be crashed any more; so there is no use of completing activities 1-3, 3-4 and 4-5 before 9 days at extra cost. Of course activity 5-6 can be crashed.

A modified Table (10.6) showing second compression is as under.

TABLE 10.6
Second Compression

Activity		*First Compression*		*Crash*			
No.	*C/NC*	*Time (Days)*	*Cost (Rs.)*	*Time (days)*	*Cost (Rs.)*	*Slope rate Rs./day*	*Max. compression (days)*
1-2 (A)	NC	1	20	1	20	–	–
2-3 (B)	NC	3	70	2	120	50	1
1-3 (C)	C	5	110	3	180	35	2
3-4 (D)	C	3	80	2	140	60	1
4-5 (E)	C	1	30	1	30	–	–
1-5 (F)	C	9	370	9	370	–	–
5-6 (G)	C	2	160	2	160	–	–
6-7 (H)	C	1	20	1	20	–	–
Total	–	–	860	–	1040	–	–

The arrow diagram drawn after second compression is given in Fig. 10.9.

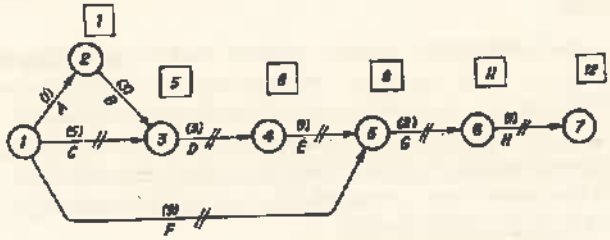


Fig. 10.9. Arrow diagram after second compression.

There are two critical paths, *i.e.*, 1-5-6-7 and 1-3-4-5-6-7 both with a project duration of 12 days.

Further crashing of activities is not going to reduce the project duration as one critical path 1-5-6-7 has reached its compression limit ; all its activities, 1-5, 5-6 and 6-7 are at crash time and crash cost. Figure 10.9 shows the all crash diagram. After that, an all crash Table (10.7) is prepared.

TABLE 10.7

All Crash Table

Activity	*Crash Time (days)*	*Crash Cost (Rs.)*
1-2 (A)	1	20
2-3 (B)	2	120
1-3 (C)	3	180
3-4 (D)	2	140
4-5 (E)	1	30
1-5 (F)	9	370
5-6 (G)	2	160
6-7 (H)	1	20
Total	–	1040

Table 10.8 shows the summary of cost under normal and various compressions.

TABLE 10.8

Activity	*All Normal (16 days)*	*First Compression (13 days)*	*Second Compression (12 days)*	*All Crash (12 days)*
1-2 (A)	20	20	20	20
2-3 (B)	70	70	70	120
1-3 (C)	110	110	110	180
3-4 (D)	80	80	80	140
4-5 (E)	30	30	30	30
1-5 (F)	250	370	370	370
5-6 (G)	90	90	160	160
6-7 (H)	20	20	20	20
Total Rs.	670	790	860	1040

E. 10.3 (d). OPTIMISING COST

A number of costs are associated with a project. A direct cost is one which involves cost of equipment, machinery, workers and other resources. An indirect cost includes overhead charges, depreciation, taxes, administrative costs, etc. Another cost may be market loss and penalty cost. Individual cost curves are plotted and a total cost curve is constructed by adding all the individual cost curves. The total cost curve takes a U-shape and the lowest point of the curve when projected on X and Y axis gives the value of *Optimum Time* and *Optimum Cost* respectively. The procedure of optimising the cost will be explained by continuing the example 10.3 (still) further.

TABLE 10.9

Project Duration (Days)	*Direct Cost (Rs.)*	*Indirect Cost @ Rs. 50 per day (Rs.)*	*Total Cost Rs.*
12	1040	600	1640
12	860	600	1460
13	790	650	1440
16	670	800	1470

Table 10.9 gives the value of total direct costs under normal and (various) compression conditions. These values have been plotted in Fig. 10.10 as curve (*a*).

The indirect cost varies linearly with time and takes a straight line shape. Assuming, indirect charges at the rate of Rs. 50 per day, the value of indirect costs have been marked in Table 10.9 ; and the indirect cost curve (*b*) has been plotted in Fig. 10.10. Curves (*a*) and (*b*) are then added to give the total cost curve (*c*). The bottom-most point of the curve (*c*) when projected on *X*- and *Y*-axis gives the values of optimum time (13 days) and *Optimum Cost* (Rs. 1440) respectively as marked in Fig. 10.10.

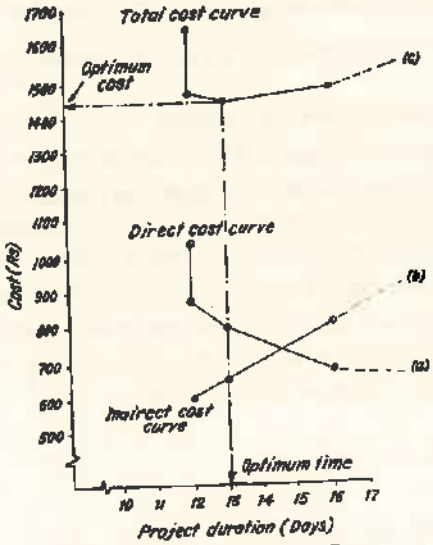


Fig. 10.10 Optimising Cost.

E 10.3. (e) UPDATING THE NETWORK

Hardly any project can be claimed as perfectly planned. There are bound to be unforeseen delays and difficulties which may be due to delay in supply of raw materials, labour turnover, breakdown of key machinery, or non-availability of skilled workers. Under other circumstances the situations may improve too, for example if additional workers or machinery is made available, the work can be finished earlier also. The arrow diagram should always be kept up-to-date by incorporating changes occurring due to replanning. Thus updated network diagram warns against the effects the unforeseen problems will create if nothing is done. Moreover the updated arrow diagram can suggest the ways and means to overcome the new problems.

Network *updating* may be *defined* as any adjustment to the arrow diagram which becomes necessary owing to departure from the project schedule laid down earlier. It is the process of incorporating in the

network the changes which have occurred due to replanning and rescheduling.

Updating can be *undertaken* at regular time intervals depending upon the progress of the project. The frequency of updating is more in case of small projects as compared to large projects, because little problems here and there can easily delay a small project (*i.e.*, a project with small duration). Large projects also need updating, but generally near their completion stage.

The *technique* of network updating has been explained below :

The original arrow diagram of example 10.3, is replotted in Fig. 10.11 and the critical path 1-5-6-7 is marked.

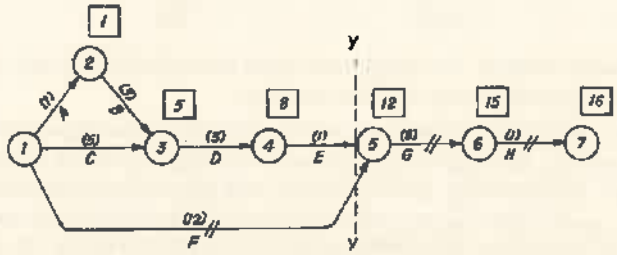


Fig. 10.11. Arrow diagram showing EST and critical path.

Assuming that 9 days are over (marked by *YY*), and progress of the project as evaluated is given below:

(1) Activities 1-2, 2-3, 1-3, 3-4, and 4-5 are complete,

(2) Activity 1-5 is still in process and needs 3 more days to complete.

Assume that at the end of 9th day, two more workers join the team and it is estimated that activity 1-5 will take only 1 more day to complete. The activity 5-6 will also be completed in 2 days instead of 3. This is how the situation changes and necessitates *updating of network*, which is carried out as under.

(1) Activities 1-2, 2-3, 1-3, 3-4, and 4-5 take 1, 3, 5, 3, and 1, days respectively to complete.

(2) Activities 1-5, 5-6 and 6-7 will take 10, 2 and 1 days respectively to complete.

Arrow diagram of Fig. 10.11 is then modified and replotted in Fig. 10.12 and the project can now be completed in 13 days instead of 16 days estimated earlier.

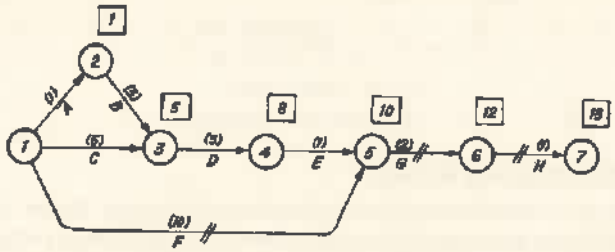


Fig. 10.12. Updated network diagram.

The critical path is 1-5-6-7. If activity 1-5 could be finished in 8 days (instead of 12) the critical path would have changed. In that case the critical path (*i.e.*, longest path) would be 1-3-4-5-6-7. So, updating under certain circumstances may change the critical path also.

From the updated network, Table 10.10 is constructed to show *effects* of updating, on different activities.

TABLE 10.10

Activity	*Whether Complete*	*In-process & needs (X) days to complete*	*Yet to start and will need (Y) days to complete*
1-2	Yes		
2-3	Yes		
1-3	Yes		
3-4	Yes		
4-5	Yes		
1-5	–	(1)	
5-6	–		(2)
6-7	–		(1)

10.6. SMOOTHING

Smoothing of the load or resources of a network implies scheduling the activities within the limits of their total floats such that fluctuations in load or resource requirements are minimized. In other words peaks and valleys in the load chart are levelled in order to keep constant and stable optimum work force throughout the project duration ; because keeping of unnecessary large work force means extra cost and dismissing the workers under off peak times brings a bad name to the concern. Moreover, there is no guarantee that again during peak season the same or better (experienced) workers will be available.

Smoothing affixes actual dates to the activities, reallocates the resources between them and actually improves the utilisation of resources. Of course there is a constraint in case of resource smoothing and that is the total project duration, within which everything has to be managed.

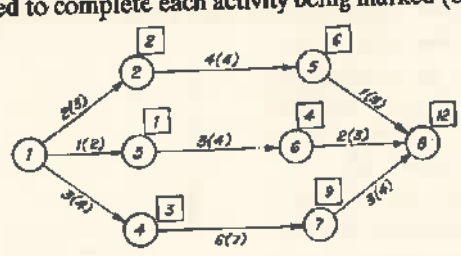
The smoothing *technique* makes use of floats in different activities. The activities are adjusted within the period equal to their duration plus float ($D+F$). In other words an activity having float may be started at any time within this period and finished within the same period. The activity can be taken during the earlier, middle or later part of the ($D+F$) band of period. Various activities can be scattered so that no high peaks or low valleys are formed in the manpower (worker) loading chart.

Smoothing manually by juggling with available float of each activity may be alright for small projects, but large and complex projects definitely demand the use of a computer.

The *Heuristic* approach to smoothing is simply the testing of various arrangements to achieve the acceptable solution. Smoothing is very essential in the project were overloading and under-loading is not easy to avoid.

Example 10.4 will explain the technique of *Resource Smoothing.*

Example 10.4 : Figure 10.13 shows an arrow diagram, with activity duration and number of workers required to complete each activity being marked (on all activities).



2(3) means that this activity will require 3 workers to finish the same in 2 days.
Fig. 10.13. Arrow diagram.

Solution : Figure 10.14 shows the initial schedule graph in which various activities have been placed with the number of workers written on them.

Figure. 10.15 shows the manpower loading chart or work load distribution chart framed from the data of Fig. 10.14. This chart shows that the minimum number of workers required on any day are 4 and the maximum work force size is 15. There is a large variation in the day-to-day load distribution.

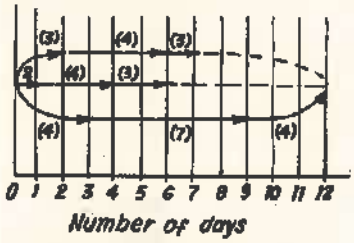


Fig. 10.14. Initial Schedule Graph.

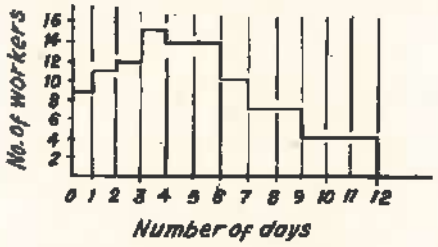


Fig. 10.15. Manpower Loading Chart.

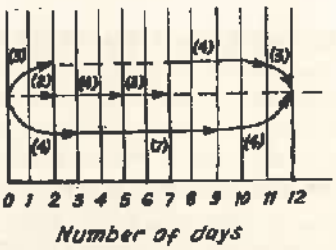


Fig. 10.16. Modified Schedule Graph.

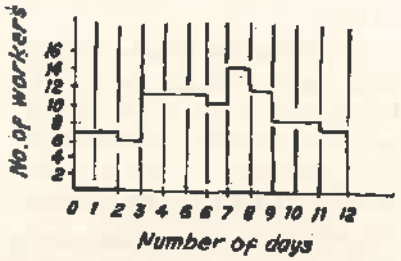


Fig. 10.17. Modified Manpower Loading Chart.

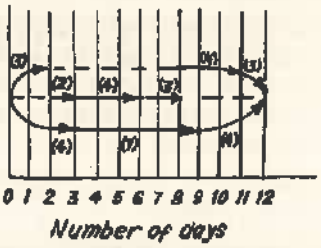


Fig. 10.18. Further Modified Schedule Graph.

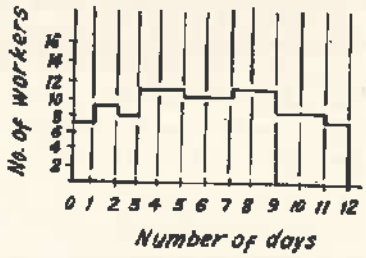


Fig. 10.19. Further Modified Manpower Loading Chart.

Figure 10.16 shows the modified schedule graph in which activities 2-5 and 5-8 have been shifted to extreme right-hand side and activities 1-3, 3-6 and 6-8 (Fig. 10.13) have been displaced from extreme left towards the middle of the graph. Activities 1-4, 4-7 and 7-8 have no float and hence they cannot be shifted. Modified manpower loading chart (Fig. 10.17) is an outcome of the modified schedule graph and shows better smoothing as compared to Fig. 10.15. The variation in the work force is only 7 (*i.e.*, 14-7) against 11 (*i.e.*, 15-4) in case of initial manpower loading chart (Fig. 10.15).

Fig. 10.16 is further modified to Fig. 10.18 by reshifting the activities 1-3, 3-6 and 6-8 and Fig. 10.19 shows the further modified manpower loading chart which gives, workforce variation of only 4 (*i.e.*, 11-7) and hence still better smoothing of the work load.

The ideal manpower loading chart is one shown in Fig. 10.20 which perhaps can rarely be achieved in normal industrial practice. But, it should always be the aim to approach to reach this ideal manpower loading chart. It shows a perfectly constant workforce throughout the duration.

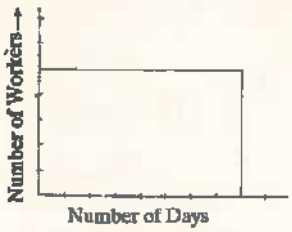


Fig. 10.20. Ideal manpower loading chart.

10.7. APPLICATIONS OF NETWORK TECHNIQUE TO SIMPLE ENGINEERING PROBLEMS

Introduction. Network planning techniques find wide range of engineering and non-engineering applications. Whenever a number of projects are handled simultaneously, it becomes extremely difficult, rather impossible for one or two co-ordinators to keep all the facts and figures in their mind or on conventional devices, because large number of resources and their co-ordination gives rise to a highly complex situation. At this stage, the management looks towards the network planning techniques which plan and control, time resources and capital expenditure. The different *applications* of network techniques are as under :

(1) Research and development,

(2) Civil engineering and construction projects including bridges, motor-ways, etc.,

(3) Major plant, building and equipment maintenance and overhauls,

(4) Town planning,

(5) Ship building, construction and repair,

(6) Modification of existing plants for improvements,

(7) Manufacturing activities-building of pressure vessels, boilers and generators,

(8) Weapon system development,

(9) Space programmes, and

(10) Computer system.

Network techniques can be applied at any place where conventional techniques do not serve the purpose (of planning, scheduling and control).

Network Technique as Applied to Engineering Problems. Examples 10.1 to 10.4 discuss in detail the network techniques (PERT and CPM) employed in solving engineering problems. A few more simple engineering problems are given below which the readers may try for practice sake.

Problem 10.1 : *ABC* Wire Drawing Co. is interested to develop the resistance heating method of annealing steel wires before galvanising. This method will possibly replace the Lead Patenting process. The procedure involves the fabrication of two stands, each having two rollers (like that of a rolling mill). Electric power is connected to each stand and the circuit completes through the wire passing between the rollers. The wire, after the passage of electric current through it, gets softened. It is required to employ PERT technique for planning this *R & D* work. The various activities are, fabrication of two stands (frames), 4 rollers, assembling the two stands ; procuring samples of wires, a high current low voltage power source, wire temperature measuring device and lastly conducting the experimental work. There are in all 7 activities and the estimated times for them are given below :

Activity	*Duration (days)*		
	t_o	t_m	t_p
Fabrication of frame	2	2	8
Fabrication of rollers	1	1	7
Assembling frame and rollers	1	1	1
Procurement of power source	2	2	8
Procurement of wire samples	2	5	8
Procurement of temperature measuring device	2	2	8
Conducting the experimental work	5	11	17

(*i*) Draw project network, (*ii*) calculate *EST, LFT,* S_i and V_i (*iii*) Calculate total slack for each activity, (*iv*) Identify critical path and find project duration, and (*v*) What due date has 80% chance of being met.

Problem 10.2 : A maintenance supervisor gives following estimates of time and cost for overhauling electric motors. The various activities involved are, (*a*) dissemble the electric motor, (*b*) clean the stator and paint it, (*c*) remove the burnt windings and rewind the armature, (*d*) replace the worn out bearings, (*e*) assemble the motor. Activity (*a*) precedes activities (*b*), (*c*) and (*d*) and activity (*e*) can be taken up only when (*b*), (*c*) and (*d*) have been completed. Activities (*a*), (*b*), (*c*), (*d*) and (*e*) consume 6, 5, 10, 8 and 6 hours and Rs. 60, 30, 80, 50 and 40 respectively (arbitrary values) for a lot. However activities (*a*), (*c*) and (*d*) can be completed 2 hours before, whereas activities (*b*) and (*e*) can be finished 1 hour before their scheduled time. But in doing so, the firm will have to spend Rs. 90, 80, 160, 100 and 60 (*i.e.*, crash cost) on activities (*a*), (*b*), (*c*), (*d*) and (*e*) respectively.

(*i*) Plot the arrow diagram,
(*ii*) Calculate *EST, LFT* and floats,
(*iii*) Identify the critical path and calculate project duration,
(*iv*) Crash the critical activities, and
(*v*) Find the optimum cost.
Assume the missing data.

Problem 10.3. The following information is given in the CPM network.

Job i-j

Successor event-j	*Predecessor event-i*	*Duration* t_{ij}
9	8	6
8	7	11
8	6	6
7	6	0
7	5	9
6	4	9
6	3	8
5	2	6
4	2	7
4	1	11
3	1	12
2	1	5

(*i*) Sketch the network ; (*ii*) Calculate the total float, free float and the independent float for each activity ; (*iii*) Identify the critical path for network, (*iv*) Give the report at the expiry of 21st day.

Problem 10.4 : Explain the terms : 'Slack time', 'Free float' and 'Independent float' used in network analysis.

Table below gives the schedule of welding activities in an assembly shop :

(a) Find the critical path, and
(b) Determine the slack times for each activity and indicate how you would proceed to improve upon the network.

Activity No.	*Duration (days)*	*Activity No.*	*Duration (days)*
0-1	2	0-6	1
1-2	4	3-7	8
2-3	2	6-7	3
3-4	5	5-8	3
2-5	1	7-8	5
4-5	1		

11
Operations Research

11.1. CONCEPT OF OPTIMISATION

An industrialist has two industries (A and B) at different locations. He is interested to send the finished goods to five different stations. There are several alternate ways of accomplishing this task. From industry A he can send F_1, F_2, F_3, F_4 and F_5 number of finished goods to each of the five stations or he can send N_1, N_2, N_3, N_4 and N_5 numbers of goods to each station or any other number of goods ; and similarly from industry B. But, the point is which of the several alternatives will be the best and the most favourable. In this case, it is the one for which the industrialist has to pay the minimum transport charges. Such problems are solved through the use of *Optimisation* techniques. The word optimisation is from *Optimum* which implies, a point at which the conditions are best and most favourable. An optimum point may represent a maximum position or a minimum position.

The approach of optimisation involves the following :

(a) The criteria which will judge the best of the several alternatives.

(b) Characteristics of various alternatives being judged.

(c) Methods available to judge the best performance for the selected criteria.

Methods of Optimising

(a) Search,

(b) Differential calculus,

(c) Calculus of variations,

(d) Statistical methods, and

(e) Linear programming :

1. Graphical method,
2. Transportation method, and
3. Simplex method.

(f) Queuing theory,

(g) Dynamic programming, and

(h) Hill climbing.

Applications of Optimisation. Some of the processes to which optimisation is applicable are load allocation problems, component selection, dynamic load sharing, dynamic terminal value problems, etc.

11.2. OPERATIONS RESEARCH

Introduction. Historically, the term *Operations Research* originated during second world war when U.S.A. and Great Britain's Armed Forces sought the assistance of Scientists to solve complex and very difficult strategical and tactical problems of warfare, like making mines harmless or increasing the efficiency of antisubmarine aerial warfare, etc.

Operations research employs mathematical logic to complex problems requiring managerial decisions.

The linear programming model may look as under :

Maximise $Z = C_1x_1+C_2x_2+C_3x_3+ \ldots\ldots +C_nx_n$

Subject to the conditions

$$a_{11}x_1+a_{12}x_2+a_{13}\ x_3+ \ldots\ldots\ldots\ldots a_{1n}x_n \le b_1$$
$$a_{21}x_1+a_{22}x_2+a_{23}x_3+\ldots\ldots\ldots\ldots\ldots a_{2n}x_n \le b_2$$
$$\vdots \qquad \vdots \qquad \vdots \qquad\qquad \vdots \qquad \vdots$$
$$a_{m1}x_1+a_{m2}x_2+a_{m3}x_3+ \ldots\ldots\ldots\ldots a_{mn}x_n \le b_m$$

$b_i \ge 0,\ i=1, 2, 3 \ldots\ldots\ldots m$

$x_j \ge 0,\ j=1, 2, 3 \ldots\ldots\ldots n$

The methods, which are commonly used to solve linear programming problems are discussed below.

11.5. GRAPHICAL METHOD

Simple two dimensional linear programming problems can be easily and rapidly solved by this technique. The technique can be easily mastered and shows a visual illustration of the relationships. But, as the number of products and constraints increase, it is very difficult to show and interpret the relationship (among the variables of the problem) on a simple two dimensional graph. This method can easily be applied up to three variables.

Example 11.1. will explain how to solve a linear programming problem by graphical method.

Example 11.1. A furniture manufacturer makes two products X_1 and X_2 namely Chairs and Tables. Each chair contributes a profit of Rs. 20 and each table that of Rs. 40. Chairs and Tables, from raw material to finished product, are processed in three sections S_1, S_2, S_3. In section S_1 each chair (X_1) requires one hour and each table (X_2) requires 4 hours of processing. In section S_2, each chair requires 3 hours and each table one hour and in section S_3 the times are 1 and 1 hour respectively. The manufacturer wants to optimize his profits if sections S_1, S_2 and S_3 can be availed for not more than 24, 21 and 8 hours respectively.

Solution. The *First Step* is to formulate the linear programming model, *i.e.*, a mathematical model from the data given above. The model is as under :

Maximize $Z = \text{Rs. } 20X_1+\text{Rs. } 40X_2 \ldots\ldots\ldots\ldots (Z)$

Subject to
$$X_1+4X_2 \le 24 \ldots\ldots\ldots (C_1)$$
$$3X_1+X_2 \le 21 \ldots\ldots\ldots (C_2)$$
$$X_1+X_2 \le 8 \ldots\ldots\ldots (C_3)$$
$$X_1, X_2 \ge 0 \ldots\ldots\ldots (C_4)$$

C_1 is constraint No. 1 and so on.

The *Second Step* is to convert the constraint inequalities temporarily, into equations, *i.e.*,

$$X_1+4X_2 = 24 \ldots\ldots\ldots (C_1)$$
$$3X_1+X_2 = 21 \ldots\ldots\ldots (C_2)$$
$$X_1+X_2 = 8 \ldots\ldots\ldots (C_3)$$

In *Third Step* axis are marked on the graph paper and are labelled with variables X_1 and X_2.

Fourth Step is to draw straight lines on the graph paper using the constraint equations, and to mark the feasible solution on the graph paper. For example, taking first constraint equation.

$$X_1+4X_2 = 24$$

Substitute $X_1 = 0$, then $X_2 = 24/4=6$

Next, Substitute $X_2 = 0$, then $X_1=24$

Mark the point of 24 at X_1 axis and point of 6 on X_2 axis. Join them. This straight line represents C_1 equation. Similarly constraint equations C_2 and C_3 can be plotted (Fig. 11.2).

According to constraint C_s, X_1 and X_2 are greater than (or equal to) zero, hence the marked area (region) between $X_1=X_2=0$ and C_1, C_2, C_3 represents the feasible solution.

As the *Fifth Step*, a (dotted) straight line representing the equation (Z) is drawn, assuming any suitable value of Z say 120.

In the *Sixth step*, a straight line Z_m is drawn parallel to the line Z, at the farthest point of the region of feasible solution, *i.e.*, point B, at the intersection of C_1 and C_3. The co-ordinates of point B can be found by solving equations C_1 and C_3.

$$X_1+4X_2 = 24 \qquad \ldots(C_1)$$
$$X_1+X_2=8 \qquad \ldots(C_3)$$

Subtracting, $3X_2 = 16$, therefore, $X_2 = \frac{16}{3}$ and $X_1 = \frac{8}{3}$

These values of X_1 and X_2 can also be read from the graph itself. Thus the maximum value of Z is

$$Z_m = 20X_1+40X_2 = 20 \times \frac{8}{3} + 40 \times \frac{16}{3} = \frac{800}{3} = 266.6 \text{ (Ans)}$$

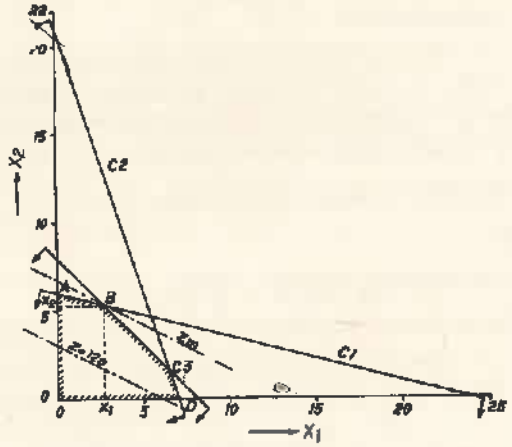


Fig. 11.2. Graphical method.

The following problems may be tried for gaining practice over the Graphical Technique.

Problem 11.1 :

Maximize $Z=X+5Y$ when

$5X+6Y \leq 30$

$3X+2Y \leq 12$

$X, Y \geq 0$ (Answer : $Z_{max} = 25$)

Problem 11.2 :

Minimize $Z=2X+3Y$ when

$X+Y \geq 6$

$2X+Y \geq 7$

$X+4Y \geq 8$

$X, Y \geq 0$ (Answer : $Z_{min} = 12.67$)

Problem 11.3 :

Maximize $Z=2X+5Y$ when

$X \leq 4$

$Y \leq 6$

$X+Y \leq 8$

$X, Y \geq 0$ (Answer : $Z_{max} = 34$).

11.6. TRANSPORTATION PROBLEM

Transportation or Distribution methods of solving Linear programming problems aim at minimizing costs of (material handling) sending goods from dispatch stations to receiving ends. Generally, specific quantities of goods are shipped from several dispatch stations to a number of receiving centres. Linear programming approach in such situations tends to find, how many goods may be transported from which despatch station to which receiving end in order to make the shipment most economical (least costly). Transportation technique in such problems gives a feasible solution which is improved in a number of subsequent steps till the optimum (best) feasible solution is arrived at.

Two methods for solving transportation problems have been explained below :

(*a*) Vogel's approximate method, and

(*b*) North-West corner method.

Vogel's method was developed by W. R. Vogel, and gives good approximation to the solution. It provides optimum solution in simple problems. In complex transportation problems also, the first solution is obtained using Vogel's method which is further worked upon and tested for optimality by stepping stone method or modified distribution method.

11.6.1. VOGEL'S APPROXIMATE METHOD

Procedural steps :

(*a*) Form the matrix based on the given problem.

(*b*) Find the difference between the minimum and next to minimum cost of every column and row.

(*c*) Select a row or column containing the largest difference and mark it by an arrow. If the same largest value of difference in cost exists both in a column and a row, any one of two, either column or row can be selected.

(*d*) Mark the maximum quantity of goods in that square, of the column or row, which carries the lowest cost. This either meets all the requirements of the receiving end (*DR*) or exhausts the capacity of a dispatching station (*FC*), and thus that particular row or column is cancelled.

(*e*) Steps (*a*) to (*d*) are repeated until all the goods have been distributed.

(*f*) Stepping stone method can be used at this stage for checking optimality.

Example 11.2 will explain Vogel' method.

Example 11.2. An industrialist has three factories one each at Banglore (*A*), Bhopal (*B*) and Kanpur (*C*) and three dealers to sell his goods at Delhi (1), Bombay (2) and Madras (3). The cost of transporting an item from a factory to a dealer along with the number of goods (or items) available at factories *A, B, E* and those required by dealers 1, 2 and 3 are shown in the matrix given below :

Find the least cost of transportation.

FROM \ TO	D1	D2	D3	FC *
F_A	3	6	4	10
F_B	2	5 **	7	5
F_E	4	6	8	7
DR +	6	8	8	22 / 22

* *FC—Factory capacity (Number of goods)*

\+ *DR—Dealers requirements (Number of goods)*

** *The cost of transporting one item from factory B to dealer 2 is Rs. 5/- and so on for other values similarly placed.*

Fig. 11.3. Step (*a*).

Solution. *First Trial*

FROM \ TO	D1	D2	D3	FC *	Difference
F_A	3	6	4	10	4-3=1
F_B	2	5	7	5	5-2=3 ←
F_E	4	6	8	7	6-4=2
DR	6	8	8	22 / 22	
Difference	3-2=1	6-5=1	7-4=3		

* FC Factory capacity

Fig. 11.4. Steps (*b*) and (*c*).

FROM \ TO	D1	D2	D3	FC
F_A	3	6	4	10
F_B	2 5	5 Cancelled	7	5
F_E	4	6	8	7
DR	6	8	8	

Fig. 11.5. Step (*d*).

Second Trial

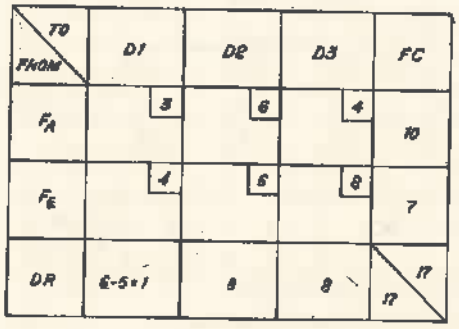


Fig. 11.6. Step (*a*).

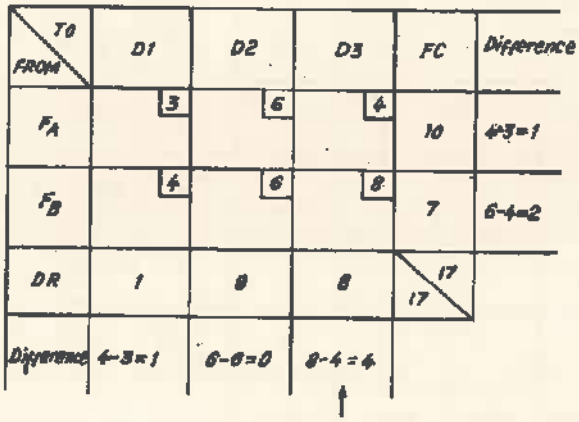


Fig. 11.7. Steps (*b*) and (*c*).

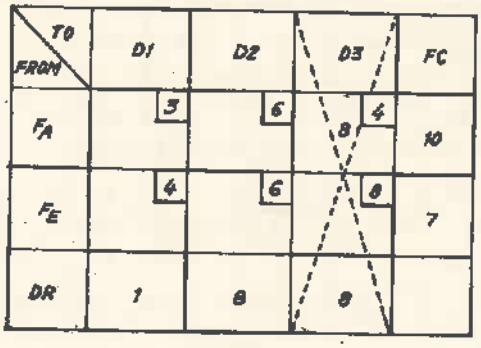


Fig. 11.8. Step (*d*).

Third Trial

TO / FROM	D1	D2	FC
F_A	3	6	10-8=2
F_E	4	6	7
DR	1	8	9 / 9

Fig. 11.9. Step (*a*).

TO / FROM	D1	D2	FC	Difference
F_A	3	6	2	6-3=3
F_E	4	6	7	6-4=2
DR	1	8	9 / 9	
Difference	4-3=1	6-6=0		

Fig. 11.10. Steps (*b*) and (*c*).

TO / FROM	D1	D2	FC
F_A	* 1 / 3	6	2
F_E	4	6	7
DR	1	8	9 / 9

* *Only 1 item has been assigned and not 2, because dealer's requirement is only 1.*

Fig. 11.11. Step (*d*).

The matrix reduces to that of Fig. 11.12 as given below :

TO / FROM	D2	FC
F_A	1	1
F_E	7	7
DR		8 / 8

Fig. 11.12. Reduced matrix.

The only alternative now left is to transport to dealer No. 2, one item from factory *A* and seven items from factory *E* (shown dotted).

TO / FROM	D1	D2	D3	FC
F_A	3 1	6 1	4 8	10
F_B	2 5	5	7	6
F_E	4	6 7	8	7
DR	6	8	8	22 / 22

Fig. 11.13. Final feasible* solution.

* It may or may not be optimum feasible solution. This has to be checked by stepping stone method for optimality.

When all the goods as distributed from factories to dealers are shown in the original matrix of Fig. 11.3 it takes the shape of Fig. 11.13. It is evident that from factory *A*, one item each is sent to dealer No. 1 and dealer No. 2 and eight goods are shipped to dealer No. 3 and similarly from factories *B* and *E*. The optimum minimum cost of transportation or distribution of goods is equal to

$$(1\times3) + (1\times6) + (8\times4) + (5\times2) + (7\times6) = \text{Rs. } 93.$$

As done above, it is not necessary to construct separate matrix for each step when solving such a problem. Once the practice is attained, many steps may be combined together to arrive at the final results in a much shorter duration.

11.6.2. NORTH-WEST CORNER METHOD

Figure 11.14 shows the matrix of Fig. 11.3 taken from the Vogel's method.

The North-West Corner method derives its name from the fact that initial allocation of resources is started from the north-west corner of the matrix. Ignoring other things (*i.e.*, cost) and simply considering the factory capacity and dealer's requirements, the minimum (number of goods) of the two (*i.e.*, *FC* & *DR*) is placed in north-west corner ; for example, though factory *A* can supply 10 items, dealer 1 needs only 6. Therefore, 6 items are marked in the north-west corner, (Fig. 11.15). Next it is just 'stair stepping down'

the matrix from north-west corner to south-east corner and allocating the goods. For example, by placing 6 goods in the *NW* corner, the requirements of dealer 1 are over, but dealer 2 needs 8 goods. To him, 4 can be supplied from factory *A* and naturally 4 from factory *B* if one has to step down the stairs in the matrix. In this manner the initial north-west solution is marked in the matrix, Fig. 11.15.

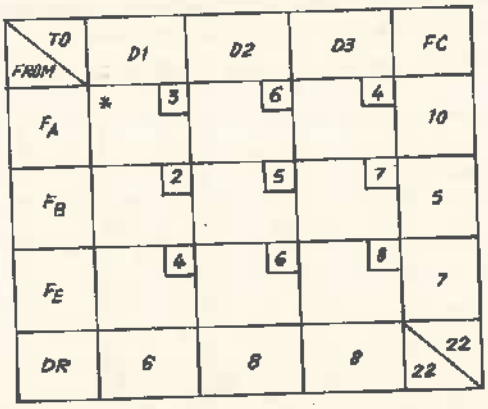


Fig. 11.14. Matrix showing cost of transportation, factory capacity (*FC*) and dealer's requirements (*DR*).

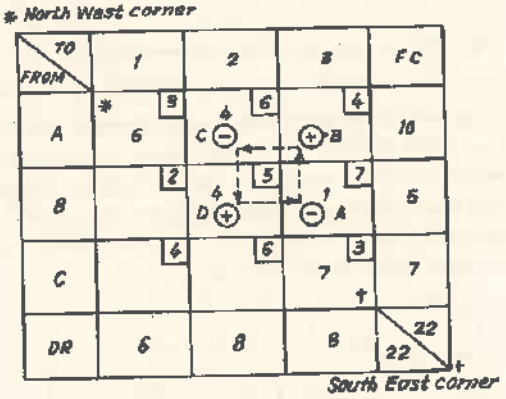


Fig. 11.15. Initial allocation of goods by North-West Corner method.

This initial solution can be improved by using *Stepping Stone Method* developed by Cooper and Charnes. The empty or open squares are called *Water Squares* and the squares having assignment of goods are known as *Stone Squares*. The stepping stone method is explained below :

The criteria of judging whether the solution has been improved or not is based upon the fact whether the transportation cost has been reduced or not. The cost of transportation for the initial solution by north-west corner allocation is

$$(6\times3) + (4\times6) + (4\times5) + (1\times7) + (7\times8) = \text{Rs. } 125.$$

The stepping stone procedure involves stepping or shifting some goods to an empty square from a stone square if it can bring about a saving in transportation cost. The number of goods to be shifted is restricted by the number of goods available (*FC*) and goods required (*DR*). For doing so, first of all a closed loop, (of 4 or more squares is imagined) having one empty square and rest all stone squares, is selected,

as in Fig. 11.15. Only one item can be moved from square *A* to square *B*, only 3 will be accommodated in square *C*, and it will become 5 in square *D*. When one item leaves square *A* it means the transportation cost is reduced by Rs. 7 so it is marked −ve. Since one item goes to square *B*, the transportation cost increases by Rs. 4 and it is marked +ve. And naturally for balancing *FC* and *DR* one item leaves square *C* and one item goes to square *D* and they are marked −ve and +ve respectively. Next, it is estimated whether by this shifting has there been any saving in the transportation cost or not. This is Rs. −7+4−6+5=−4, which (being negative) shows that transportation cost has decreased by Rs. 4 per item. Fig. 11.16 shows, thus modified matrix. The total cost of transportation is

$$(6\times3) + (3\times6) + (1\times4) + (5\times5) + (7\times8) = \text{Rs. } 121.$$

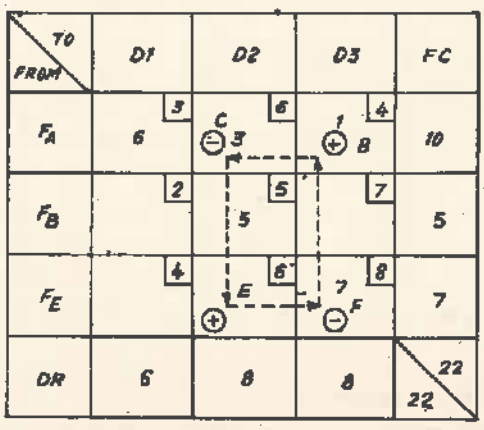


Fig. 11.16. Matrix with first modification or improvement.

The total cost of transportation is Rs. 121 against Rs. 125 (Fig. 11.15) which shows an improvement.

Again, another loop is tried which shows a saving in the transportation cost. This loop is marked in Fig. 11.16. The saving in this case will be (+6−8+4−6=−4) of Rs. 4 per item. In this loop 3 goods can be shifted from square *C* to square *E* and corresponding adjustments in the goods of squares *F* and *B* will be done in accordance with the restrictions imposed by factory capacity (*FC*) and dealer's requirements (*DR*). The second improved solution is given in Fig. 11.17. The total cost of transportation is Rs. 109 which when compared with earlier values shows improvement.

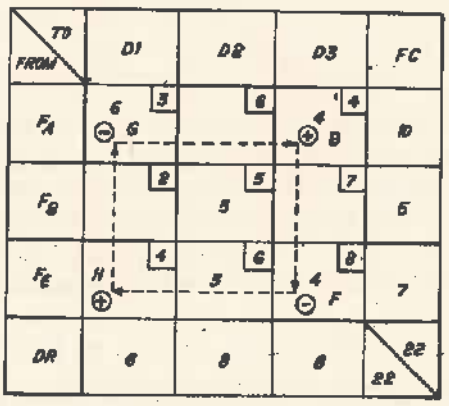


Fig. 11.17. Matrix with second improvement.

Another loop which promises saving has been marked in Fig. 11.17. The saving in this case will be of (+4−8+4−3=−3) Rs. 3 per item. Four items can be shifted from square *F* to square *H* and accordingly

the number of items can be adjusted in squares *B* and *G*. The third improved matrix is shown in Fig. 11.18. The total cost of transportation being Rs. 97 which shows an improvement over the previous solutions.

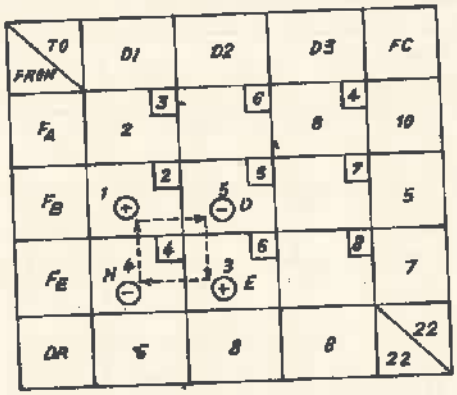


Fig. 11.18. Matrix with third improvement.

Saving can further be achieved by considering the loop marked in Fig. 11.18. The saving in this case is of Rs. (+2−4+6−5=−1) one per item and 4 items can be shifted from square *H* to square *I*, etc. This improved matrix is shown in Fig. 11.19 and the total cost of transportation is Rs. 93 which is a further improvement.

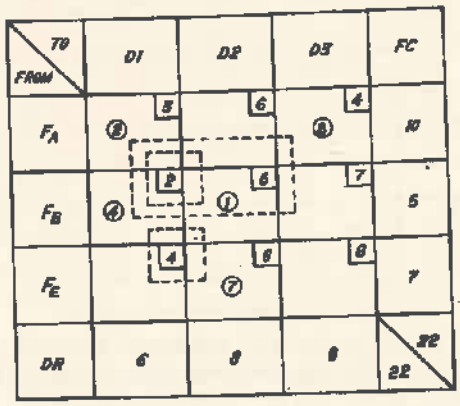


Fig 11.19. Matrix with fourth improvement
(Optimum feasible solution).

Still, a number of more loops as shown in Fig. 11.19 can be tried but it is found that they do not do any saving rather they increase the total cost of transportation. Hence we take the solution of Fig. 11.19 as *Optimum Feasible Solution.*

The same problem was solved earlier by *Vogel's* Method and the solution found was marked in Fig. 11.13. Though the two solutions (Fig. 11.13 and 11.19) differ as regards the distribution of goods from factories to dealers, yet the total cost of transportation (Rs. 93) remains the same. Hence both the methods, *i.e. Vogel's* method, and *Stepping Stone* method have optimised the transportation or distribution cost.

11.6.3. TRANSPORTATION PROBLEMS (COST MATRIX) WITH UNEQUAL SUPPLY AND DEMAND

Problem solved under Example 11.2 had total factories capacity of 22 goods and the dealer's

requirements were also 22 ; but it rarely happens in real situations. It is quite liable that the supply and demand may not be equal. Such problems are dealt in the following way :

Assume the matrices as under [Fig. 11.20 (*a*) and (*b*)].

TO / FROM	D1	D2	D3	FC
F_A	3	6	4	8
F_B	2	5	7	5
F_E	4	6	8	7
DR	6	8	8	20 / 22

Fig. 11.20. (*a*) Demand is more than supply.

TO / FROM	D1	D2	D3	FC
F_A	3	6	4	10
F_B	2	5	7	6
F_E	4	6	8	7
DR	6	8	6	22 / 29

Fig. 11.20. (*b*) Supply is more than demand.

Such problems are solved exactly in the same manner as described previously, except that the original matrices of Fig. 11.20 (*a*) and (*b*) are adjusted to the matrices of Fig. 11.21 (*a*) and (*b*) respectively

TO / FROM	D1	D2	D3	FC
F_A	3	6	4	8
F_B	2	5	7	5
F_E	4	6	8	7
Dummy factory	0	0	0	2
DR	6	8	8	22 / 22

(*a*)

before using Vogel's method or North-West Corner method. The adjustment is carried out by using *Dummy* factories or *Dummy* dealers to equalise (*FC* and *DR*) supply and demand. These *dummy* entities are assigned zero transportation cost as the goods will never be distributed.

TO / FROM	D1	D2	D3	Dummy Dealer	FC
F_A	3	8	4	0	10
F_B	2	5	7	0	5
F_E	4	6	8	0	7
DR	6	8	6	2	22 / 22

(*b*)

Fig. 11.21. Adjusted matrices.

In Fig. 11.21 (*a*), a dummy factory with an output of 2 goods has been added which equalises total factory capacity and total dealer's requirements. Similarly in Fig. 11.21 (*b*) a dummy dealer has been added and with his requirements of 2 goods, the total supply and demand becomes equal. Now the matrices can be solved by Vogel's method or North-West Corner method.

11.6.4. PROFIT MATRIX WITH EQUAL SUPPLY AND DEMAND

Example 11.2 used a *Cost Matrix* as it contained values of transportation costs of goods and the purpose was to minimize total transportation cost. If transportation cost values are replaced by *Profit* values (Rs.), then the total profit which a firm will get by transporting different number of goods to different places can be *Maximised*. Fig. 11.22 shows a profit matrix, according to which factory *A* earns a profit of Rs. 4 for each item which is sent to dealer 1. But it earns Rs. 8 and Rs. 6 respectively if the same item is sent to dealers 2 and 3. Similarly factories *B* and *E* earn different amounts of profits by sending items to three different dealers. The problem before the factories owner is—how many goods from which factory should be sent to which dealer so that he earns the maximum profit ?

TO / FROM	D1	D2	D3	FC
F_A	4 A	8	6	7
F_B	2	5 B	7	5
F_E	1 C	3	2	8
DR	5	10	5	20 / 20

Fig. 11.22. Profit matrix.

The first step in solving such a problem is to *Convert the Profit Matrix into a Cost Matrix* as in Fig. 11.23. The maximum profit (Fig. 11.22) is Rs. 8 which is assumed equal to *Zero Cost* and costs for all other

squares are calculated by subtracting their profits from Rs. 8. For example, for square *A*, *B* and *C* the profits are Rs. 4, 5 and 1, and therefore the cost will be Rs. (8−4)=4, (8−5)=3 and (8−1)=7 respectively.

The cost can now be minimized by the methods explained earlier. After optimum assignments have been made in different squares, the cost figures in different squares are replaced by profit figures as those of original profit matrix, Fig. 11.22. Number of goods in each stone square is multiplied by the profit figure of that square. When all such multiplied profit values are added, it gives the optimum profit.

11.6.5. PROFIT MATRIX WITH UNEQUAL SUPPLY AND DEMAND

Fig. 11.22 of profit matrix has supply of goods equal to their demand, *i.e.*, 20 and 20. If due to some reasons *FC* becomes 18, but *DR* remains 20 or *DR* changes to 17 and *FC* remains 20 then what should be done. The procedure is simple and is given below :

TO / FROM	D1	D2	D3	FC
F_A	4	0	2	7
F_B	6	3	1	5
F_E	7	5	6	8
DR	5	10	5	20 / 20

Fig. 11.23. Converted cost matrix.

Step-1. Draw the profit matrix.

Step-2. Equalise supply and demand by inserting a dummy factory or a dummy dealer with zero profit value in each square.

Step-3. Change over to cost matrix.

Step-4. Minimize the cost by the methods explained earlier.

Step-5. After getting optimum assigned values (of goods) convert cost matrix into profit matrix.

Step-6. Calculate the optimum profit.

The following problems can be tried for gaining practice to solve distribution problems.

TO / FROM	D1	D2	D3	FC
F_A	5	10	2	100
F_B	3	7	5	25
F_C	6	8	4	75
DR	80	30	90	200 / 200

Fig. 11.24

(Answer : Rs. 815)

Problem 11.1 : Find the optimum (minimum) transportation cost. Solve the problem by both Vogel's method and North-West Corner method. (Fig. 11.24)

Problem 11.2: Find optimum solution and the optimum (minimum) transportation cost. Compare the results obtained by North-West Corner method and Vogel's method. (Fig. 11.25)

TO / FROM	D1	D2	D3	FC
F_A	3	1	3	8
F_B	3	4	1	7
F_E	4	2	2	9
DR	10	8	9	24 / 27

[Ans. Rs. 47]

Fig. 11.25.

Problem 11.3: *ABC* company has three plants and three warehouses. With the following matrix find the optimum profit pattern and the optimum profit. Solve the problem using Vogel's method as well as North-West Corner method and explain the difference in results, if any. (Fig. 11.26)

TO / FROM	W1	W2	W3	SUPPLY
P_1	10	12	8	6
P_2	15	10	9	10
P_3	9	11	10	9
Demand	7	13	5	25

[Ans. Rs. 301]

Fig. 11.26.

Problem 11.4 : Solve the following transportation problem and find the optimum distribution pattern and the optimum cost. (Fig 11.27)

Ware Houses

Plants \ TO / FROM	W1	W2	W3	W4	Supply
P_A	10	22	10	20	8
P_B	15	20	12	8	13
P_C	20	12	10	15	11
Demand	7	10	6	9	32

Fig. 11.27.

(Answer : Rs. 330)

11.7. DEGENERACY

- A Transportation problem can only be optimized if it contains $(m+n-1)$ *stone* squares (*i.e.*, squares having assignment of goods), where m is the number of rows and n is the number of columns in the matrix (refer Fig. 11.28).
- If the number of stones is less than (m+n−1) values, then the closed path to evaluate the water squares cannot be traced and the matrix is said to be ***degenerate.***
- The first step, therefore, in optimising any matrix is to count the number of stones and to continue the solution in a degenerate matrix, it is necessary to increase the number of stones to $(m+n-1)$. This is done by adding a *dummy stone,* ϵ, in a water square.

  The dummy stone is merely a device to permit the solution to continue. It is inserted in the *greatest profit (or least cost) square* on the path that created the degeneracy.
- The infinitesimal quantity, ϵ, which is assigned to a promising unoccupied cell has the unusual but convenient properties of

(1) being large enough to treat the cell in which it is placed as occupied, and

(2) being small enough to assume that its placement does not change *rim conditions*. Supply and demand (quantities) entries are called rim conditions. They correspond to the *constraints* provided.

- Degeneracy can develop in either an initial solution itself or in a revised solution during the process of optimization. In both cases the treatment is the same. One or more cells receive epsilon (ϵ) allocations to make the total number of occupied cells equal to (m+n−1). The cells to receive ϵ allocations should be carefully chosen because a transfer circuit cannot have a negative epsilon stepping stone. The reason, of course, is that you cannot subtract a unit from a cell that contains only an infinitesimal part of a unit. Therefore, epsilon quantities should be introduced in cells that accommode the solution procedures.

$$1+\epsilon = 1$$
$$1-\epsilon = 1$$
$$\epsilon-\epsilon = 0$$

The following example will explain, how to optimize a degenerate solution.

Example 11.6. A company has three factories and five dealers. With the following matrix, minimize

the transportation cost. The matrix shows an initial solution which is degenerate.

m \ To / From	D1	D2	D3	D4	D5	Supply
F_A	16 [14]	[24]	1 [30]	[44]	5 [16]	22
F_B	[20]	18 [14]	[16]	[16]	[14]	18
F_C	[35]	[26]	14 [18]	10 [20]	[50]	24
Demand	16	18	15	10	5	64

n

Fig. 11.28. Initial degenerate solution.

Solution

– The initial solution is degenerate owing to 6 instead of m+n−1 = 3+5−1=7 occupied cells. A logical improvement is to eliminate the high cost F_A−D3 route. The unoccupied cell F_B−D3 makes a good starting point. In the existing degenerate condition, it is impossible to make a stepping stone circuit around F_B−D3. An epsilon (ϵ) quantity must be introduced. Epsilon could be added to F_B−D1 to complete a transfer circuit as shown in Fig. 11.29, but the epsilon stepping stone is *negative* and consequently allows only an inconsequential transfer.

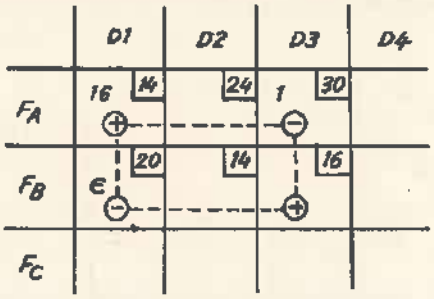


Fig. 11.29. Incorrect ϵ placement.

– By placing epsilon in F_A−D2, it becomes a positive transfer cell in the circuit +(F_B−D3)−(F_A−D3)+(F_A−D2)−(F_B−D2) or (+16−30+24−14) = −Rs. 4 cost or Rs. 4 saving results from the transfer of one unit (Fig. 11.30).

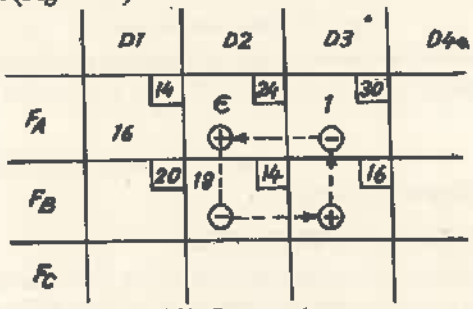


Fig. 11.30. Correct ϵ placement.

– Hence the revised solution is as follows (Fig. 11.31).

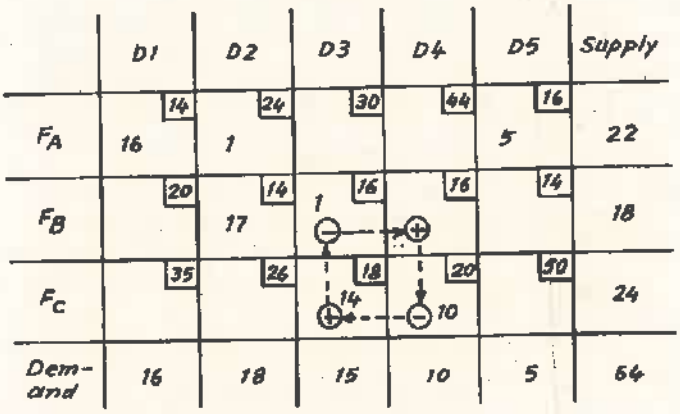


Fig. 11.31. First revised solution.

In first revised solution (Fig. 11.31), $m+n-1 = 3+5-1 = 7$ and the occupied cells are also 7, hence the degeneracy is eliminated.

– Now, the problem can be solved as usual as explained earlier, however, degeneracy is to be checked after every revision.

– Trying another loop for minimization of cost (Fig. 11.31).

$$+16-20+18-16 = -\text{Rs. } 2.$$

– Thus, second revision is shown in Fig. 11.32.

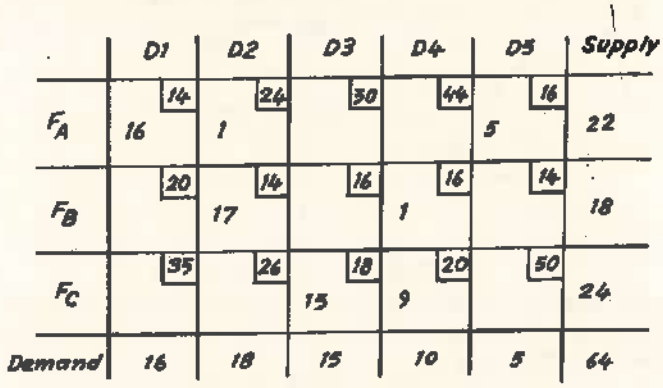


Fig. 11.32. The second revision.

The second revision is the final optimal solution; all remaining routes/loops exhibit greater transfer costs. Thus, the minimum transportation cost = (16×14) + (1×24) + (5×16) + (17×14) + (1×16) + (15×18) + (9×20)

= Rs. 1032; which is Rs. 27 less than the transportation cost (Rs. 1059) of the initial (degenerate) solution.

11.8. FUNDAMENTALS OF SIMPLEX PROCEDURE

Introduction. The simplex method was first described by Dr. G. B. Dantzig in the year 1947 and later on, due to further developments in it, it has become an excellent technique for solving linear programming

problems. It provides an orderly approach to the linear programming (*e.g.*, business) problems having dozens of variables. Problems which cannot possibly be solved with graphical technique, for them the simplex method is an alternative approach. Unlike graphical method, the simplex method uses algebraic equations. The simplex method can handle any number of activities and can solve even those equations which have more number of unknowns than the equations. Fundamentally, the simplex procedure requires to make a table. Variables and constraints are entered into it and are subjected to a regular algorithm to arrive at the optimum solution. Once the simplex table for a problem is established, the procedure leading to optimum solution is just mechanical.

The simplex method, as compared to transportation method is more general as regards the application and is employed where transportation method cannot.

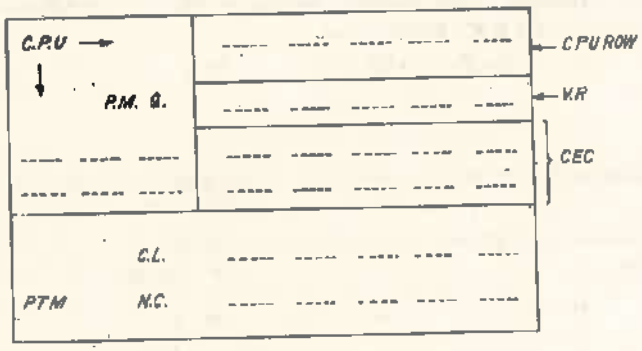
Simplex Procedure

(*a*) Express the problem as an equation.

(*b*) Express the constraints of the problem as inequalities.

(*c*) Convert the inequalities to equalities by adding slack variables.

(*d*) Enter the inequalities in the so-called simplex table. A simplex table is given in Fig. 11.33.



CPU : Contribution or profit per unit.

PM : Product mix (Name of the variable. There is one row for each variable).

Q : Quantity of each variable.

CPU Row shows the profit per unit of each of the variables in the product mix.

VR : Row showing all the variables.

CES : Row showing the coefficients of constraint equations.

PTM : Profit of this product mix.

CL : Contribution lost.

NC : Net contribution or profit.

Fig. 11.33. Nomenclature of the simplex table.

(*e*) Complete the simplex table.

(*f*) Calculate contribution lost and net contribution and mark them on the simplex table.

(*g*) Locate highest value of net contribution and mark it by an arrow.

(*h*) Divide the quantity column values by the corresponding values of the column marked by arrow and obtain the respective figures (values).

(*i*) Select the smallest non-negative value amongst these figures to determine the row to be replaced.

(*j*) Compute all the values for the new row.

(*k*) Compute the values for the rest of the rows.

(*l*) Calculate contribution lost and net contribution and mark them on the simplex table.

(*m*) Repeat steps from (*h*) to (*l*) till there is no positive value of net contribution or net profit. This implies that nothing more can be introduced into the mix to increase the profit and hence it is the *Optimum Solution*.

Example 11.7 will explain the simplex procedure.

Example 11.7. A furniture manufacturer makes wooden racks (X) and cots (Y). These products are completed in two sections. Each rack contributes a profit of Re. 1 and each cot of Rs. 5. In first section each rack requires 5 hours and each cot 6 hours of processing. Similarly in section number 2 each rack has 3 hours and each cot has 2 hours of work on them. The manufacturer is interested to optimise his profits if the two sections can be availed for not more than 30 and 12 hours respectively.

Solution : The Problem can be expressed as follows :

$$\left.\begin{array}{ll} \text{Maximize} & Z=X+5Y \\ \text{Subject to} & 5X+6Y\leq 30 \\ & 3X+2Y\leq 12 \end{array}\right\} \quad ...(1)$$

The inequalities can be removed by adding slack variables. Slack variables represent unused time in each section which yields no profit, *i.e.*, which contributes nothing towards profit. Since same variables should appear in all the equations, those variables having no effect on an equation are given a zero coefficient, for example, (1) above is are rewritten as,

$$\left.\begin{array}{ll} \text{Maximize} & Z=X+5Y+0S_1+0S_2 \\ \text{Subject to} & 5X+6Y+S_1+0S_2=30 \\ & 3X+2Y+0S_1+S_2=12 \end{array}\right\} \quad ...(2)$$

From the data given in (2), the simplex table (Fig. 11.34) is constructed.

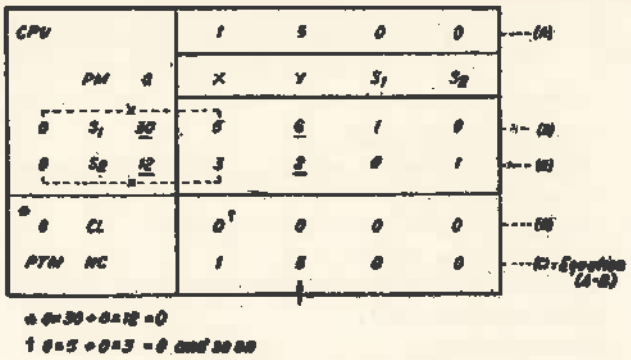


Fig. 11.34. Simplex table – Initial solution.

In the initial solution (Fig. 11.34) there is no output, all the time is unused and there is no contribution or profit, *i.e.*, initial solution is zero profit (*PTM*) solution. Till this point, steps up to (*f*) have been completed.

Step-g. The highest-value of net contribution is 5 and has been marked by an arrow (Fig. 11.34).

Step-h. 30/6=5

12/2=6

Step-i. Value 5 is selected.

Step-j & k. Selecting value 5 means – Y and its profit will replace S_1 and its zero profit. Divide row (*D*) by 6 throughout and rewrite.

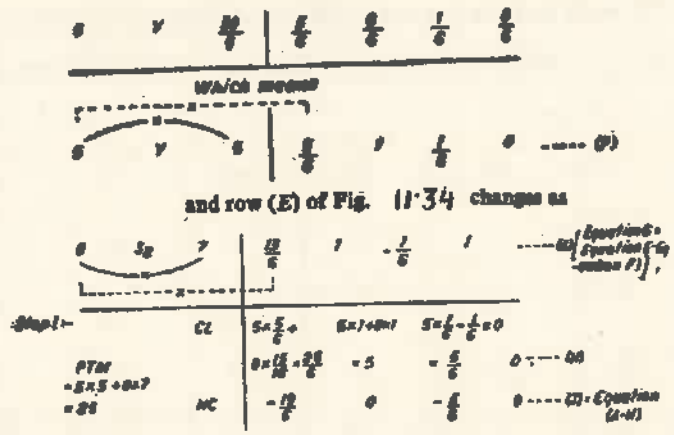


Fig. 11.35. Optimum solution.

Step-m. On checking the equation (*j*), it is found that there is no positive value of net contribution (*NC*). Hence it is the *Optimum Solution*. The optimum profit Z = Rs. 25, (the *PTM* value marked).

It was a simple problem which could be optimized in the second solution. More complex problems involve a number of iterations.

Example 11.8.

Maximize $P = 8a + 17b + 14c$

Subject to $3a + 7b + 4c \leq 70$

$2b + 4c \leq 80$

$a, b, c \geq 0$

Solution. The inequalities in the above equations can be removed by adding slack variables (S_1 and S_2) and the problem can be rewritten as

Maximize $P = 8a + 17b + 14c + 0S_1 + 0S_2$

Subject to $3a + 7b + 4c + 1S_1 + 0S_2 = 70$

$2b + 4c + 0S_1 + 1S_2 = 80$

From these equations, the following table is framed.

			8	17	14	0	0		
			a	*b*	*c*	S_1	S_2		
(*x*)	0	S_1	3	[7]	4	1	0	70	$\frac{70}{7} = 10$ ←
(*y*)	0	S_2	0	2	4	0	1	80	$\frac{80}{2} = 40$
				↑ 1					

The highest value of net contribution is 17 and has been marked by the arrow– ↑ 1.

$\frac{70}{7} = 10$; $\frac{80}{2} = 40$. Select the smaller* of the two limits and mark it by an arrow $\overset{2}{\leftarrow}$.

The two arrows meet at $\boxed{7}$, thus $0\,S_1$ will be replaced by $17\,b$. Dividing, therefore, (x) above by 7.

			8	17	14	0	0	
			a	b	c	S_1	S_2	
(v)	17	b	$\frac{3}{7}$	1	$\frac{4}{7}$	$\frac{1}{7}$	0	10
(w)	0	S_2	0	2*	4	0	1	80
(u)	17	b	$\frac{3}{7}$	1	$\frac{4}{7}$	$\frac{1}{7}$	0	10
(t)	0	S_2	$0-\frac{2\times3}{7}$	$2-2\times1$	$4-\frac{2\times4}{7}$	$0-2\times\frac{1}{7}$	$1-2\times0$	$80-2\times10$
					$\because$	$(t) = (w) - 2^*\,(u)$		
$(u)'$	17	b	$\frac{3}{7}$	1	$\frac{4}{7}$	$\frac{1}{7}$	0	10
$(t)'$	0	S_2	$-\frac{6}{7}$	0	$\frac{20}{7}$	$-\frac{2}{7}$	1	60

To decide the variable that will enter

a	c	S_1
8	14	0
$-\frac{3}{7}\times17$	$-\frac{4}{7}\times17$	$-\frac{1}{7}\times17$
$-\left(-\frac{6}{7}\right)\times0$	$-\frac{20}{7}\times0$	$-\left(-\frac{2}{7}\right)\times0$
$=+\frac{5}{7}$	$=+\frac{30}{7}$	$=-\frac{17}{7}$
	$\uparrow 3$	

Therefore, $\uparrow 3$ and $\overset{4}{\leftarrow}$ are marked as follows

* Suppose a workshop can make 40 lamp shades in the manufacturing section, but in the painting section, the limit is 10-units only. Naturally it is of no use to send 40 units through fabrication if we could paint only 10 of them. For this reason the smaller of the two units is the choice.

			8	17	14	0	0		* The value smaller than $\frac{420}{20}$
			a	b	c	S_1	S_2		
(u')	17	b	$\frac{3}{7}$	1	$\boxed{\frac{4}{7}}$	$\frac{3}{7}$	0	10	$10/\frac{4}{7} = \frac{70}{4} = \frac{350}{20}$ * ← 4
$(t)'$	0	S_2	$-\frac{6}{7}$	0	$\frac{20}{7}$	$-\frac{2}{7}$	1	60	$60/\frac{20}{7} = \frac{420}{20}$

↑ 3

Thus 17 b will be replaced by 14 c. Dividing $(u)'$, by $\frac{4}{7}$, we get.

(r)	14	c	$\frac{3}{4}$	$\frac{7}{4}$	1	$\frac{1}{4}$	0	$\frac{70}{4}$
(s)	0	S_2	$-\frac{6}{7}$	0	$\frac{20}{7}$*	$-\frac{2}{7}$	1	60
(s)	14	c	$\frac{3}{4}$	$\frac{7}{4}$	1	$\frac{1}{4}$	0	$\frac{70}{4}$
(s)	0	S_2	$-\frac{6}{7}$	$0-\frac{20}{7}$	$\frac{20}{7}-\frac{20}{7}$	$-\frac{2}{7}$	$1-\frac{20}{7}$	$60-\frac{20}{7}$
			$-\frac{20}{7}$	$\times\frac{7}{4}$	$\times 1$	$-\frac{20}{7}$	$\times 0$	$\times\frac{70}{4}$
			$\times\frac{3}{4}$			$\times\frac{1}{4}$		

Because $(s)'=(s)-\frac{20^*}{7}(r)$. Therefore, simplifying and rewriting

			8	17	14	0	0		
			a	b	c	S_1	S_2		
(r)	14	c	$\frac{3}{4}$	$\frac{7}{4}$	1	$\frac{1}{4}$	0	$\frac{70}{4}$	[4]
$(s)'$	0	S_2	−3	−5	0	−1	1	10	

To decide the variable that will enter

	a	b	S_1
	8	17	0
	$-14\times\frac{3}{4}$	$-14\times\frac{7}{4}$	$-14\times\frac{1}{4}$
	$-0\times(-3)$	$-0\times(-5)$	$-0(-1)$
Net contribution =	$-\frac{10}{4}$	$=-\frac{30}{4}$	$=-\frac{14}{4}$

Since the net contribution comes out to be negative, the introduction of any variable such as a, b or S_1 will reduce profits. Hence [A] gives the *optimum solution*. To maximize profits.

$$c = \frac{70}{4}, S_2 = 10, S_1 = 0, a = 0, b = 0$$

The profit therefore is

$$\begin{aligned} P &= 8a + 17b + 14c \\ &= 8\times 0 + 17\times 0 + 14\times \frac{70}{4} \\ &= 245 \text{ Ans.} \end{aligned}$$

In some industrial situations, it is required to maximize the profits and in others to minimize the cost.

A case of maximization has been solved above. If there is a minimization problem, the procedure is to multiply the objective function by (-1) and maximize, *e.g.*

"If $k = 5a - 7b + 4c$ is to be minimized, then $k = -5a + 7b - 3c$ can be maximized."

Another way is to keep the objective function as it is and choose the largest (in absolute value) negative constant to determine the pivot column. For example, if $k = 5a - 7b + 4c$ is to be minimized, then choose b column (-7) as the pivot column.

The following problems, may be tried to gain practice over the simplex procedure.

Problem 11.5

Maximize $Z = 5X + 6Y$

Subject to $X + 4Y \leq 32$

$2X + Y \leq 36$

(Answer : Rs. 104)

Problem 11.6

(*a*) Maximize $Z = 8X + 6Y$

Subject to $4X + 2Y \leq 60$

$2X + 4Y \leq 48$

(*b*) Solve this problem by graphical technique also and check the optimum result.

(Answer : Rs. 132)

Problem 11.7

Maximize $Z = 10X + 5Y$

Subject to $4X + 5Y \leq 100$

$2X + 4Y \leq 80$

(Answer : Rs. 170.50)

Problem 11.8

(*a*) Maximize $Z = 200X + 300Y$

Subject to $2X + Y \leq 1000$

$X + 3Y \leq 1200$

(*b*) Solve the problem graphically also.

(Answer : Rs. 156,000)

11.9. WAITING LINE OR QUEUING THEORY

Introduction. The credit of original work on Queuing theory goes to A. K. Erlang. He started, in the year 1905, to explore the effect of fluctuating service demand on the utilization of automatic dial equipment. But today, a wide variety of problem situations can be described by waiting line model.

A queue or a waiting line is something very common in everyday routine. There is a queue for bus, queue at ration shop, queue for cinema ticket and where not. Standing in queue wastes a lot of otherwise useful time. Besides everyday experience, queues can be seen on the shop floor, where in-process goods wait for next operation or inspection or wait for getting moved to another place. Such delays in the production lines naturally, increase production cycle duration, add to the product cost, may upset the whole system and it may not be possible to meet the specified delivery dates thereby annoying the potent customers.

A queue is formed whenever the number of arriving items is more than the number which can be processed. For example, if one hundred hand tools reach electroplating section per unit time and only eighty can be plated within that duration, naturally a queue will be set up in which a number of hand tools will be waiting for getting plated.

Waiting lines if (economically) cannot be completely eliminated, they can atleast be reduced by optimizing the number of service stations, or by adjusting the service times in one or more service stations.

Waiting line theory or queuing theory is used to solve *Queue Forming* situations, for example, in post offices, banks, hospitals, telephone booths or exchanges, etc. Queuing Theory analyses the feasibility of adding facilities (equipment, manpower) and assesses the amount and cost of waiting times. In general, this theory can be applied wherever congestion occurs and a waiting line or a queue is formed. The purpose in such situations is to determine the optimum amount of facilities (manpower, machinery, etc.). Queuing theory helps finding lack of balance between items coming and going. It gives information about peak loads. It mathematically relates the length of queue and waiting time and the controllable factors, such as number of service stations or the time taken to process each article. It can also tell, how often and how long the items or persons in queue will probably have to wait.

Queuing theory mathematically predicts the way in which the waiting line will develop over given periods and in turn helps allocating facilities to deal the situation efficiently. In order to build a mathematical model for a queue forming situation, *i.e.*, where items or persons arrive in a random manner, are processed or treated (processing time is again a random variable) and then leave, following information is required :

(*a*) Distribution of gaps between the arrival of items. Say a telephone call comes after every ten minutes.

(*b*) Distribution of service times. Say every time a telephone talk continues for three minutes.

(*c*) The priority system.

(*d*) The processing facilities (It may be a doctor, or a mechanic).

Most waiting line models assume a specific distribution of arrivals (say poissons distribution) and service times (say exponential). Knowing the above-mentioned four points (model) the waiting situation can be studied and analyzed mathematically.

Structures of Queue Forming Situations. (1) Arriving units or persons form one line and are serviced through only one facility. For example, persons are standing in queue at the post office window to collect stamps, etc., and there is only one clerk sitting at the window for selling stamps. This is called single channel, single phase case, Fig. 11.36 (1).

(2) Arriving units or persons form one line but there are more than one service facility or service stations, as in a barber shop with more than one barber working at a time. This is a multichannel, single phase case, Fig. 11.36 (2).

(3) In another structure called single channel multiple phase case, arriving units again form one line but there are a number of service stations in series, Fig. 11.36 (3).

(4) Lastly, in multichannel multiple phase case there are two or more parallel servicing lines, Fig. 11.36 (4). Example—checkout counters of a super-market.

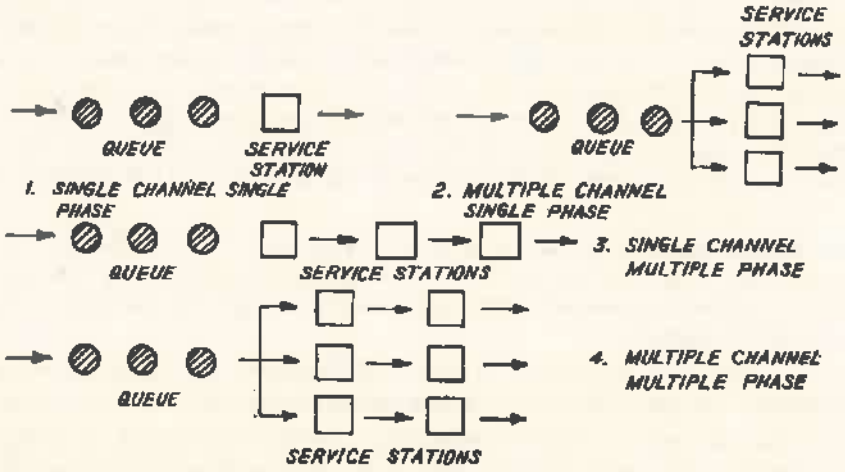


Fig. 11.36. Structures of waiting line situations.

Assumptions Involved in Waiting Line Theory. As regards the treatment of queuing theory in this chapter, the following assumptions are made :

(*a*) There is only one type of queue discipline—that is first come, first served. A unit in queue will immediately go to the service station as soon as the station is free.

(*b*) There are steady state (stable) conditions, *i.e.*, the probability that n items are in queue at any time, remains the same with the passage of time. In other words at all times the number of items in the queue remain same ; the queue does not lengthen indefinitely with time.

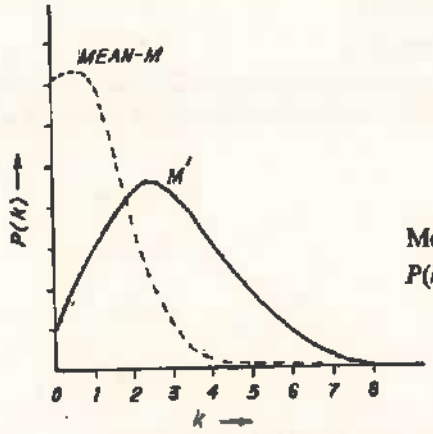
(*c*) Both, the number of items in queue at any instant and the waiting time experienced by a particular item are random variables. They are not functionally dependent on time. The problem thus reduces to estimate the average length of the queue at any instant, etc.

(*d*) Arrival rates follow Poisson distribution and service times follow exponential distribution. This situation, referred as *Poisson Arrivals and Exponential Serivce Times,* holds good in number of actual operating situations.

(*e*) Mean service rate μ is greater than mean arrival rate M.

Poisson Arrivals and Exponential Service Times

Poisson Arrivals. From the studies conducted by Nelson on Arrival, service time and waiting time distribution of a job shop production process ; by Eastman Kodak Company and by O. J. Feorene, etc., it can be safely concluded that in actual real situations the distribution of arrival rates do not significantly differ from the Poisson distribution. Poisson distribution assumes that an arrival is completely independent of other arrivals, *i.e.*, they are completely random. Unlike Normal and Exponential distribution, the Poisson distribution is a *Discrete Distribution*. In other words, the possible values of the random variables are separated, *i.e.*, discrete—for example, number of good mangoes in a basket, number of heads in N tosses of a coin, etc. Poisson distribution is shown in Fig. 11.37 and a few of its properties are given below :



Mean : M

$P(k)$: Probability of k occurrences

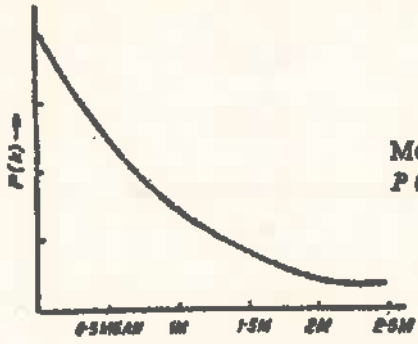
$$\frac{M^k . e^M}{K!}$$

Fig. 11.37. Poisson distribution curves with mean M and M'.

Exponential Service Times. The results of the studies conducted by Nelson[1] and Brigham[2], show different results. According to Nelson, the Exponential model does not fit the actual distributions adequately. According to him, other (mathematical) distributions such as hyperexponential and the hyper-Erlang were better descriptions of the real world distributions. But, Brigham showed that service time at a tool crib was nearly exponential distribution. One has to be very careful before assuming the type of distribution.

Though Exponential distribution does not represent large number of situations, it is used even then because of the simplicity of the mathematical treatment and derivations involved. Other distributions may make the mathematical development too complex and it may become necessary to solve the problem by simulation (Monte-Carlo) techniques.

Unlike poisson distribution, Exponential distribution is a *Continuous Distribution.* The random variables involved range over continuum of values such as, temperature in the morning, the time between two events etc. k (X-axis) can take both integer, and fractional values, so that the distribution becomes continuous. Fig. 11.38 shows Exponential distribution and a few of its properties are given below :



Mean : M

$P(k)$: Probability of k occurrences

$$= e^{-k/M}$$

Fig. 11.38. Exponential distribution curve.

Equations Governing the Queue

Let, n = number of units in the system (total number—in queue as well as under service).

P_n = Probability that there are n units in system at any time.

1. Research Report No. 60, Management Sciences Research Project,. UCLA 1959.
2. Operations Research, 3(4), 412-428, 1955.

M = Mean arrival rate.

μ = Mean service rate.

Knowing the probability of n units in the queue at any time t, the probability of getting n units in time $(t+\Delta t)$ can be calculated by summing up the probabilities of the following four mutually exclusive events (A, B, C and D).

		Events	*Probability*	
(A)	1.	At time t if $(n-1)$ units are in queue.	$P_{n-1}(t)$	...(P_1)
	2.	During time Δt if only one unit arrives.	$M(\Delta t)$	...(P_2)
	3.	During time Δt if no unit is serviced.	$1-\mu(\Delta t)$	...(P_3)
		Total probability ($P_1 \times P_2 \times P_3$)	$= P_{n-1}(t).\, M(\Delta t)\,[1-\mu(\Delta t)]$	
			$= P_{n-1}(t).\,[M(\Delta t) - M(\Delta t)\,\mu(\Delta t)]$	
			$= P_{n-1}(t).\,[M(\Delta t) - M\mu(\Delta t)^2]$	
			$= P_{n-1}(t)\, M\,\Delta t$	...(a)
(B)	1.	At time t, if $(n+1)$ units are in queue.	$P_{n+1}(t)$	
	2.	During time Δt if one unit is serviced.	$\mu(\Delta t)$	
	3.	During time Δt if no unit arrives.	$1-M(\Delta t)$	
		Total probability	$= P_{n+1}(t).\,\mu.(\Delta t).\,[1-M(\Delta t)]$	
			$= P_{n+1}(t).\,[\mu(\Delta t) - \mu(\Delta t)\,M\,[(\Delta t)]$	
			$= P_{n+1}(t)\,\mu\,\Delta t$	...(b)
(C)	1.	At time t if n units are in queue.	$P_n(t)$	
	2.	During time Δt if one unit arrives.	$M.(\Delta t)$	
	3.	During time Δt if one unit is serviced.	$\mu.(\Delta t)$	
		Total probability $= P_n(t).\, M(\Delta t).\, \mu(\Delta t)$ and it can be neglected.		...(c)
(D)	1.	At time t if n units are in queue.	$P_n(t)$	
	2.	During time Δt if no unit arrives.	$1-M(\Delta t)$	
	3.	During time Δt if no unit is serviced.	$1-\mu(\Delta t)$	
		Total probability	$= P_n(t).[1-M(\Delta t)]\,[1-\mu(\Delta t)]$	
			$= P_n(t)\,[1-\mu(\Delta t) - M(\Delta t) + M(\Delta t)\mu(\Delta t)]$	
			$= P_n(t) - P_n(t)\,.\,(\mu+M)\Delta t$	...(d)

* Δt being small $(\Delta t)^2$ will be still smaller and hence can be neglected.

The probability of n units being in queue at time $(t+\Delta t)$ is given by

$$P_n(t+\Delta t) = \text{Sum of equations } (a)+(b)+(c)+(d)$$

$$= P_{n-1}(t).M\,\Delta t + P_{n+1}(t).\mu\,\Delta t + P_n(t) - P_n(t)\,(\mu+M).\Delta t$$

$$\text{or } P_n(t+\Delta t) = P_n(t) + \Delta t[MP_{n-1}(t)+\mu P_{n+1}(t) - (\mu+M).P_n(t)].$$

$$\frac{P_n(t+\Delta t)-P_n(t)}{\Delta t} = M.P_{n-1}(t)+\mu.P_{n+1}(t)-(\mu+M)P_n(t)$$

$$\left[\frac{P_n(t+\Delta t)-P_n(t)}{\Delta t}\right] = \left[M.P_{n-1}(t)+\mu P_{n+1}(t)-(\mu+M)P_n(t)\right]$$

$$Lt_{\Delta t\to t} \qquad Lt_{\Delta t\to 0}$$

Therefore,

$$\frac{d.P_n(t)}{dt} = M.P_{n-1}(t)+\mu P_{n+1}(t)-(u+M)\,P_n(t) \text{ for } n>0 \qquad \ldots(e)$$

For $n=0$, equaton (e) can be written as,

$$\frac{d.P_0(t)}{dt} = \mu.P_1(t)-\mu P_0(t)-MP_0(t)$$

The term $\mu P_0(t)$ does not convey any meaning since there is no unit in queue for service.

Therefore, $\frac{d.P_0(t)}{dt} = \mu P_1(t)-M\,P_0(t)$ $\ldots(f)$

It has been assumed earlier, that the probability of n items being in queue at any time, remains same with the passage of time, which implies that probability is independent of time.

Therefore, $\frac{dP_n(t)}{dt}$, (equation e and f) can be equated to zero.

$$\frac{dP_n(t)}{dt} = 0 = M.P_{n-1}(t)+\mu P_{n+1}(t)-(\mu+M)\,P_n(t) \text{ for } n>0$$

and $\frac{dP_0(t)}{dt} = 0 = \mu P_1(t)-MP_0(t)$ for $n=0$

which give

$MP_{n-1}\times\mu P_{n+1}-(\mu+M)P_n=0$ for $n>0$ $\ldots(g)$

$\mu P_1-MP_0=0$ for $n=0$ $\ldots(h)$

$\ldots(i)$

or $P_1 = \frac{M}{\mu}P_0$

or $P_0 = P_0$

and $P_1 = \frac{M}{\mu}P_0$

$$P_2 = \left(\frac{M}{\mu}\right)^2 P_0 \quad \text{or} \quad P_3 = \left(\frac{M}{\mu}\right)^3 P_0$$

$$P_n = \left(\frac{M}{\mu}\right)^n P_0, \; n \geq 0$$

Since all the probabilities when summed up equate to one, the use of the condition,

$$\sum_{n=0}^{\infty} P_n = 1 \text{ and } \mu > M;$$

$$\text{gives, } P_0 \sum_{n=0}^{\infty} \left(\frac{M}{\mu}\right)^n = 1 = P_0 \left[1 + \left(\frac{M}{\mu}\right)^1 + \left(\frac{M}{\mu}\right)^2 + \ldots \infty\right]$$

$$1 = \frac{P_0}{1 - \left(\frac{M}{\mu}\right)}$$

or $$P_0 = 1 - \left(\frac{M}{\mu}\right) \qquad \ldots(j)$$

Substituting value of P_0 in equations above

$$P_1 = \frac{M}{\mu}\left[1 - \frac{M}{\mu}\right]$$

$$P_2 = \left(\frac{M}{\mu}\right)^2 \left[1 - \frac{M}{\mu}\right]$$

$$P_3 = \left(\frac{M}{\mu}\right)^3 \left[1 - \frac{M}{\mu}\right]$$

$$P_n = \left(\frac{M}{\mu}\right)^n \left[1 - \frac{M}{\mu}\right] \qquad \ldots(k)$$

Equation (*k*) holds good only when the mean service rate μ is greater than the mean arrival rate M.

The various other equations which can be computed and apply to waiting line problems are as follows :

Average queue length (*i.e.*, mean number in queue)

$$L_q = \frac{M^2}{\mu(\mu - M)} \qquad \ldots(l)$$

Average length of non-empty queues

$$L_{neq} = \frac{\mu}{\mu - M} \qquad \ldots(m)$$

Average number of units in system (including the one under service)

$$L = \frac{M}{\mu - M} \qquad \ldots(n)$$

Mean waiting time of an arrival

$$W_m = \frac{M}{\mu(\mu - M)} \quad \text{...(o)}$$

Average waiting time of an arrival who waits

$$W = \frac{1}{\mu - M} \quad \text{...(p)}$$

The following examples will give an idea as how to solve waiting line problems.

Example 11.9. On a telephone booth, average time between the arrival of one man and the next is 10 minutes and the arrivals are assumed to be Poisson. The mean time of using the phone is 4 minutes and is assumed exponentially distributed. Calculate (1) the probability that a man will have to wait after he arrives ; (2) the average length of waiting lines forming from time to time ; (3) by how much the flow of arrivals should increase to justify the installation of a second telephone booth. Assume that second booth can be provided only when a person has to wait minimum for 4 minutes for the phone.

Solution : In 10 minutes there is one arrival.

Therefore in 1 minute there are 1/10 arrivals.

$M = 1/10 = 0.1$ arrivals per minute.

Service time is 4 minutes per arrival.

Therefore $\mu = 1/4$ or 0.25 services per minute.

(1) P, the probability that one has to wait $= 1 - P_0$ ...(1)

From equation (*j*)

$$P_0 = 1 - \frac{M}{\mu} \quad \text{or} \quad 1 - P_0 = \frac{M}{\mu}$$

Thus P from (1) above $= 1 - P_0 = \frac{M}{\mu} = \frac{0.1}{0.25} = 0.4.$

(2) The average length of waiting lines or queues that from time to time, or average length of non-empty queues is given by equation (*m*)

$$L_{neq} = \frac{\mu}{\mu - M} = \frac{0.25}{0.25 - 0.1} = 1.66 \text{ persons.}$$

(3) Mean waiting time of an arrival is given by equation (*o*)

$$W_m = \frac{M}{\mu(\mu - M)}$$

$$4 = \frac{M^1}{0.25(0.25 - M^1)} \text{ ; } M^1 \text{ being the new arrivals per minute corresponding to mean waiting time}$$

of 4 minutes, which gives $M^1 = 0.125$ arrival per minute.

Thus the flow of arrivals must be increased from 0.1 per minute to 0.125 per minute or 0.1×60, *i.e.*, 6 per hour to 7.5 or say 8 per hour.

Example 11.10. Workers come to tool store room to enquire about special tools (required by them) for accomplishing a particular project assigned to them. The average time between two arrivals is 60 seconds and the arrivals are assumed to be in Poisson distribution. The average service time (of the tool room attendant) is 40 seconds. Determine :

(*a*) average queue length ;

(*b*) average length of non-empty queues ;

(*c*) average number of workers in system including the worker being attended ;

(*d*) mean waiting time of an arrival ;

(*e*) average waiting time of an arrival (worker) who waits ; and

(*f*) the type of policy to be established. In other words determine the additional number of tool store room attendants which will minimize the combined cost of attendant's idle time and the cost of workers waiting time. Assume the charges of a skilled worker, Rs. 4 per hour and that of tool store room attendant Re. 0.75 per hour.

Solution.

M = 1/60 arrivals per sec. or 60/60 = 1 arrival/minute.

μ = 1/40 services per sec. or 60/40 = 1.5 services/minute.

(*a*) Average queue length $L_q = \frac{M^2}{\mu(\mu - M)} = \frac{1}{1.5(1.5-1)} = 1.33$ workers in line.

(*b*) Average length of non-empty queues

$$L_{neq} = \frac{\mu}{\mu - M} = \frac{1.5}{1.5-1} = 3 \text{ workers.}$$

(*c*) Average number of workers in the system including the worker being served.

$$L = \frac{M}{\mu - M} = \frac{1}{1.5-1} = 2 \text{ workers.}$$

(*d*) Mean waiting time of an arrival

$$W_m = \frac{M}{\mu(\mu - M)} = \frac{1.5}{1.5(1.5-1)} = 1.33 \text{ minutes/worker.}$$

(*e*) Average waiting time for the worker who waits

$$W = \frac{1}{\mu - M} = \frac{1}{1.5-1} = 2 \text{ minutes waiting time.}$$

(*f*) Idle time $P_0 = 1 - \frac{M}{\mu} = 1 - \frac{1}{1.5} = 0.333$ or 33.3% idle time.

If there are 8 working hours a day, the cost of idle time for one attendant = $8 \times 0.333 \times 0.75$

= Rs. 2 per day.

Workers in 8 hours, will arrive as many as $60 \times 8 = 480$ times and the cost of waiting time will be

$$480 \times \frac{W_m}{60} \times 4$$

$$= 480 \times \frac{1.33}{60} \times 4 = \text{Rs. } 42.56 \text{ per day.}$$

The large cost of waiting time as compared to that of one attendant's idle time justifies the employment of one more attendant.

Applications of Queuing Theory. Queuing theory is applicable wherever a queue forms. A few places where such situation may occur are as follows :

(*a*) Super markets,

(*b*) Post offices,

(*c*) Telephone switch-boards,

(*d*) Petrol pumps,

(*e*) Stores/warehouses,

(*f*) Toll houses,

(*g*) Repair and Maintenance Sections,

(*h*) Hospitals/Doctors,

(*i*) Ports (Ships entering),

(*j*) Computer centres,

(*k*) Assembly lines,

(*l*) Bus stops,

(*m*) Auto traffic at road or railway crossings,

(*n*) Job shop production process.

(*o*) Insurance Companies,

(*p*) Banks, and

(*q*) Tool crib.

Queuing theory helps in deciding the number of persons, equipments or other facilities required in above situations for their efficient functioning.

11.10. GOAL PROGRAMMING

Concept

- Goal programming is a special approach to linear programming.
- This approach is capable of handling a single objective with multiple subobjectives.
- Higher level objectives can be maximized or minimized first, before lower level objectives are brought into the final solution. Hence preference is given to those objectives that are of greater significance to an organization. These objectives are called *goals*.

The Methodology of Goal Programming (GP)

- To solve a goal programming problem, we follow a series of iterative steps. As with the simplex method of linear programming, an algorithm is employed until the final answer is determined. The specific steps that we must follow to solve the GP problem are :-

Step-1 Review Model formulation for appropriate deviational variables

Since we need to rank the goals in order to formulate GP problems, we require a type of variable that can be used to reflect the underachievement or overachievement of stated goals, and variables of this type are termed *deviational variables*.

Although the procedures followed here for developing variables and constraint equations in goal programming problem are the same as those in the simplex method of linear programming, deviational variables must be included, where necessary, to describe the problem being formulated.

Step-2 Solve using the Simplex Method (Modified)

A GP problem can be solved using the iterative procedures of the simplex method of linear programming. If the problem features a single goal with multiple subgoals, the tableau structure need not be changed. On the other hand, if the problem treats multiple goals with multiple subgoals, one additional Z_j *row* and C_j-Z_j row must be added for each priority factor (*i.e.*, for P_1, P_2, P_3.....). This enlarged tableau structure permits evaluation of all goals that have bearing on the problem's solution. Note that the answer obtained by using the simplex method provides the best solution in terms of coming as close as possible to reaching all of the intended goals.

When starting doing computations for the simplex method, in the *first step*, the potential loss in the

objective function from one unit of each variable entering the basis is computed and written in a row called the Z_j *row* (where j is the variable column). *Second*, since the gain is known for one unit of each variable in the *objective function row* (called the C_j *row*), the net result of a gain minus its loss for all the basic and non-basic variables will be values in the C_j-Z_j rows.

- Goal programming, like linear programming will call for *sensitivity analysis* to answer managerial *What If* questions.

Applications of Goal Programming

(1) *Selection of organization objectives.* Helps determine what type of objective(s) and strategies the manager should employ to realize the vast potential of an organization's resources.

(2) *Establishing sales goals.* Assists the manager in determining the time to be spent on established customers versus new ones.

(3) *Aggregate production planning.* Aids the manager in planning and scheduling production quotas for the coming period.

(4) *Aggregate planning of work force.* Assists in minimizing payrole expenditures through more effective hiring and layoff procedures, overtime practices and the like.

(5) Analyzing *multiplant scheduling* problems.

(6) *Capital project evaluation.* Helps the manager determine what investment amounts to place on new capital projects.

11.11. SENSITIVITY ANALYSIS

- If a manager is given the ability to produce a *range* of possible outcomes in response to the request for an estimate this will reduce the worry in the mind of the manager who must produce the estimate.
- If the *range* reveals that most favourable estimate produces a favourable outcome, still there is no worry. But if the least favourable estimate produces an unfavourable outcome, there is indeed the great need to worry because if this least favourable, bottomside estimate should come to *pass* then the firm could be in trouble.
- Therefore part of the process of *forecasting* must be to highlight any such extremely critical or *sensitive* areas by seeking to answer a series of *what if ...* ? questions *e.g. what would happen to profitability and to liquidity if sales fell by 25% ? What if customers took three months to pay their accounts instead of one month ? And so on. This aspect of forecasting is called sensitivity Analysis.*
- The *object* of sensitivity analysis, by iterative combination of all possible outcomes within the range of estimates submitted, is to isolate within the forecast those critical factors or key variables, variations in which are likely to have the most critical impact upon the financial fortunes of the firm. Management attention must then be focused on these key variables because these are the killer areas : areas where it is worth seeking more information in order to improve the quality of the best guess estimate ; areas where some form of insurance might be sought ; areas where subsequent vigilance in the monitoring both of forecasting assumptions and of actual cash flows must be strongest in order to give the earliest warning of an impending financial crisis.
- It must be stressed that *sensitivity analysis* is a relatively simple and unsophisticated concept : all it implies is that several forecasts are produced from a range of estimates fed into the process instead of producing one forecast from single point estimates. The firm is thereby more easily able to ascertain under what combination of circumstances it might be exposed to risks which it would prefer not to face. At the best these risks might represent a break in the continuity of cash flows so as to frustrate certain management decisions considered to be essential to the firm ; at worst they might represent insolvency.

11.12. DYNAMIC PROGRAMMING

Introduction and Concept

- Dynamic programming is a newly developed mathematical technique which is useful in many types of decision problems.
- Many business problems, as a rule, share a common characteristic : they are *static*. That is, the problems are stated and solved in terms of some specific situation that occurs at a given moment.

  Other problems, however, are concerned with variations that occur over *time* or through some sequence of events and to solve such problems, another Management Science, called *Dynamic Programming* is used.
- Dynamic programming is an extension of the basic Linear Programming technique.

  When a problem is considered with reference to its parameters varying over time, techniques like Linear Programming, are no longer applicable and the Dynamic Programming has to be used as it includes the time element.
- Dynamic Programming was developed by Richard Bellman and G.B. Dantzig, whose important contributions to this quantitative technique were first published in the 1950s.
- In its simplest sense, dynamic programming can be thought of as an attempt to break large, complex problems into a series of smaller problems that are easier to solve separately.

  In other words, dynamic programming divides the *problem* into a number of *subproblems* or *decision stages*. General recurrence relations between one stage and the next describe the problem.

  There are number of decision stages and at each stage there are several alternate courses of action. The decision generated by stage one, acts as conditions of the problem for stage two and so on. In other words, at each of the several stages there is a choice of decisions and the decisions, initially taken affect the choice of subsequent decisions. The various rules of decision making can be established after considering the effects of each decision (separately) and the optimum policy for further decisions.

  The basis of dynamic programming is to select the best amongst the final possible alternative decisions. This process is then repeated, ignoring all those alternatives which do not lead to selected best (optimum). The best sequence of decisions can thus be defined, by repeating the above procedure.
- Dynamic programming is also concerned with problems in which *time* is not a relevant variable ; for example, in the case where a decision must be made as to the allocation of resources in fixed quantity among a number of alternative uses.
- A dynamic problem approach is advantageous for solving problems where a sequence of decisions must be made. Even though incorrect or less-than-optimal decisions may have been made in the past, dynamic programming enables one to still make decisions for future periods.

Dynamic programming terms

The following basic terms and concepts are central to the theory of dynamic programming :-

1. *State Variables*

- These are variables whose values specify the conditions of the process.
- The values of state variables tell us all we need to know about the system for the purpose of making decisions. For example, in a production problem, we might require state variables that relate to plant capacity and present inventory.

  The lesser the number of state variables, the easier is to solve a problem.

2. *Decision Variables*

These constitute opportunities to change the state variables (possibly in a probabilistic manner), and the net change in the state variables over some time period will be subject to considerable uncertainty. The returns generated from each decision will depend on the starting and ending states for that decision, hence they will add up as a sequence of decisions. Depending on circumstances, the task is to make decisions that will either maximize or minimize a certain objective.

3. *Stages*

The ability to make decisions about some problem at various stages (or points in time), is an important feature of dynamic programming problem formulation. In problems where decisions are made through a series of events, stages are represented by the events. At each stage in a problem, a decision is made to change the state and, thereby, maximize or minimize a certain objective. Then, at the next stage, decisions are made using the values of the state variables having resulted from the preceding decision and so forth.

The solution is ultimately reached by moving backwards (or forwards, if desired), stage by stage, and determining the optimal policy (*i.e.*, set of decisions) for each state variable at each stage in time, until the overall optimal policy has emerged in the final stage.

– To see how the above explained concepts are applied in a problem, consider the following question :

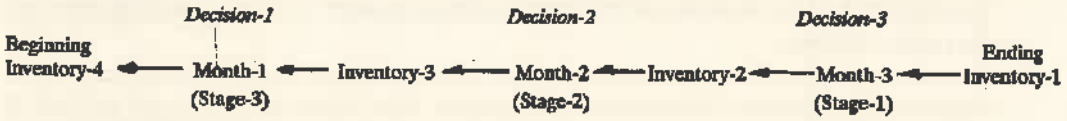
"What is the minimium cost production schedule for the next three months" ?

If the *state variable* is *inventory*,

the *decision variable* is the *level of production*, and

each *month* is a *stage*, then

the dynamic programming formulation for this problem's sequential, multistage decision making is as follows :-



4. *Objective*

As with other Management Science models, a dynamic programming problem requires an objective (*i.e.*, an objective function). A typical objective may be to maximize total profit or to minimize total cost.

The Methodology of Dynamic Programming

The following steps constitute the basic methodology of dynamic programming :-

Step-1. Determine an appropriate mathematical modelling technique

In this first step of the methodology of dynamic programming, the appropriate mathematical technique, either standard or custom-made, for solving the problem is selected.

Step-2. Solve for the objective function using a multistage-problem solving approach.

To employ the multistage problem-solving approach, it is necessary to break the problem down into component stages. Using the appropriate mathematical technique, the solution is then obtained by moving backwards from the problem's desired end results, stage by stage, to its beginning. In the process, an optimal set of decisions is determined at each stage which can guide the manager in decision making over time or through a series of events.

Applications of Dynamic Programming

Dynamic programming finds application in the following areas :-

1. Scheduling production.
2. Scheduling equipment and machinery overhauls.
3. Smoothing employment (of workers) in an environment with widely fluctuating demand.
4. Determining equipment replacement policy.
5. Maximizing expected sales by determining the best combination of advertising media to use and the best efficiency of use, within a certain budget constraint, to maximize expected sales.
6. Allocating capital funds to new ventures for maximizing profits over the long term.
7. Evaluating investment opportunities : Determines the most profitable investment of resources or the best alternative among given opportunities.
8. Determining the best long-range strategy for replacement of depreciating assets.

11.13. DIFFERENCE BETWEEN LINEAR PROGRAMMING AND DYNAMIC PROGRAMMING

(1) Dynamic programming is characterized as a *multi-stage decision making process* that spans time intervals ; however, the intervals may consist only of *stages* in which the problem is solved.

Linear programming, conversely, gives a solution that will *pertain* only to *one time period* within given capacity, quantity and contribution (or cost) constraints.

(2) With dynamic programming, wrong decisions in the past will not prevent correct decisions from being made either at present or in the future.

In essence, dynamic programming permits one to determine optimal decisions for future time periods, regardless of any earlier decisions, unlike linear programming, which requires constant updating of any values obtained in order to reflect the current constraints necessary for an optimal answer.

(3) Dynamic programming is more powerful in the sense of a concept than linear programming, but weaker as a computational technique.

(4) Dynamic programming is similar to calculus, whereas linear programming is analogous to solving sets of simultaneous linear equations.

(5) Dynamic programming takes a quite different form than linear programming ; whereas certain rules must always be followed in the iterative process of linear programming, dynamic programming uses whatever mathematics are deemed appropriate to the solution of the problem.

11.14. NONLINEAR PROGRAMMING

- The underlying theory for much of the research done in non-linear programming was presented in a paper by Kuhn and Tucker in 1951. However, the major thrust in solving real-life nonlinear programming problems was made after 1960.
- In the case where either the objective function or the *constraints* are non-linear, use is made of non-linear programming techniques.

  Non-linearities exist, for example, when a firm must lower prices to induce more people to buy.
- In many of these nonlinear situations, linear programmes have been used as approximations and have proved to be adequate. However, with the increase in sophistication of the users, together with availability of non-linear computer routines, there will be a marked increase in the use of this technique.
- There are problems of business and industry where the assumption of linearity is not quite valid. In *transportation problems*, for instance, there are bulk transportation rates which are cheaper than the regular transportation rates. These rates are applicable if the amount transported is above a certain quantity. Thus, the objective function no longer remains linear, but becomes a non-linear function of decision variables.

12

Systems Concept & Value Analysis

12.1. SYSTEMS CONCEPT

Introduction. The society and the industry is more complex today than it was ever before. More and more persons are acquiring higher education and technical skills, newer materials and informations are being rigged up and under such situations, rules of thumb cannot be highly relied upon.

Systems concept gives to industry and to other large business organisations, a systematic approach to get the task accomplished more efficiently, effectively and economically. Systems approach is an organised approach for complex (Military and Industrial) equipment design and the same can be completed in a much shorter duration with comparatively less efforts.

Systems concept furnishes a frame of references which tells how to manage the jobs or how to analyse complex phenomena under different environments.

Systems approach is more common in the field of physical sciences and engineering because it is comparatively easier to build a model of such systems. However, the systems approach can also be used to solve problems related to business or human values (like fire protection, housing, etc.)

Systems Engineering differs from Industrial Engineering in the sense that industrial engineering sub-sciences like work study, production planning and (quality) control, etc., take interest in both physical and non-physical systems whereas systems engineering is primarily concerned with *Information Systems* (or non-physical systems). Secondly, the different sub-sciences or industrial engineering came out as a result of the development of industries whereas systems engineering coined out of the information models which controlled the industries, industrial operations and organisation.

System. A system may be defined as a collection of interacting elements that operate to achieve a predetermined objective. In simple terms, a system may be visualized as a processing unit which receives certain inputs and is urged to act upon them in some desirable fashion to produce outputs with a purpose to optimize some function of input and output. Inputs may be in the form of energy, matter, information, etc. Processing unit may be activated and controlled by men or machines. The output may be in the form of products, services or information and the objective may be to maximize output.

A system is dynamic in nature. A system may have animate or inanimate interacting elements. A thunder storm is an inanimate system whereas a hospital (building) together with its staff and operating conditions is an animate system. In this system, the input is medicines, medical instruments, patients, etc.; the processing unit includes doctors, other staff and machinery; the output is the relief to the patients and the objective is to treat satisfactorily as many patients as possible in a given time.

A few *examples* of other systems are as under :

(*a*) A human body is a system with various sub-systems like nervous, blood circulation, breathing, eating and drinking, etc.

(*b*) An industry is a system with various subsystems like purchase, production, sales, etc.

(*c*) A transportation system. It has its subsystems like road, rail, air and marine transportation.

SHEETAL GAUTAM

Classification of Systems. A system may be :

(*i*) *Mechanistic*. A mechanistic system is one which though is fully mechanised yet the choice of system composition remains in the hands of human beings. The examples of the mechanistic systems are, dial telephone, guided missiles, space rockets, etc.

(*ii*) *Quasi-Mechanistic*. In a quasi-mechanistic system human beings carry out some of the mechanical functions. A fighter plane is a quasi-mechanistic system.

(*iii*) In another type of system, human elements act in a non-mechanical manner, take decisions and improve the system. Production system is an example of this kind of system.

12.2. SYSTEMS ANALYSIS

Introduction. Systems analysis involves the *Study* and *Construction of Systems.*

Systems analysis is the study of each part of the system, both as an individual and in relation to the whole in order to design, modify or improve the system ; it is immaterial whether it is an abstract system like inventory control procedure or it is a physical system such as power transmission in a vehicle.

Procedure. Systems analysis involves a continuous cycle of the following :

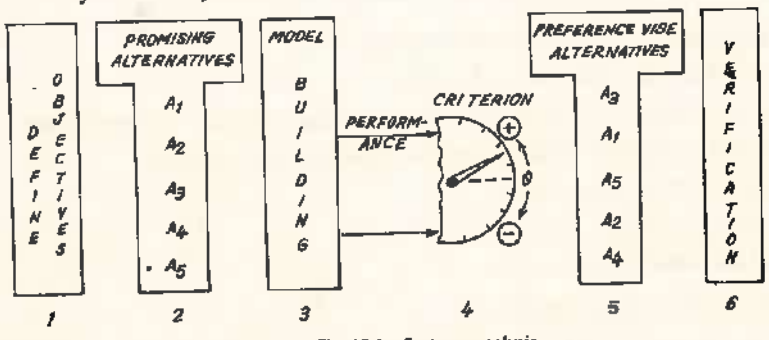


Fig. 12.1. Systems analysis.

(1) Define Objectives. It is the conceptual phase in which the objectives are clarified and defined with a view to select a policy regarding action or decision-making for solving the problem.

(2) Promising Alternatives. Promising alternative programmes, which can possibly achieve the objectives, are thought of and designed.

(3) Model Building. Promising alternative programmes can be shaped into models.

A *Model* is an analog of reality. It represents the system qualitatively or quantitatively. A model may be in the physical form or it may be a mathematical presentation of the system. It is always cheaper and convenient to forecast the consequences and to test the performance of a system from its model rather getting the same information after going through the complicated process of actually fabricating the system being considered. Depending upon the type of problem, there can be an *overall process model, performance model, reliability model, time model* or *cost model.*

(4) Criterion. The individual models are evaluated in terms of the criterion specified before. The criterion may be effectiveness, cost, performance or cost against performance, etc.

(5) Preference-wise Alternatives. From the performance of models, various alternative programmes are listed in order of preference.

(6) Verification. The most promising alternative/alternatives are tested by experiments and their good points are verified.

12.3. SYSTEMS ENGINEERING

Systems engineering involves the *Analysis* and *Synthesis* of systems. The systems engineering

includes the following three major steps for designing complex and highly engineered Military and Industrial equipment systems.

(*a*) **Define the Problem.** Specify the input-output requirements of the system.

(*b*) **Solve the Problem.** Select and define the sub-systems ; write system, sub-system and sub-system interface specifications ; and find out the performance of the system.

(*c*) **Check the Solution.** Check the solution to ascertain if the designed equipment system fulfils the requirements expected of it.

12.4. TECHNIQUES IN SYSTEMS ANALYSIS

Mostly the techniques of systems analysis depend upon mathematical equations to exhibit the behaviour of the system components and the effect they exercise on one another. Some such techniques are named below :

(*a*) Operations Research (refer Chapter 11)

(*b*) PERT and CPM (refer Chapter 10), and

(*c*) Simulation.

12.5. APPLICATIONS OF SYSTEMS ENGINEERING

Systems approach finds the following applications :

(1) Design and development of complex, highly engineered Industrial equipment systems,

(2) Design and development of Military equipments and weapon systems,

(3) In the choice of tactical alternatives,

(4) Management of operations, and

(5) In deciding major policy alternatives.

12.6. VALUE ANALYSIS/ENGINEERING

Value analysis developed as a cost reduction technique in U.S.A. in 1947. The credit for it goes to Lorry D. Miles who was working at G.E. and who, subsequently became the President of SAVE (Society of American Value Engineers) also. Value engineering got developed because of the inherent desire in the man to make cheaper and to sell cheaper ; keeping the utility of the products, of course, same.

Value. Value differs from both price, and cost in the sense that it is the cost proportionate to the function, *i.e.*,

$$\text{Value} = \frac{\text{Function (or Utility)}}{\text{Cost}}$$

It can therefore be seen that the value of a product can be increased either by increasing its utility with the same cost or by decreasing its cost for the same function.

Function specifies the purpose of the product or what the product does, what is its utility etc. There can be three functions of a product, namely

(*i*) Primary function,

(*ii*) Secondary function, and

(*iii*) Tertiary function.

Taking an example of 'painting a merchant navy ship' ; the primary function of the paint is to save the ship against corrosion and deterioration. The secondary purpose is to make it recognizable, *i.e.*, from the colour one should be able to identify the company it belongs to. The tertiary function of the paint is to impart a brilliant appearance to the ship.

Types of Values :

(*a*) *Cost Value*. It is the cost of manufacturing a product/component.

(*b*) *Use Value*. It may also be called Functional Value. It considers the work done, functions performed or services rendered by a product/component.

(*c*) *Esteem Value*. It involves the qualities and appearance of a product (like a T.V. set or a car) which attracts persons and creates in them a desire to possess the product.

(*d*) *Exchange Value*. A product is said to possess exchange value if the same (because of its qualities) can be exchanged for something else.

Value Approach. It is an organised system dedicated to every effective means of identifying and thus eliminating the unnecessary costs. An unnecessary cost is one which neither adds to quality nor to life or appearance.

Value approach has two elements, namely *value analysis* and *value engineering*.

12.7. VALUE ANALYSIS

Introduction. Value Analysis discovers new tactical alternatives. It is a special type of cost reduction technique which unlike other (similar) methods does not blindly accept the product design. Rather, it critically investigates and analyses the different aspects of materials (purchase), design and production of each and every component of the product. A component, to be a part of the product must perform some function and serve some purpose. Value analysis examines the design, function and cost of each and every component in order to produce it economically without decreasing its utility, function or reliability.

Value analysis is normally applied to existing rather than to new products.

Aim of Value Analysis. The aim of Value Analysis is to generate promising ideas, to

(*i*) Simplify the product,

(*ii*) Use (new) cheaper and better materials,

(*iii*) Modify and improve product design,

(*iv*) Use efficient processes,

(*v*) Reduce the product cost,

(*vi*) Increase the utility of the product by economical means, and

(*vii*) Save money or to increase the profits.

A *Value Analysis Team* consists of personnel from different sections such as *R & D*, purchase, material control, design, manufacture, inspection, marketing, finance, etc.

Value Analysis Technique. A number of questions as framed by Miles at G.E. and others are given below. Each component part of the product is analysed in the light of these questions (or tests).

(*i*) Does it (*i.e.*, component) contribute value to end product ?

(*ii*) Is its cost proportionate to its function ?

(*iii*) Can some of its features be combined or eliminated ?

(*iv*) Would there be a better product ?

(*v*) Can a component be produced by less costly process ? For example G.E. (U.S.A.) changed from die-cast cover to a stamping and saved $39,000 annually.

(*vi*) Can one go for an available standard product/component ?

(*vii*) Taking into account the quantity required, is the product being made with proper tools ?

(*viii*) Does the product has reasonable selling price ?

(*ix*) Can the product/component be procured at less cost from elsewhere ?

(*x*) Is any body purchasing the product/component at lower rates.

Besides these questions, the detailed Value Analysis procedure is discussed as under :

Value Analysis Procedure. The basic steps are :

(*a*) *Blast* – Identify the product (1)
– Collect relevant information (2)
– Define different functions (3)

(*b*) *Create* – Create different alternatives (4)
– Critically evaluate the alternatives (5)

(*c*) *Refine* – Develop the best alternative (6)
– Implement the alternative (7)

Step-1. The first step is to *Identify the Product* for which Value Analysis is to be carried out. The product should be one which if redesigned can add to the sales income and would not become obsolete in near future. Value Analysis may be applied to the product as a whole or to only some of its component parts.

Step-2. The information relevant to the product may be as follows :

(*i*) Technical specifications with drawings,

(*ii*) Manufacturing processes, machine layout and instruction sheets,

(*iii*) Time study details and manufacturing capacity,

(*iv*) Complete cost data and marketing details, and

(*v*) Latest developments in related products.

Step-3. Identify the primary, secondary, and tertiary functions of the product. Specify value content of each function and identify the high cost areas.

Step-4. Knowing the functions of each component part and its manufacturing details, generate the ideas and create different alternatives so as to increase the value of the product. The Value Analysis team can hold *Brainstorming* sessions. All suggestions feasible or non-feasible are recorded without any criticism ; rather, persons are encouraged to express their views freely.

Step-5. The different ideas recorded under step-4 are compared, evaluated and critically assessed for their virtues, validity and feasibility as regards their financial and technical requirements. Ideas technically sound and involving lower costs are further developed.

Step-6. Detailed development plans are made for those ideas which, during step-5, appear most suitable and promising. Development plans comprise of, drawing the sketches, building of models, and conducting discussions with the purchase section, finance section, marketing division, etc.

Step-7. The best found idea under step-6 is converted into a prototype manufacture which ultimately goes into operation and its results are recorded. The product cost and functional analysis is carried out to assess the net saving as the result of Value Analysis.

Advantages :

1. Value Analysis is a much faster cost reduction technique.

2. It requires little expenditure because the Value Analysis team can be formulated out of the staff available in different sections like purchase, production, finance, etc.

3. Value analysis reduces production costs and adds to sales income of the product.

Applications. A few applications of Value Analysis/Value Engineering are listed below :

1. Military equipments (*T-55* tanks and many other equipments).

2. Import substitutes.

3. Machine tool industry.

4. Industries making material handling equipments.

5. Auto industries, etc.

Value Engineering. Value Engineering is the application of the concepts of value analysis at the design or premanufacture stage of the component parts with a view to cut down the unnecessary costs, without impairing the function or utility of the product.

Value Control. Value Control means controlling the value of a product; either by reducing its cost for the given function or by increasing its utility for the given cost.

13

Plant Maintenance

13.1. PLANT

A plant is a place, where men, materials, money, equipment, machinery, etc., are brought together for manufacturing products.

13.2. MAINTENANCE

Today, in modern industry, equipment and machinery are a very important part of the total productive effort than was the case years ago. Moreover, with the development of special purpose and sophisticated machines, equipment and machinery cost a lot more money and therefore their idle or downtime becomes much more expensive. For this reason, it is vitally important that the plant machinery should be properly maintained.

13.3. OBJECTIVES OF PLANT MAINTENANCE

(*i*) The objective of plant maintenance is to achieve minimum breakdown and to keep the plant in good working condition at the lowest possible cost.

(*ii*) Machines and other facilities should be kept in such a condition which permits them to be used at their optimum (profit making) capacity without any interruption or hindrance.

(*iii*) Maintenance division of the factory ensures the availability of the machines, buildings and services required by other sections of the factory for the performance of their functions at optimum return on investment whether this investment be in material, machinery or personnel.

13.4. IMPORTANCE OF MAINTENANCE

(*i*) The importance of plant maintenance varies with the type of plant and its production.

(*ii*) Equipment breakdown leads to an inevitable loss of production.

- If a piece of equipment goes out of order in a flow production factory, the whole line will soon come to a halt. Other production lines may also stop unless the initial fault is cleared.
- This results in an immediate loss in productivity and a diminution of several thousand rupees per hour of output.

(*iii*) An unproperly maintained or neglected plant will sooner or later require expensive and frequent repairs, because with the passage of time all machines or other facilities (such as transportation facilities), buildings, etc., wear out and need to be maintained to function properly.

(*iv*) Plant maintenance plays a prominent role in production management because plant breakdown creates problems such as

- Loss in production time.
- Rescheduling of production.
- Spoilt materials (because sudden stoppage of process damages in-process materials).
- Failure to recover overheads (because of loss in production hours).

— Need for over-time.

— Need for subcontracting work.

— Temporary work shortages—workers require alternative work.

13.5. DUTIES, FUNCTIONS AND RESPONSIBILITIES OF PLANT MAINTENANCE ENGINEERING DEPARTMENT

(*i*) Depending upon the size of the maintenance department, it has a wide variety of duties or functions to perform.

The work is under the control of *plant engineer* or *maintenance engineer* who normally reports to the *Works Manager*.

(*ii*) The different duties, functions and responsibilities of the maintenance department are as follows :

(A) Inspection

(1) Inspection is concerned with the routine schedule checks of the plant facilities to examine their condition and to check for needed repairs.

(2) Inspections ensure the safe and efficient operation of equipment and machinery.

(3) Frequency of inspections depends upon the intensity of the use of the equipment. For example, belts in a machine may be checked every week ; furnace equipment every month ; an over-head bridge crane every four months and so on.

(4) Inspection section makes certain that every working equipment receives proper attention.

(5) Items removed during maintenance and overhaul operations are inspected to determine the feasibility of repairs.

(6) Maintenance items received from vendors are inspected for their fitness.

(B) Engineering

(1) Engineering involves alterations and improvements in existing equipments and building to minimize breakdowns.

(2) Maintenance department also undertakes engineering and supervision of constructional projects that will eventually become part of the plant.

(3) Engineering and consulting services to production supervision are also the responsibilities of maintenance department.

(C) Maintenance (including Preventive Maintenance)

(1) Maintenance of existing plant equipment.

(2) Maintenance of existing plant buildings, and other service facilities such as yards, central stores, roadways, sewers, etc.

(3) Engineering and execution of planned maintenance, minor installations of equipment, building and replacements.

(4) Preventive maintenance, *i.e.*, preventing breakdown (before it occurs) by well-conceived plans of inspection, lubrication, adjustments, repair and overhaul.

(D) Repair

(1) Maintenance department carries out corrective repairs to alleviate unsatisfactory conditions found during preventive maintenance inspection.

(2) Such a repair is an unscheduled work often of an emergency nature, and is necessary to correct

breakdowns and it includes trouble calls.

(E) Overhaul

(1) Overhaul is a planned, scheduled reconditioning of plant facilities such as machinery, etc.

(2) Overhaul involves replacement, reconditioning, reassembly, etc.

(F) Construction

(1) In some organizations, maintenance department is provided with equipment and personnel and it takes up construction jobs also.

(2) Maintenance department handles construction of wood, brick and steel structures, cement and asphalt paving, electrical installations, etc.

(G) Salvage

(1) Maintenance department may also handle disposition of scrap or surplus materials.

This function involves,

- Segregation, reclamation and disposition of production scrap, and
- The collection and disposition of surplus equipments, materials and supplies.

(H) Clerical Jobs

(1) Maintenance department keeps records

- of costs,
- of time progress on jobs,
- pertaining to important features of buildings and production equipments ; electrical installations ; water, steam, air and oil lines ; transportation facilities (such as elevators, conveyors, powered trucks, cranes, etc.), etc.

(I) Generation and distribution of power and other utilities.

(J) Administration and supervision of labour force (of maintenance department).

(K) Providing plant protection, including fire protection.

(L) Insurance administration.

(M) Establishing and maintaining a suitable store of maintenance materials.

(N) Janitorial service.

(O) *Housekeeping.*

Good housekeeping involves upkeep and cleaning of equipments, building, toilets, wash-rooms, etc.

(P) Pollution and noise abatement.

13.6. ORGANISATION OF MAINTENANCE DEPARTMENT

(1) The buildings, plant and services are called by the accountant fixed assets and in many companies they form at least 50% of the money invested.

In any company, small or big, it is therefore essential that some part of the main *organization* should be responsible for *maintaining* these important assets.

(2) The section or department which preserves and looks after the upkeep of equipments, building etc., is called maintenance department.

(3) To work satisfactorily, the maintenance department has an organization structure.

Figure 13.1 shows the maintenance organization of a plant.

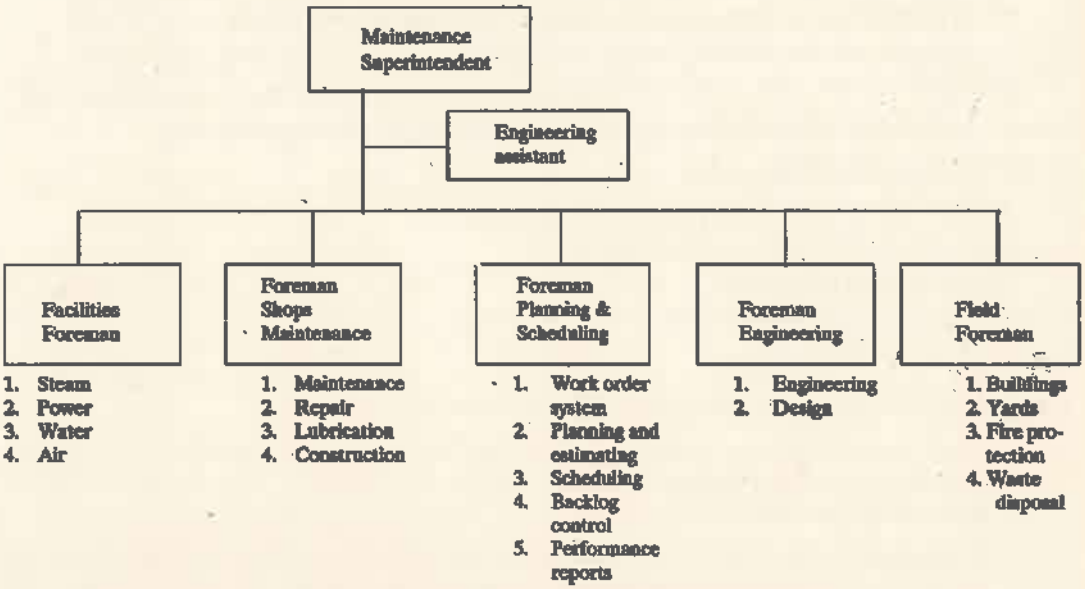


Fig. 13.1. Organization structure of maintenance department.

(4) A few *basic concepts of good organisations* that should be kept in mind in developing an organisation are :

(*a*) A reasonably clear division of authority with little or no overlap.

(*b*) Vertical lines of authority and responsibility should be kept as short as possible. In other words, a level which simply transmits information up and instructions down should be eliminated.

(*c*) Keep optimum number of persons (3 to 6 is the average value) reporting to an individual.

(*d*) Fit the organisation to the personalities involved. This means that the organisation structure should be flexible and it may be revised periodically to fit changing personnel and conditions.

(5) The basic *organisation structure of maintenance department* depends upon :

(*a*) *Types of maintenance activities to be looked after*

The wider the maintenance field to be covered, the bigger is the organisation.

(*b*) *Continuity of operations*

The size of the maintenance force and therefore the structure of maintenance organisation depends upon :

- whether it is a four, five or six working days week, and
- whether the plant runs in one, two or three shifts.

(*c*) *Size of the plant*

The organisation structure of the maintenance department varies with the size of plant. The larger the plant the more the number of persons in the maintenance force.

(*d*) *Compact or dispersed plant*

A plant spread in a wider area (like ECIL Hyderabad) needs decentralization and may require several parallel maintenance organisations. A compact plant may need only one such organisation.

(*e*) *Nature of industry, i.e.,* whether it is primarily an electrical, electronics, chemical or a mechanical industry.

(*f*) State of training and reliability of work force.

(6) *In establishing a maintenance organisation, it is essential to recognise that :*

(*a*) the plant is to be maintained at a level consistent with low cost and high productivity ;

(*b*) supervisors should be appointed according to the duties and responsibilities involved ; and

(*c*) modern age indicates greater need of newer engineering techniques and skills.

13.7. TYPES OF MAINTENANCE

Maintenance may be classified into following categories :

(*a*) Corrective or breakdown maintenance,

(*b*) Scheduled maintenance,

(*c*) Preventive maintenance, and

(*d*) Predictive maintenance.

13.8. CORRECTIVE OR BREAKDOWN MAINTENANCE

- Corrective or breakdown maintenance implies that repairs are made after the equipment is out of order and it cannot perform its normal function any longer, *e.g.,* an electric motor will not start, a belt is broken, etc.
- Under such conditions, production department calls on the maintenance department to rectify the defect. The maintenance department checks into the difficulty and makes the necessary repairs.
- After removing the fault, maintenance engineers do not attend the equipment again until another failure or breakdown occurs.
- *This type of maintenance may be quite justified* in small factories which :
  - (*i*) are indifferent to the benefits of scheduling ;
  - (*ii*) do not feel a financial justification for scheduling techniques ; and
  - (*iii*) get seldom (temporary or permanent) demand in excess of normal operating capacity.
- In many factories *make-and-mend* is the rule rather than the exception.
- Breakdown maintenance practice is economical for those (non-critical) equipments whose down-time and repair costs are less this way than with any other type of maintenance.
- Breakdown type of maintenance involves little administrative work, few records and a comparative small staff.

  There is no planned interference with production programmes.
- **Typical Causes of Equipment Breakdown**
  - (*i*) Failure to replace worn out parts.
  - (*ii*) Lack of lubrication.
  - (*iii*) Neglected cooling system.
  - (*iv*) Indifference towards minor faults.
  - (*v*) External factors (such as too low or too high line voltage, wrong fuel, etc.)

(*vi*) Indifference towards – equipment vibrations, unusual sounds coming out of the rotating machinery, equipment getting too much heated up, etc.

– **Disadvantages of Breakdown Maintenance**

(*i*) Breakdowns generally occur at inopportunate times. This leads to poor, hurried maintenance and excessive delays in production.

(*ii*) Reduction of output.

(*iii*) Faster plant deterioration.

(*iv*) Increased chances of accidents and less safety to both workers and machines.

(*v*) More spoilt material.

(*vi*) Direct loss of profit.

(*vii*) Breakdown maintenance practice cannot be employed for those plant items which are regulated by statutory provisions, for example cranes, lifts, hoists and pressure vessels.

13.9. SCHEDULED MAINTENANCE

– Scheduled maintenance is a stich-in-time procedure aimed at avoiding breakdowns.

– Breakdowns can be dangerous to life and as far as possible should be minimized.

– Scheduled maintenance practice incorporates (in it), inspection, lubrication, repair and overhaul of certain equipments which if neglected can result in breakdown.

Inspection, lubrication, servicing, etc., of these equipments are included in the predetermined schedule.

– Scheduled maintenance practice is generally followed for overhauling of machines, cleaning of water and other tanks, white-washing of buildings, etc.

13.10. PREVENTIVE MAINTENANCE

Introduction

– A system of scheduled, planned or preventive maintenance tries to minimize the problems of breakdown maintenance.

– It is a stich-in-time procedure.

– It locates weak spots (such as bearing surfaces, parts under excessive vibrations, etc.) in all equipments, provides them regular inspection and minor repairs thereby reducing the danger of unanticipated breakdown. The underlying principle of preventive maintenance is that *prevention is better than cure*.

Preventive Maintenance (or PM) Involves

(*a*) Periodic inspection of equipment and machinery to uncover conditions that lead to production breakdown and harmful depreciation.

(*b*) Upkeep of plant equipment to correct such conditions while they are still in a minor stage.

– Preventive maintenance is practised to some extent in about 75% of all manufacturing companies, but every preventive maintenance programme is tailored as per the requirements of each company.

– The key to all good preventive maintenance programmes, however, is inspection.

– Help can be taken of suitable statistical techniques in order to find how often to inspect.

Objectives of PM

(*i*) To minimize the possibility of unanticipated production interruption or major breakdown by locating or uncovering any condition which may lead to it.

(*ii*) To make plant equipment and machinery always available and ready for use.

(*iii*) To maintain the value of equipment and machinery by periodic inspections, repairs, overhauls, etc.

(*iv*) To maintain the optimum productive efficiency of the plant equipment and machinery.

(*v*) To maintain the operational accuracy of the plant equipment.

(*vi*) To reduce the work content of maintenance jobs.

(*vii*) To achieve maximum production at minimum repair cost.

(*viii*) To ensure safety of life and limbs of the workmen.

Elements (or Procedure) of Preventive Maintenance

(*i*) There is no ready-made, on-the-shelf, preventive maintenance programme for any industry. It must be tailor-made-measured and cut to fit the requirements of individual industry or plant ; this is because all industries differ in size, age, location, machinery, resources, layout, and construction.

(*ii*) A well-conceived preventive maintenance programme contains the following elements, features or steps.

1. Who should do PM ?

Preventive maintenance may be taken care by

(*a*) Production department.

(*b*) Maintenance department.

(*c*) A separate division of inspectors, crafts and supervisors.

- The choice depends upon, again, the conditions (such as size, age, location, machinery, etc.) of the plant.
- However, a perfect coordination between production department and PM personnel is highly essential for the success of the preventive maintenance practice, because PM personnel can carry out (preventive) maintenance only when production department releases the machinery for the same.
- For this reason, certain industries keep PM under production department. But as the work load of PM increases, PM is transferred either to maintenance department or to a separate division of inspectors, crafts and supervisors.
- Approximate size of *preventive maintenance force* :

Nature of industry	Manpower PM : Total maintenance
(*i*) Primary-metal industries	1 : 2.37 Men
(*ii*) Machinery manufacturers	1 : 2.69 Men
(*iii*) General manufacturing	1 : 10 Men

2. Where to start PM ?

- One should not apply PM to the entire plant at once.
- PM programme should be built up in pieces ; when one piece is finished, start the next.
- It is better to tackle one section (or department) at a time or one type of machinery over the entire plant.

– The entire PM programme hangs on inspections and their related duties of adjustments and repairs.

3. What to inspect in PM ?

– Preventive maintenance is costly, therefore one should strike a favourable balance between this cost and the cost of not utilizing PM.

– Application of PM to all the items in a plant may be uneconomical.

– In almost all industries, there are certain *key items* which are more essential for continuing the production than others. In other words, a breakdown of key items would seriously interrupt production and badly affect production schedule, etc.

– A few examples of key-items are as follows :

(*i*) Material handling equipments such as cranes, lifts, conveyors, hoists, trucks, etc.

(*ii*) Safety equipments such as vacuum and pressure relief valves, flame and flashback arresters, fire extinguishers ; safety alarms, etc.

(*iii*) Process equipments such as furnaces, compressors, pumps, boosters, motors, pipings, etc.

(*iv*) Special purpose—unique equipments and machines.

(*v*) Water, air and fuel lines.

4. What to inspect for ?

– After listing the equipments requiring PM, the next step is to decide—what physical *parts* of each piece of equipment need attention.

– These parts can be identified by the craftmen and supervisors who maintain these equipments ; they, by their experience, know the items liable to wear or equipment maladjustments taking place under normal conditions.

– Another guide in this matter can be the service manual issued by the equipment manufacturer.

– After making the list of machines and their parts needing PM, *i.e.*, their inspection points, one makes, a CHECK-LIST to ensure that no inspection point has missed.

5. How often to inspect—frequency ?

– The decision—how often to inspect is made,

(*i*) In the light of past experience. For example, if annual inspection keeps a key-item in perfect running condition, one may not think of inspecting the same every six months. However, one may try to see if the same key-item will work well if instead annually is inspected after every 18 months.

(*ii*) Also, on the basis of costs and savings of the PM programme. If the cost of PM is greater than the savings, one may go for reducing the frequency of inspections.

The exception is safety standards—they must always take precedence over financial considerations.

– Over-inspection is needless expensive and may involve more productive downtime than an emergency breakdown. Under-inspection results in (frequent and) more breakdowns and earlier

replacements. A good balance between the two is very essential to bring optimum saving.

– *Frequency of inspections* may be decided depending upon the following equipment conditions :

(*i*) Severity of service and hours of operation, *i.e.*, whether an equipment runs in one shift, two shifts or for all the 24 hours.

(*ii*) Age, condition and value of the equipment.

(*iii*) Safety requirements and health hazards (associated with equipment breakdown).

(*iv*) Exposure (of equipment) to dirt, friction, fatigue, stresses, corrosion, *i.e.*, the susceptibility (of the equipment) to wear.

(*v*) Exposure to vibrations, overloading etc., *i.e.*, susceptibility (of the equipment) to damage.

(*vi*) Susceptibility to lose adjustments and the effect of misalignments in the equipment on production jobs.

6. When to inspect–schedules ?

– Scheduling involves determining calendar inspection dates that will fulfil the frequency requirements in the most efficient way.

– In setting up schedules one must ensure to keep production going at lowest overall cost. Schedules should be set in consultation with production department and as per the production needs, as far as possible.

– *PM inspection and service functions can be classified* into three following groups :

(*i*) Routine up-keep, *i.e.*, adjustment, lubrication and cleaning of equipments.

(*ii*) Periodic inspections, *i.e.*, visual inspections, tear down inspections, overhauls, scheduled replacement of parts, etc. .

(*iii*) Contingent work, *e.g.*, inspection of oil burners while relining a furnace.

– *Routine upkeep or periodic inspections may be scheduled as follows* :

(*i*) Do them in the day-shift (to reduce over-time).

(*ii*) Spread them over the year to even up the total work load of maintenance.

(*iii*) Plan them when equipment is not producing, *i.e.*, during set up time, etc.

(*iv*) Ensure that *PM* consumes least productive time.

– Fig. 13.2 shows a *PM* schedule

DEPTT–I
WEEKLY MAINTENANCE SCHEDULE PRODUCTION MACHINERY
C–CLEAN, O–OVERHAUL, F–FUNCTIONAL CHECK

MACHINE NO.	MACHINE DESCRIPTION	1	2	3	4	5	6	7	8	9
1201	Lathe				C					O
162	Shaper		C					O		
980	Surface grinder			F						
650	Milling					F				

Fig. 13.2. Weekly PM Schedule.

7. Preventive maintenance stages and cycle

Stages of PM and a PM cycle for material handling equipments have been discussed under section 25.6.

8. Preventive maintenance records

- It is very necessary to keep records because they are the only reliable guides for measuring the effectiveness of the preventive maintenance programme. Only records tell us, what is the situation at present and where it is going.
- Good updated records, proper filing equipment and adequate clerical help are the backbone of PM programme.
- *Record keeing is also necessary :*
  - (*i*) When budgeting for major overhauls.
  - (*ii*) When budgeting for general maintenance costs.
  - (*iii*) For finding equipment reliability.
  - (*iv*) For determining frequency of inspections.
  - (*v*) For preparing maintenance schedules.
  - (*vi*) For predicting equipment life.
  - (*vii*) For designing maintenance cost control systems.
  - (*viii*) For equipment replacement analysis.
  - (*ix*) For carrying out cost reduction studies (*e.g.*, value analysis).
- *Guidelines to good PM records*

(*i*) Minimize the number of forms and entries.

(*ii*) Integrate PM system with other maintenance paper work systems in order to reduce administrative costs.

(*iii*) Account for costs of all primary PM inspection activities in order to show what exact costs are and how far the PM programme is justified.

(*iv*) Arrange for a periodic control report (weekly or monthly) to check on PM performance.

- *Records should show*
  - (*i*) Type of equipment and its description.
  - (*ii*) Whether it is a key item ?
  - (*iii*) Name of the manufacturer.
  - (*iv*) Cost and date of purchase of the equipment.
  - (*v*) Location of the equipment in the factory.
  - (*vi*) Equipment identification (*e.g.*, chassis) number.
  - (*vii*) Inspection of job specification reference number.
  - (*viii*) Estimated cost of inspection and the cost and data of planned repairs.
  - (*ix*) Breakdowns, their dates and reasons.
  - (*x*) Cost of breakdowns and other associated implications.

9. Storage of spare parts

- Spare parts are stored in order to reduce the loss of production time.

– *What spare parts to keep and how much to keep* depends upon :

(*i*) The past experience.

(*ii*) Advice from plant manufacturers.

(*iii*) The cost of buying and storing the spares.

(*iv*) The cost of having idle plant waiting for spare parts in case of a breakdown or at the time of need.

(*v*) The ease or difficulty with which the spare parts can be made available when required.

(*vi*) Whether spare parts are standard or not.

– *Spare parts once procured should be stored adequately in order to locate them immediately at the time of need. For this*

(*i*) Spare parts should have stamped code number.

(*ii*) The stock card may be identified by this number.

(*iii*) The bin or rack, in which the part is lying, should have its location reference number recorded on the stock card.

(*iv*) Spare parts for an equipment may be grouped together and referred to by their plant number.

(*v*) For locating a part, the storekeeper would first check the stock card bearing the plant number and take down the bin (or storage rack) reference number. Then, by the code number of the part, he will identify the required spare part from the many parts lying in that bin.

10. Control and evaluation of PM

– A PM programme be coordinated and must remain under control at all times.

– To maintain control of the PM programme, the following measures should be taken.

(*i*) Periodic review of PM programme with the operating department.

(*ii*) Review of monthly reports of PM inspections.

(*iii*) Analytical approach to the evaluation of PM. Analytical approach makes use of following relations :

(*a*) $\frac{\text{Inspections incomplete}}{\text{Inspections scheduled}} \times 100 = 10\%$ Max.

(*b*) $\frac{\text{Job resulting}}{\text{Inspections completed}} \times 100 = 20$ to 30%

(*c*) $\frac{\text{Hours worked as forecast jobs}}{\text{Total hours worked}} \times 100 =$ Percentage of performance

When plotted, percentage of performance should have a trend either increasing or stabilized above 80%.

Advantages of PM

1. Reduced breakdowns and connected down-time.
2. Lesser odd-time repairs and reduced overtime to the maintenance work-force.
3. Greater safety for workers.
4. Fewer large-scale and repetitive repairs.

5. Low maintenance and repair costs.

6. Less stand-by or reserve equipment, and spare parts.

7. Identification of equipments requiring high maintenance costs.

8. Lower unit cost of manufacture.

9. Better product quality and fewer product rejects.

10. Increased equipment life.

11. Better industrial relations because production workers do not face involuntary lay-offs or loss of incentive bonus because of breakdowns.

13.11. PREDICTIVE MAINTENANCE

- It is comparatively a newer maintenance technique.
- It makes use of human senses or other sensitive instruments such as

  Audio gauges,

  Vibration analyzers,

  Amplitude meters,

  Pressure, temperature and resistance strain gauges, etc., to predict troubles before the equipment fails.
- Unusual sounds coming out of a rotating equipment predict a (coming) trouble ; an electric cable excessively hot at one point predicts a trouble.
- Simple hand touch can point out many unusual (equipment) conditions and thus predict a trouble.
- In predictive maintenance, equipment conditions are measured periodically or on a continuous basis and this enables maintenance men to take a timely action such as equipment adjustments, repair or overhaul.
- Predictive maintenance extends the service life of an equipment without fear of failure.

13.12. PLANT MAINTENANCE SCHEDULE

Introduction

- Maintenance scheduling follows a similar procedure to that outlined for production. It is required to know that how long a job will take, when it should be done and if resources are available.
- As explained earlier, scheduling means determining calender inspection dates that will fulfil the frequency requirements in the most efficient way.
- **Scheduling**

(1) system should be clear, precise and easy to operate,

(2) should be based upon accurately determined time standards,

(3) should be finalised in consultation with production department so that the equipments for maintenance purposes can be spared,

(4) should aim at creating a balanced work load on each trade section in the department, that is, each section should be evenly loaded.

- Maintenance schedule should be flexible.

– *Maintenance schedule should*

(1) be such that, the maintenance work can be carried out during lunch hours, between shifts or at week ends etc.,

(2) take advantage of planned machine stoppages such as tool changes, loading and unloading of job etc.,

(3) plan major repairs and overhauls during holidays,

(4) make use of reserve plant if the need arises.

Procedure. The scheduling of maintenance work involves essentially two steps.

1. Preparation of *master maintenance schedule.*

2. Preparation of *Detailed weekly or daily schedule.*

Master maintenance schedule indicates the nature and magnitude of each repair and construction task segment of maintenance for a specified time span.

– Considering total man hours needed for each task segment and the manpower available, the distribution of jobs (that will give reasonable man loadings, and can be accomplished) is done.

– A master schedule is flexible and a *cushion* always exists to accommodate, unanticipated tasks and jobs which are lagging behind schedule.

Detailed schedules are prepared by breaking overall time spans allocated under master schedule.

– Detailed weekly work schedule provides information to each craft and shop regarding the task to be carried on each job for each day in the coming week.

– Detailed scheduling requires records of work capacity of each section of the maintenance department and of the maintenance department as a whole.

– Like master schedule, the detailed schedule should also be flexible and able to accommodate emergency jobs.

– Detailed schedule may be issued to concerned persons every day or near the week-end.

Maintenance schedule of each machine may be prepared and it will indicate the list of works which must be carried out (together with the frequency) and will contain servicing, adjustments, lubrication details and particulars of replacement work. Fig. 13.3 shows the schedule of maintenance.

		January				*February*				*March*				*April*				*May*			
Plant	*Ref.*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
LATHES																					
1.....	*XYZ*	*X*	*Y*		*Z*	*X*				*X*	*Y*			*X*			*Z*	*X*	*Y*		
2.....	*XYZ*	*Z*	*X*	*Y*			*X*				*X*	*Y*		*Z*	*X*				*X*	*Y*	
SHAPER																					
1.....	*XZ*			*X*	*Z*			*X*				*X*				*X*	*Z*			*X*	
MILLING MACHINE																					
1.....	*XY*	*Y*			*X*				*X*	*Y*			*X*				*X*	*Y*			*X*

N.B. It is one, two and three monthly inspection for jobs *X, Y* and *Z* respectively.

Fig. 13.3. Schedule of Maintenance.

Scheduling tools (Devices). They are classed as :

1. Visual charts.
2. Scheduling boards.
3. Individual cards.

1. Visual chart is shown in Fig. 13.3.

2. Scheduling boards have been discussed in chapter 7.

3. Individual cards. As compared to scheduling board, individual cards contain more written details and can be used for historical records.

13.13 STANDARD DATA FOR MAINTENANCE

Introduction

– No maintenance programme can be accurately developed and maintained without various standards such as

(*i*) *Time standards* which indicate the time to complete a maintenance job.

(*ii*) *Lubrication standards* which mark the interval between lubrications, etc.

Purpose. Maintenance standards are used for,

(*i*) Planning and scheduling maintenance work.

(*ii*) Providing fair number of maintenance–men.

(*iii*) Measuring the output or effectiveness of performance of maintenance–men.

(*iv*) Providing incentive earnings for maintenance–men.

Setting and Using Standard Data

[N.B. Refer to chapter 9 also]

– Owing to the variable, non-repetitive nature of maintenance work, a great deal of technical study is required before the *standard data* assembled represents sufficient coverage of the work to do effective planning.

– Standard data derived from *time studies* is probably the most widely used system for applying sophisticated labour control to maintenance departments.

– For an individual concern, to collect standard data, would require many engineering hours and thus make it prohibitive because of initial cost.

However, there are management consulting firms who have assembled standard data (for maintenance) and have established programmes that are available to clients for installation of maintenance controls.

– Table 13.1 gives an example of Maintenance Standard Data.

TABLE 13.1
MAINTENANCE STANDARD DATA

Section : *Pipe fitters*

Operation : *Pipe fitting, standard screw pipe joint*

(Summary of studies for installing and removing pipe-lines of various diameters).

Pipe Size (mm)	*Standard Man-hours per Piece of Pipe*	
	Make	Break
6 to 12	0.12	0.08
18	0.17	0.11
25	0.20	0.13
30	0.23	0.15
37.5	0.26	0.18
50	0.31	0.23

TABLE 13.2
Planning Work Sheet

Master order _____
Date received _____
Date released to scheduling _____
Planner _____

Install Machine A

Building craft

Job description	*Section and page No.*	*No. of occurs*	*Time per occur*	*Total time (mins.)*
Make holes for anchor bolts	XY 5-8	3	25 mins	75
Chip trench in floor for conduit & air line	XY 5-8	3000 cc	3 cc per min.	1000
Planned Time				1075
Auxiliary time	FM 1-2			150
				1225
Personal time @ 10%				122.5
Total time in minutes				1347.5
Total time in hours				22.48

– Table 13.2 shows the method to calculate the time required to install a machine with the help of standard maintenance data.

Advantages of Using Standard Data for Maintenance Control

1. Consistent estimating of maintenance jobs.
2. Elimination of delays through improved scheduling.

3. Improved supervisory controls.

4. Alternate methods of maintenance can be properly weighed and compared.

5. Determination of labour content for each craft provides proper coordination of crafts.

6. Through application of maintenance standards and proper estimating, the work backlogs can be adjusted as required.

7. Through controlled means, the fluctuations in maintenance requirements are handled properly.

8. Standard data forms a basis for accurately evaluating, forecasting and controlling maintenance expenditures.

13.14 SOME RECENT DEVELOPMENTS IN PLANT MAINTENANCE

- In recent years there has been a tendency to use a variety of management techniques for plant maintenance. These techniques have led to
  - (*i*) An increase in maintenance efficiency.
  - (*ii*) Reduced maintenance costs.
  - (*iii*) Improved services.

(A) Use of Workstudy (refer Chapter 9)

Workstudy can improve maintenance scheduling and eliminate a great deal of frustration and anxiety on the part of production supervision.

(B) Use of Network Planning Techniques (refer Chapter 10)

(*i*) CPM has enabled some firms to cut their downtime by 20 to 30%.

(*ii*) Maintenance costs have been cut down.

(*iii*) Plant utilization has been raised.

(*iv*) CPM is very useful for planning and control of large maintenance projects.

(*v*) Dramatic reductions in time (about 70%) were experienced with the overhaul of generating plant by Central Electricity Generating Board in Great Britain, by using network planning techniques.

(*vi*) When applied to the maintenance and overhaul of a refinery, PERT reduced its shutdown time from 18 to 16 days and thus added 90,000 barrels to its production volume.

(C) Use of Operations Research (refer Chapter 11)

Operations Research handles maintenance problems such as the economic level of spare parts or when to replace an item, etc.

(D) Use of Computers (refer Chapter 36)

- Computers when used for managing maintenance problems provide more efficient operation and control.
- Computers can prepare maintenance work orders giving accurate work order descriptions and job timing.
- The following improvements over manual systems of PM have been claimed by using a computerized system of preventive maintenance :
  - (*i*) Eliminated human error in preparing work order, etc.
  - (*ii*) Reduced cost of keeping records of equipments, etc.
  - (*iii*) Reduced premature replacement of parts.

14

Replacement Analysis

14.1. INTRODUCTION

- In replacement, one is concerned with equipment and machinery that deteriorates with the passage of time.
- Since over time, an equipment ages, every piece of equipment in an industry is a candidate for replacement.
- However, with increasing maintenance, the productive life of an equipment can be increased but the maintenance cost goes high.

Fig. 14.1 shows the maintenance costs per unit time of the presently owned equipment called the *Defender* and the new equipment (under consideration for replacing the present equipment) hereafter known as the *challenger*.

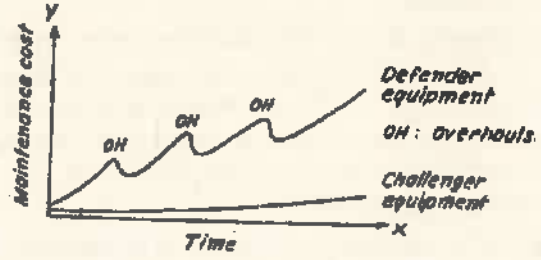


Fig. 14.1. Maintenance cost comparison between the defender and the challenger.

- Replacement whereas reduces (equipment) maintenance cost, it involves a high average capital cost.
- It is *decided to replace* an equipment when the maintenance and capital costs of the defender equipment is more than the average capital and operating costs of the replacement, *i.e.*, the challenger equipment.
- Many people feel that an equipment should not be replaced until it is physically worn out. But it is not correct ; preferably equipments must be constantly renewed and updated (taking financial aspects into consideration) otherwise there is increasing risk that it will become obsolete.
- In recent years manufacturing management has given serious thought to the *policies for equipment replacement.*

The new trend is to replace all those equipments which are not operating as productively as

possible. For example, a lathe which cannot produce jobs as per the desired surface finish and dimensional tolerance or if it cannot make use of the capabilities of the newer cutting tool materials, should be replaced.

14.2. REASONS FOR REPLACEMENT

Equipments are generally considered for replacement for the following reasons :

(*a*) Deterioration

- Deterioration is the decline in performance of an equipment as compared to a new equipment identical to the present one.
- Deterioration may occur due to equipment wear and tear, misalignments, etc.
- Deterioration
  - (*i*) increases maintenance costs ;
  - (*ii*) reduces product quality ;
  - (*iii*) decreases rate of production ;
  - (*iv*) causes loss in operating time ;
  - (*v*) increases labour costs ; and
  - (*vi*) reduces efficiency of the equipment.

(*b*) Obsolescence

- Technology is progressing rapidly ; newer and better equipments are being developed and turned out every year.
- If management of a concern does not go for a change in the equipment or machinery, the unwarranted manufacturing costs arising from obsolete equipment will
  - (*i*) reduce profits ; and
  - (*ii*) seriously impair the concern's competitive position in the market.
- A first class machine, but producing only 15 pieces per hour is rendered *obsolete* in spite of its excellent mechanical condition, when another new machine capable of satisfactorily producing 100 pieces per hour comes into the market ; because with the new machine cost per piece produced is much lower.
- Obsolescence causes loss in value of machinery.

(*c*) Inadequacy

- When an existing equipment becomes *inadequate* to meet the challenge of making new products or existing product in large quantities, the question of replacement arises.
- An existing pit furnace may be melting gray cast iron till present in a foundry, but huge orders necessitate its replacement by a cupola. The pit crucible furnace is inadequate to boost the production rate.
- A milling machine may not become obsolete, but it is inadequate in producing gears on mass production. Under such conditions one may go for automatic gear cutting machines and form cutters.

(*d*) Working Conditions

- It may be thought of replacing old equipments and machinery which create unpleasant (*i.e.*,

smoky, noisy, etc.) and hazardous working conditions causing worker unsafety and leading to accidents.

14.3. FACTORS TO BE CONSIDERED FOR REPLACING EQUIPMENTS

Two main factors are :

(*a*) Technical factors.

(*b*) Financial factors.

(*a*) **Technical factors.** They tend to consider,

(*i*) Whether the present equipment has *deteriorated, i.e.,* whether it is functioning properly or not?

(*ii*) Whether the present equipment has become *obsolete* ?

(*iii*) Is the present equipment *inadequate* in meeting production rate ?

(*iv*) Can the present equipment hold *tight tolerances* ?

(*v*) Can the present equipment provide required *surface finish* ?

(*vi*) Is the new equipment better designed from a method's standpoint ?

(*vii*) Is the present equipment polluting or spoiling working conditions of the factory ?

(*viii*) Is the present equipment making more noise and vibrations and thus distracting the attention of the workers ?

(*ix*) Is the existing equipment hard on the workers ?

(*x*) Does the existing equipment increase likelihood of accidents ?

(*xi*) To what extent the existing equipment is not capable of making use of the newer developments in the field ?

(*xii*) How often the existing equipment needs maintenance and repairs ?

(*b*) **Financial factors** : They are

(*i*) The initial cost of the challenger.

(*ii*) Operating expenses. They include

(*a*) Direct and indirect labour cost,

(*b*) Direct and indirect material cost,

(*c*) Power,

(*d*) Maintenance cost,

(*e*) Cost of replacing parts,

(*f*) Insurance, and

(*g*) Interest on invested capital, etc.

(*iii*) Expected salvage value at the end of the service life.

At the time of replacement, rather than considering only the factors pertaining to the particular equipment involved, replacement studies should be carried out on plant-wide cost basis because the effect of replacement upon other operating costs may be highly significant.

14.4. METHODS USED IN SELECTION OF ALTERNATIVES

Introduction

- A well designed equipment replacement policy should compare thoroughly an existing equipment with its possible replacement or replacements.
- In order to make a sound economic comparison, all the factors should be converted into cost

considerations.

– Several common methods used for evaluating proposals for capital expenditures and for comparing and selecting alternative machines or equipments involving capital assets are discussed below :

1. Total life average method,
2. Annual cost method,
3. Present worth method,
4. Rate of return method,
5. MAPI method, and
6. Approximate MAPI solution.

1. Total Life Average Method :

Steps involved

(*i*) Add the initial cost of the machine and its operating expenses.

(*ii*) Divide this figure by the estimated life of the machine to arrive at the average annual cost.

Example 14.1. The following data are available for the existing equipment and for the proposed equipment to replace the existing one. Find whether the concern should go for replacement or not.

Factors	*Existing equipment*	*Proposed equipment*
1. Cost	Rs. 1500 (market value)	Rs. 10,000 (installed cost)
2. Operating expenses (annual)	Rs. 5000	Rs. 3888.9
3. Scrap value	Rs. 500	Rs. 1000
4. Interest	10%	10%
5. Life of equipment	1 year	9 years

Solution.

	Existing equipment	*Proposed equipment*
Depreciation	Rs. 1500–500 = Rs. 1000	Rs. 10000–1000 = Rs. 9000
Operating costs	Rs. 5000 × 1 = Rs. 5000 (for 1 year)	Rs. 3888.9 × 9 = Rs. 35000 (for 9 years)
Interest @ 10%	Rs. 100*	Rs. 5400
Total life cost	= Rs. 6100	Rs. 49400
Average cost per year	$= \text{Rs. } \frac{6100}{1}$ = Rs. 6100	$= \text{Rs. } \frac{49400}{9}$ = Rs. 5489

* The interest has been calculated as follows :

The existing equipment depreciates at the rate of Rs. 1000 per year, therefore, the interest is

$$1000 \times \frac{10}{100} = \text{Rs. } 100$$

Proposed equipment is costing Rs. 10000 and after 9 years its scrap value will be only Rs. 1000 ; therefore interest for first year will be Rs. $10000 \times \frac{10}{100}$ = Rs. 1000, for second year $9000 \times \frac{10}{100}$ = Rs. 900,

for third year $8000 \times \frac{10}{100}$ = Rs. 800 and so on ; for 9 years it will be 1000 + 900 + 800 + 700 + 600 + 500 + 400 + 300 + 200 = Rs.5400.

Since average cost per year is less for the proposed equipment it is better to go for the replacement.

Example 14.2. An existing piece of equipment has its market value as Rs. 10,000, maintenance cost of Rs. 1000 per year, a life of 10 years and no scrap value. The proposed new equipment for replacement has an installed cost of Rs. 100,000, maintenance cost Rs. 800 per year, a life of 50 years and scrap value of 16,000. Suggest if the proposed equipment should be purchased. **(Answer : No)**

2. Annual Cost Method. Annual cost method of evaluating alternatives, compares the annual costs of obtaining service from different equipments.

Annual Cost=Capital recovery+Operating Costs.

The annual cost of capital recovery (C.R.) is calculated as follows (for equal annual costs) :

$$\text{C.R.} = (P-L)\left[\frac{i(1+i)^n}{(1+i)^n-1}\right] + Li$$

or $$\text{C.R.} = (P-L)(CRF) + Li$$

where CRF is capital recovery factor

(refer Table 14.1).

P is first cost of equipment

n is life of equipment in years

L is salvage value at the end of life of equipment

i is interest rate.

TABLE 14.1

5% interest factors for annual compounding interest

n	*Single payment* *Present worth factor* $(PWF)_1$	*Equal payment series* *Present worth factor* $(PWF)_2$	*Equal payment series* *Capital recovery factor (CRF)*
1	0.9524	0.9524	1.0500
2	0.9070	1.8594	0.5378
4	0.8227	3.5460	0.2820
6	0.7462	5.0756	0.1970
8	0.6768	6.4632	0.1547
10	0.6139	7.7217	0.1295
15	0.4810	10.3796	0.0963
20	0.3768	12.4622	0.0802
|	|	|	|
50	0.0872	18.2559	0.0547
|	|	|	|
100	0.0076	19.8479	0.05038

Note : Tables are available for 4%, 6% and 10% interest values also.

Example 14.3. Given below is the data for two equipments. Find out which alternative you will select.

	Equipment-1	*Equipment-2*
Initial cost (P)	Rs. 10,000	Rs. 15,000
Annual operating cost	Rs. 1,000	Rs. 800
Life of the equipment	8 years	8 years
Salvage value (L)	Rs. 1,000	Rs. 3,000

Interest rate (i) 5%

Solution.

Capital recovery C.R. = $(P-L)\,CRF+Li$

(To find CRF, refer Table 14.1) CRF for 8 years $i=5\%$ is 0.1547

Equipment-1

$$\text{C.R.} = (10000-1000)\,0.1547 + 1000 \times \frac{6}{100}$$

$= 1392.3 + 60$

$=$ Rs. 1452.3

Total annual cost

= C.R. + Operating costs

$= 1452.3 + 1000$

$=$ Rs. 2452.3

Equipment-2

$$\text{C.R.} = (15000-3000)\,0.1547 + 1400 \times \frac{6}{100}$$

$= 1856.4 + 84$

$=$ Rs. 1944.4

Total annual cost

= C.R. + Operating costs

$= 1944.4 + 800$

$=$ Rs. 2744.4

Equipment-1 should be selected as it involves lower total annual cost.

Example 14.4. For the data given below suggest whether to purchase the new machine or not.

Old existing machine

(*i*) Market value = Rs. 30,000

(*ii*) Overhaul charges to make it work for another (n) 5 years = Rs. 25000

(*iii*) Resale value = Rs. 40,000

(*iv*) Maintenance cost = Rs. 200 per year more than required for new proposed equipment

New proposed machine

(*i*) Installed cost = Rs. 100,000

(*ii*) Expected life = 15 years (n)

(*iii*) Maintenance cost = Rs. 100 per year

(*iv*) Resale value = Rs. 10,000

(*v*) Assume an interest rate of 10%

(*vi*) For $n=5$, $i=10\%$, $CRF = 0.2638$ & for $n=15$, $i=10\%$, $CRF = 0.13147$.

Solution.

Capital recovery ($C.R.$) = $(P-L)\,CRF + L.i$

Old existing machine

$$CR = (30{,}000 + 25{,}000-40{,}000) \times 0.2638 + 40{,}000 \times \frac{10}{100}$$

$= 3957+4000=$Rs. 7957

Total annual cost = CR + maintenance cost
= Rs. 7957 + (200 + 100)
= **Rs. 8257.**

New proposed machine

$$CR = (100{,}000 - 10{,}000) \times 0.13147 + 10{,}000 \times \frac{10}{100}$$

= Rs. 11823.3 + 1000 = Rs. 12823.3

Total annual cost = CR + maintenance cost
= 12823.3 + 100
= **Rs. 12923.3**

Since old existing machine involves lower total annual cost, the new proposed machine should not be purchased.

3. Present Worth Method

- This method of comparing alternatives, consists of reducing all receipts and expenditures for each alternative equipment to a *present worth basis.*
- While using this method, one should make sure that equal services are being compared.

Example 14.5. Use the data given in example 14.3 and solve the problem by Present Worth Method.

Solution.

Equipment-1

Initial cost = Rs. 10,000

Present worth of annual operating Costs = 1000 × $(PWF)_2$ for 8 years and 5% i from Table 14.1

= 1000 × 6.4632 = Rs. 6463.2

Total present worth of disbursements = Rs. 16463.2 ...(*a*)

Present worth of salvage value = 1000 × $(PWF)_1$ = 1000 × 0.6768 = Rs. 676.8 ... (*b*)

Present worth of net disbursements for equipment-1 for 8 years, (*a*)−(*b*) **Rs. 15786.4**

Equipment-2

Initial cost = Rs. 15,000

Present worth of annual operating costs = 800 × $(PWF)_2$ for 8 years and 5% i from Table 14.1

= 800 × 6.4632 = Rs. 5170.56

Total present worth of disbursements = Rs. 20170.56 ... (*c*)

Present worth of salvage value = 3000 × $(PWF)_1$ = 3000 × 0.6768 = Rs. 2030.30 ... (*d*)

Present worth of net disbursements for equipment-2 for 8 years, (*c*)−(*d*) = **Rs. 18140.16**

Since present worth of net disbursements for *equipment-1* is lesser than that for *equipment-2*, it *should be selected.*

Out of *Present worth method and Annual cost method*, perhaps the latter fits in well with the thinking of many people and they are better able to interpret the results.

Problem 14.1. Solve example 14.4 by Present worth method and check the answer.

Example 14.6. A concern has got an old equipment which, if is overhauled after every 3 years, can give service up to a total period of 9 years. Considering the data given below, suggest whether new equipment which also has a life of 9 years should be purchased or not.

Old Equipment

1. Cost of present repair : Rs. 1200.
2. Cost of repair after 3 years : Rs. 1500.
3. Cost of repair after next 3 years : Rs. 2000.
4. Resale value after 9 years : Rs. 1000.
5. Operating costs : Rs. 2000 per year for 9 years of equipment life.
6. Old equipment at present can be sold for Rs. 1000.

New Equipment

1. Installed cost : Rs. 10,000.
2. Resale value after 9 years : Rs. 1000.
3. Operating costs : Rs. 1200 per year for 9 years of equipment life.

Assume interest @ 10%

Given that for i = 10% and

n = 3, Single payment present worth factor = 0.75131

n = 6, S.P.P.W.F. = 0.56447

n = 9, S.P.P.W.F. = 0.42410

and Equal payment series present worth factor for i = 10% and n = 9 years is 5.7590.

Solution.

Old Equipment

Present worth of repair expenditure of

Rs. 1200 (Present repair)		= Rs. 1200.00
Rs. 1500 (3 years)	: Rs. 1500 × 0.75131	= Rs. 1126.96
Rs. 2000 (6 years)	: Rs. 2000 × 0.56447	= Rs. 1128.94
Rs. 1000 (resale value)	: Rs. 1000 × 0.4241	= Rs. 424.10
Present worth of operating cost of Rs. 2000 per year for 9 years	: Rs. 2000 × 5.759	= 11518.00
	Total present worth	= Rs. 15398.00 ....(*a*)

New Equipment

Present worth of

Installed cost of new machine–present cost of old equipment, *i.e.*, (10000–1000)	= Rs. 9000.00
Rs. 1000 (resale value after 9 years) : 1000 × 0.4241	= Rs. 424.10

Rs. 1200 per year for 9 years
(operating cost) : 1200 × 5.759 = Rs. 6910.80

Total present worth = Rs. 16334.90 ....(*b*)

Since present worth of old equipment is less than that of new equipment, therefore new equipment should not be purchased.

4. Rate of Return Method

- Rate of return method calculates a rate of return which is then examined for adequacy.
- Interest costs are not accounted and therefore the resulting figure is known as *unadjusted rate of return.*
- Unadjusted rate of return

$$= \frac{100\ (\text{Net monetary operating advantage} - \text{Amortization})}{\text{Average investment}} \quad ...(1)$$

- Net monetary advantage is the algebraic sum of operation, maintenance and differences in revenue.
- $\text{Amortization} = \frac{\text{Incremental investment}}{\text{Economic life}}$
- The above written relationship holds good if the rate of return computed is *Before tax* rate.
- If an *after tax* rate is to be found, the net increase in income taxes due to the project is subtracted from the net monetary advantage.

Therefore, rate of return

$$= \frac{100\ (\text{Net monetary operating advantage} - \text{Incremental tax due to the project} - \text{amortization}}{\text{Average investment}} \quad ...(2)$$

The following example will illustrate the method.

Example 14.7. A new material handling system costs Rs. 25000 (installed) including the cost of relayout. This decreases the number of material handling workers by five. After adding increased maintenance and power costs, the net monetary operating advantage is estimated as Rs. 1200 per year. If estimated economic life is 5 years, calculate the rate of return *before tax* and *after tax.* Assume a depreciation term of 10 years.

Solution.

1. The unadjusted *before tax* rate of return can be calculated by using relationship (1) ; it is

$$= \frac{100\left(12000 - \frac{25000}{5}\right)}{\frac{25000}{2}} = 56\%$$

2. The *after tax* rate of return is calculated as follows,

Assuming a straight line depreciation,

$$\text{Incremental taxable income} = 12000 - \frac{25000}{10\ (\text{years})} = \text{Rs. } 9500$$

Assuming an income tax rate of 50%, the incremental tax due to the project is $\text{Rs.}\frac{9500}{2} = \text{Rs. } 4750$. Therefore, the after tax return, using relationship (2) is given by

$$\frac{100\left(12000 - 4750 - \frac{25000}{5}\right)}{\frac{25000}{2}} = 18\%$$

Whether the rate of return of 56% or 18% is adequate or not, it can be judged in relation to the risk involved in the particular project and the returns possible through alternate uses of the capital.

5. MAPI (Machinery Allied Products Institute) Method

Introduction

- MAPI, the Machinery and Allied Products Institute of Washington, D.C. has done a lot of thinking and research on the subject of equipment replacement.
- The MAPI system has been updated and improved with the latest version being described in 1967.
- The MAPI system is widely used by industry, because it is easy to follow.
- The MAPI formula might be characterized best as an *adjusted* after-tax rate of return criterion.
- A critical requirement of MAPI method is that costs should be based on the process and system performance. In other words, costs for an individual facility should not be measured in isolation from the system.
- MAPI method differs from previously described rate of return methods, because
  - (*i*) It estimates the initial rate of return rather than an average rate of return over the life of the investment.
  - (*ii*) It allows for obsolescence.
  - (*iii*) MAPI charts account for the type of tax depreciation used, (*i.e.*, whether straight line, sum of digits etc.)
  - (*iv*) MAPI method takes the help of a set of forms and charts to simplify the mechanics of calculations.
- The major *advantage* of MAPI method is that it permits a simple and consistent method to be applied for evaluating all company facilities.

Taxes are generally overlooked in the investment decision process; but the fact that MAPI procedure considers taxes is an important point which goes in its favour.

- MAPI method makes use of *MAPI Summary form* and *MAPI-charts* No. 1A, 2A and 3A.
  - (*i*) Chart No. 1A—It is for one year comparison period and sum-of-digits tax depreciation.
  - (*ii*) Chart No. 2A—It is for one year comparison period and double declining balance tax depreciation (refer Fig. 14.2)
  - (*iii*) Chart No. 3A—It is for one year comparison period and straight-line tax depreciation.

Besides one year (*i.e.*, next year) comparison, MAPI method covers the second approach also *i.e.*, a multi-year comparison of say, twenty, thirty or more years. However, one year comparison is by far the most common and can be effectively used for comparing the costs of machines for periods of ten years or less.

Procedure. The MAPI procedure will be explained with the help of following example.

Example 14.8. A machine tools making concern was purchasing several component parts for their milling machines from outside suppliers. It decided to install the equipments to produce those parts itself. Cost for this new equipment is Rs. 30,000. Other relevant data has been entered in MAPI summary form given below.

Calculate the after-tax return so that a sound judgement can be made as regards the profitability of the given proposal (of purchasing new equipment).

(N.B. It should be noted clearly that MAPI approach does not give a final answer in the form as whether or not to go for the replacement ; it only guides for action).

MAPI CHART No. 2A

(ONE-YEAR COMPARISON PERIOD AND DOUBLE-DECLINING BALANCE TAX DEPRECIATION)

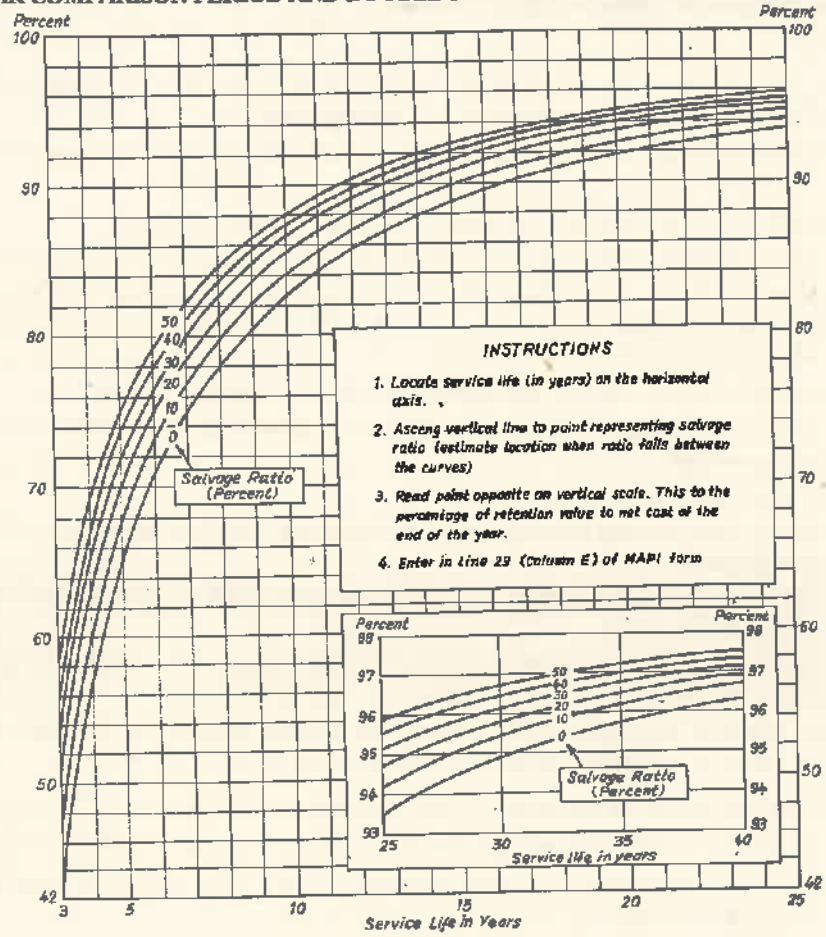


Fig. 14.2

Solution.

PROJECT No..... SHEET 1

MAPI SUMMARY FORM
(Averaging Shortcut)

Project : New equipment

Alternative : Continue to buy from outside suppliers

Comparison Period (years) (P) 1

Assumed Operating Rate of Project (Hours per year) 500

I. OPERATING ADVANTAGE

(*Next year* for a 1-year comparison period*, Annual averages for longer periods)

* Next year means the first year of project operation. For projects with a significant break-in period, use performance after break-in.

REPLACEMENT ANALYSIS

A. Effect of Project on Revenue

		Increase		*Decrease*		
1.	From change in quality of products	Rs.		Rs.		1
2.	From change in volume of output					2
3.	*Total*	Rs.	*X*	Rs.	*Y*	3
	B. Effect on Operating Costs					
4.	Direct labour	Rs. 1000				4
5.	Indirect labour	100				5
6.	Fringe benefits	200				6
7.	Maintenance	200				7
8.	Tooling	50				8
9.	Materials and supplies			16000		9
10.	Inspection					10
11.	Assembly					11
12.	Scrap and rework					12
13.	Down time					13
14.	Power	50				14
15.	Floor space			1400		15
16.	Property taxes and insurance	300				16
17.	Subcontracting					17
18.	Inventory			1300		18
19.	Safety					19
20.	Flexibility					20
21.	Others					21
22.	*Total*	Rs. 1900 (*Y*)		18700(*X*)		22
	C. Combined Effect					
23.	Net increase in revenue (3*X*–3*Y*)	Rs.				23
24.	Net decrease in operating costs (22*x*–22*y*)	Rs. 16800				24
25.	*Annual operating advantage* (23+24)	Rs. 16800				25

SHEET 2

II. INVESTMENT AND RETURN

A. Initial Investment

26.	Installed cost of project	Rs. 30000		
	minus initial tax benefit of	Rs. 2000	(Net cost) Rs. 28000	26
27.	Investment in alternative capital additions minus initial tax benefit plus : Disposal value of assets retired by project (after terminal tax adjustments)	Rs.		
		Rs. 4000	Rs. 4000	27
28.	Initial net investment (26–27)		Rs. 24000	28

B. Terminal Investment

29. Retention Value of project at end of comparison period.

(Estimate for assets, if any, that cannot be depreciated or expensed, for others, estimate or use MAPI charts)

Item or group	*Installed cost minus initial tax benefit (net cost)* A	*Service life (Years)* B	*Disposal value End of life (% of net cost)* C	*MAPI chart Number* D	*Chart percentage* E	*Retention value* $\frac{A \times E}{100}$ F
New equipment	Rs. 28000 (26 above)	12	10	2A*	87**	Rs. 24360

Note: * MAPI chart No. 2A is being used because the concern is employing double-declining balance method for depreciation.

** Refer MAPI chart No. 2A (Fig. 14.2). For 12 years of service life and 10% salvage ratio, read percent value on vertical scale. It comes out to be 87%.

	Estimated from charts (total of col. F)	Rs. 24360		
	Plus other estimated	Rs.	Rs. 24360	29
30.	Disposal value of alternative at end of period (after terminal tax adjustment)		Rs. 4000	30
31.	Terminal net investment (29–30)		Rs. 20360	31
	C. Return			
32.	Average net capital consumption $\left(\frac{28-31}{P}\right)$ (P = 1 year)		Rs. 3640	32
33.	Average net investment $\left(\frac{28+31}{2}\right)$		Rs. 22180	33
34.	*Before tax return* $\left(\frac{25-32}{33} \times 100\right)$		59.3%	34
35.	Increase in depreciation and interest deductions		Rs. 4100	35
36.	Taxable operating advantage (25–35)		Rs. 12700	36
37.	Increase in income tax (36×tax rate 50%)		Rs. 6350	37
38.	After-tax operating advantage (25–37)		Rs. 10450	38
39.	Available for return on investment (38–32)		Rs. 6810	39
40.	AFTER TAX RETURN $\left(\frac{39}{33} \times 100\right)$		30.7%	40

– The calculations of the MAPI summary form are self explanatory. Certain values such as those in lines 4, 5, 6, 7, 8 and others have been arbitrarily assumed.

– MAPI method can be used just mechanically by following the necessary instructions.

Conclusions. The after-tax return has been calculated as 30.7%. This is a large enough figure to command immediate management attention.

– Actually, after-tax return is a measure of *investment urgency.*

– If relative urgency of alternative investments can be calculated, it will serve a good guide for action.

In other words, the (line 40) MAPI urgency rating may be compared with the rates computed for other alternative projects competing for the same funds so that the most genuine projects may be funded first.

BESIDES THE ACCURATE MAPI METHOD DISCUSSED ABOVE, *an approximate MAPI solution* was published by G. TERBORGH (of MAPI–Machinery and Allied Products Institute), which is explained as under.

6. Terborgh's Short Cut (Approximate MAPI Solution)

– The method developed by Terborgh is very useful in some situations.

Two different short cuts, *i.e.,* regarding CAM and DAM will be discussed below.

(*a*) Short cut for determining the *challenger's* (economic life and) adverse minimum (CAM).

(*b*) Short cut for determining the *defender's* adverse minimum (DAM).

(*a*) Short cut : Challenger

Approximations to the adverse minimum of the challenger can be made by using the following formula.

$$UAE = \frac{g(n-1)}{2} + \frac{C-S}{n} + \frac{i(C-S)}{2} \qquad ...(1)$$

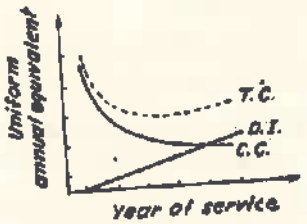
where UAE = Uniform annual equivalent for period ending with year n (*i.e.,* capital cost+operating inferiority), Fig. 14.3.

g is inferiority gradient

C is capital cost

S is salvage value

i is interest rate.



$O.I.$ = Operating inferiority

$C.C.$ = Capital cost

$T.C.$ = Total cost

Fig. 14.3. Uniform annual equivalent.

Operating Inferiority. It indicates the amount by which the defender is operationally inferior to its challenger. Operating inferiority of a machine is the result of wear and tear.

Inferiority gradient is the combined effect of obsolescence and deterioration. The inferiority gradient shows the increase per year in operating cost and opportunity cost due to deterioration and obsolescence.

Opportunity cost includes interest on opening salvage value and loss in salvage value during the year.

– Assuming salvage value S to be zero, equation (1) can be simplified as

$$UAE = \frac{g(n-1)}{2} + \frac{C}{n} + \frac{iC}{2} \quad ...(2)$$

By putting $\frac{d(UAE)}{dn} = 0$, the life n^* which minimizes the equation (2) is found to be

$$n^* = \sqrt{\frac{2C}{g}} \quad ...(3)$$

where n^* is the *economic life of the challenger.*

Substituting value of n^* from equation (3) into equation (2) above

The challenger's adverse minimum

$$CAM = \frac{gn^*}{2} - \frac{g}{2} + \frac{C}{n^*} + \frac{iC}{2}$$

$$= \frac{g\sqrt{\frac{2C}{g}}}{2} - \frac{g}{2} + \frac{C}{\sqrt{\frac{2C}{g}}} + \frac{iC}{2}$$

$$= \sqrt{\frac{Cg}{2}} - \frac{g}{2} + \sqrt{\frac{Cg}{2}} + \frac{iC}{2}$$

$$CAM = \sqrt{2Cg} + \left(\frac{iC-g}{2}\right) \quad ...(4)$$

CAM in terms of n^* is given by equation (5).

$$CAM = C\left(\frac{(2n^*-1)}{n^{*2}} + \frac{i}{1.4}\right) \quad ...(5)$$

(b) Short Cut : Defender

– A replacement decision is considered only when the defender has been in service for many years and it is now operationally inferior to the challenger in the market.

– For the defender, the value for next year will be lower than for any other (because the time adjusted cost is already rising from year to year).

– Therefore the *adverse minimum of the defender* may be approximated by the next-year sum of capital cost and operating inferiority.

Defender's adverse minimum.

$$DAM = \frac{g(n+1)}{2} + \frac{C-S}{n} + \frac{i(C+S)}{2} + \text{Next year inferiority} \quad ...(6)$$

Example 14.9. It is to be considered whether or not to replace an existing machine with a new design. The new machine costs Rs. 25000 and does a saving per year of Rs. 2500 in direct labour, Rs. 500 in wasted material, Rs. 1000 in supplies and Rs. 400 in repair and maintenance; however it involves an insurance and property tax of Rs. 500 per year.

The 10 year old machine has adverse minimum (*DAM*) of Rs. 5000. Assuming an inferiority gradient same for defender and challenger and an interest rate of 10%, suggest whether to replace old machine by new design or not.

Solution.

	Operating advantage challenger	*Defender*
Direct labour	2500	
Wasted material	500	
Supplies	1000	
Repair and Maintenance	400	
Taxes		500
Total	Rs. 4400	Rs. 500

Net decrease in operating cost or net challenger's advantage or defender's inferiority = Rs. 4400–500 = Rs. 3900.

Inferiority gradient for the defender

$$= \frac{\text{Rs. } 3900}{10 \text{ years}} = \text{Rs. } 390 \text{ per year}$$

According to the problem

$$g_{defender} = g_{challenger} = \text{Rs. } 390 \text{ per year}$$

Adverse minimum of the challenger as per equation (4)

$$CAM = \sqrt{2Cg} + \frac{iC - g}{2}$$

$$= \sqrt{2 \times 25000 \times 390} + \frac{\frac{10}{100} \times 25000 - 390}{2}$$

$$= \text{Rs. } 5471 \quad \text{...(1)}$$

As given in the problem, DAM = Rs. 5000

Since $CAM > DAM$, there is no need to replace the old machine by new design.

15

Management Concepts

15.1. MANAGEMENT

- Management may be labelled as the art of getting work done through people, with satisfaction for employer, employees and the public.
- For getting the work done (of an enterprise) through the efforts of other people, it is necessary to *guide, direct, coordinate* and *control* human efforts towards the fulfilment of the *goals* of the enterprise.
- The *goals* of the enterprise are fulfilled through the use of resources like men, money, materials and machines.
- Management may be called an **Art** as well as **Science.**
  - (*a*) Management has *scientific* basis because management techniques are susceptible to measurement and factual determination.
  - (*b*) Management is an *Art* because management means coordinating and getting work done through others.
- Management is an executive function which actively directs human efforts towards common goals.
- The main *Characteristics* of the management is to integrate and apply the knowledge and analytical approaches developed by numerous other disciplines.
- Management does not frame policies, it only implements/executes the policies laid down by administration.
- The *functions* of management are executive and largely governing.
- Management is the *servant* of administration; it gets salary or a part of profit in lieu of its services.
- Management requires technical ability to function properly.
- Management uses *organisation* for achieving the goals of an enterprise.
- Management is *productive* in character.
- Planning, organising, staffing, motivation, directing, coordination and control are all functions of Management.
- There are different levels in management *i.e.,* top level and middle level management.

15.2. ADMINISTRATION

- Any enterprise whether it is run for profit or not need be controlled.
- The control of the enterprise is effected through *Administration* and *Management.*
- *Administration* consists of deciding *determination* of the goals and policies of the enterprise.
- Administration is concerned mainly with decision making, policy making and making necessary adjustments.
- The three main *elements* of administrations are :-
  - (*i*) The formulation of goals,

(*ii*) The choice of ways and means, and

(*iii*) The direction of the people in some group purpose.

- Administration makes policies and decides the goals/targets to be achieved. It is not directly concerned with the implementation of policies.
- The functions of administration are legislative and largely determinative.
- Administration does not need technical ability.
- It is not productive in character.
- Administration coordinates finance, production and distribution.
- It frames the organisational structure and exercises control over the enterprise.
- Administration is the master of industry. It relates to top-level management. Persons like owners or the Board of Directors are in charge of it.
- An *Administrator*

  (*a*) organises his own work and that of his subordinates;

  (*b*) delegates responsibility and authority; and

  (*c*) measures, evaluates and controls position activities.

15.3. ORGANISATION

- Organisation is the frame work of management.
- Organisation is the function of putting together the different parts of an enterprise into working order.
- Organisation is a *system*,

  It is a *group* of persons,

  It is a *structure* of relationships among the individuals working together for a common goal.
- Organization is concerned with the building, developing and maintaining of a structure of *working* relationships in order to accomplish the objectives of the enterprise.
- Organisation means the determination and assignment of *duties* to individuals and also the establishment and the maintenance of authority relationships among the grouped activities.
- *Organising* is the determining, grouping and arranging of the various activities deemed necessary for the attainment of the objectives,

  (*ii*) the assigning of people to those activities,

  (*iii*) the providing of suitable physical factors of environment, and

  (*iv*) the indicating of the relative authority delegated to each individual charged with the execution of each respective activity.

For further details refer article no 2.1.

15.4. DIFFERENCE AND RELATIONSHIP BETWEEN MANAGEMENT, ADMINISTRATION AND ORGANISATION

- *Administration* determines the objectives and policies of the enterprise, *Management* carries out these policies to achieve objectives of the enterprise.
- For *Administration* and *Management* to function effectively, there must be proper structuring of the enterprise and this is known as *organisation* (structure). Organisation has been termed the keystone on which the entire structure of any enterprise is based.
- *Administration* gives proper direction; it is a directing (or direction) function. *Management* properly executes; it is an execution function. And, organisation is an effective machinery for

accomplishing company objectives in a team spirit.

– In brief, it may be said that, "Management carries out the policies of Administration through the framework of the organization".

15.5. IMPORTANCE OF MANAGEMENT

(*i*) Truely speaking, no enterprise can survive without management, even if it possesses huge money, excellent machinery and expert man-power, because without management, it will be all confusion and no body will know what to do and when to do.

It is management which *guides* and *controls* the activities of man-power for the optimum utilisation of company resources, such as men, materials, money, machines, methods etc.

(*ii*) Management creates a vital, dynamic and life giving *force* to the enterprise.

(*iii*) Management *coordinates* activities of different departments in an enterprise and establishes team-spirit among the persons.

(*iv*) Management provides new *ideas and vision* to the organisation to do better.

(*v*) Management *tackles business problems* and provides a tool for the best way of doing things.

(*vi*) Management only can meet the *challenge of change.*

(*vii*) Management provides *stability* to the enterprise by changing and modifying the resources in accordance with the changing environment of the society.

(*viii*) Management helps *personality development* thereby raising efficiency and productivity.

15.6. CHARACTERISTICS OF MANAGEMENT

(*i*) Management is *goal oriented.* It achieves the organizational goals through coordination of the efforts of the personnel.

(*ii*) Management works as a *catalyst* to produce goods using labour, materials, and capital.

(*iii*) Management is a distinct *process* comprising of functions such as planning, organising, staffing directing and controlling.

(*iv*) Management represents a system of *authority*—a hierarchy of command and control. Managers at different levels possess varying degrees of authority.

(*v*) Management is a *unifying force.* It integrates human and other resources to achieve the desired objectives.

(*vi*) Management *harmonises* the individual's goals with the organisational goals to minimize conflicts in the organisation.

(*vii*) Management is a *multi-disciplinary subject.* It grew taking the helps of subjects such as Engineering, Psychology, Sociology, Anthropology, Operations Research etc.

(*viii*) Management is *universal* in character. The principles and techniques of management are equally applicable in the fields of business, industry, education, government, army, hospitals etc.

15.7. MANAGERIAL SKILLS

The skills required of a successful manager, whether he is working in a business organisation, an educational institute or a hospital can be classified or follows :-

(*a*) Technical skill (1)
(*b*) Decision making skills] Conceptual skills (2)
(*c*) Organisational skills]
(*d*) Communicating skills]
(*e*) Motivating skills] Human relation skills (3)
(*f*) Leadership skills]

(1) Technical skills

- Technical skill refers to the proficiency in handling methods, processes and techniques of a particular kind of business.
- It is essential for a manager to know which technical skill should be employed in a particular work.

(2) Conceptual skills

Conceptual skill is the ability to see the organisation as a whole, to recognise inter-relationships among different functions of the business and external forces and to guide effectively the organisational efforts.

Conceptual skill is critical in top executive positions whereas technical skill is essential for lower level management.

It is easier to learn technical skill then the conceptual skill.

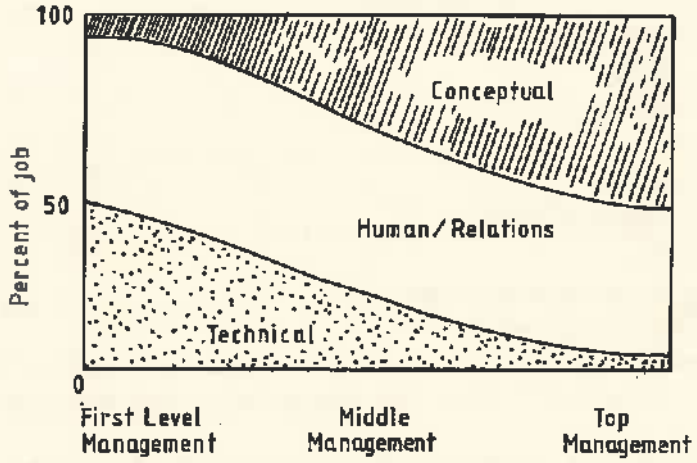


Fig. 15.1. Managerial skills.

Decision making skills

Decision making skill is the ability of a person to take timely and accurate decisions. This requires mental ability and presence of mind.

Organisational skills

Organisational skills help select and fix different people at different work. This means placing right people for the right job.

(3) Human relation skills

Human relation skill refers to the ability to work effectively with others and build cooperative work groups to achieve organisational goals.

Communicating skills

Communicating skill is the ability to pass on information to other. Improper, insufficient and poorly expressed information can create confusion and annoy the subordinates.

Motivating skills

Motivating skill inspires people to do what the manager wants them to do. The manager can use

positive or *negative* motivational methods. Positive motivational methods include, reward, praise etc, whereas negative motivational methods involve punishment, reprimand, threat etc.

Leadership skills

Leadership skill enables a manager to lead the people working under him.

It is the ability to inspire confidence and trust in the subordinates in order to have maximum co-operation from them for getting the work done.

15.8. MANAGERIAL OBJECTIVES

- The end results to be achieved are described as *objectives. Managerial objectives* may be defined as the intended goals which prescribe definite scope and suggest direction to the efforts of a manager.
- **Managerial objectives** should be
  - (*i*) Clearly defined and communicated,
  - (*ii*) Reasonably attainable, and
  - (*iii*) Based upon the overall organisational goals.
- **Managerial objectives may be classified as**
  - (*a*) General objectives
  - (*b*) Specific objectives
- **General objectives**
  - (1) Nature of business
  - (2) Continuous supply of capital
  - (3) Growth of firm
  - (4) Increasing production and productivity
  - (5) *Economic objectives* (*e.g.* profit).
  - (6) *Social objectives* (*e.g.* to offer goods of superior quality and services to the society at reasonable rates, to provide workers with fair wages and incentives and to pay taxes honestly etc.).
  - (7) *Human objectives* (*e.g.*, to understand the needs of subordinates to motivate them and to boost their morale).
- **Specific objectives**
  - (1) Nature of goods to be produced or services to be rendered.
  - (2) Type of Customers (*e.g.*, rich, poor, individuals, business houses, Government etc.)
  - (3) Market standing (*e.g.* local, national or international)
  - (4) Product diversification, if any.

15.9. HARMONIZATION OF OBJECTIVES

- People do not work in isolation; rather they work to a great extent in groups toward the achievement of personal and company's objectives. Unfortunately, these objectives are not always harmonious. Nor should one take for granted that the objectives of subordinates are the same as those of the management/enterprise.

  Therefore, one of the most important single activities of management is to harmonize the needs of the individuals with the demands of the enterprise.
- There is no way that the desires and objectives of individuals can be made to help achieve enterprise objectives unless it is known what individuals want. Then, managers must be able to

design an environment that will take advantage of these individual drives.

Managers must know how to communicate with and guide their subordinates so that they will see how their interests are served by working efficiently for the enterprise.

- As stated above, in any business firm or industry, two classes of objectives control the show.
- First, the *objectives of the industry/business firm,* which undoubtedly is to maximize the *production* and the *profits.*
- Second, the *individual personal objectives* which refer to the aspirations and goals of individual members of the enterprise and include financial and non-financial incentives like salaries, allowances, bonus, status in the organisation and the society, chances for promotion, etc.
- If a business firm has to achieve its objectives it must give due consideration to the personal objectives.
- There must be a reasonable correlation, congruence and *harmony* in the personal and business objectives.
- *Harmony of objectives* is most important for the survival and progress of any organisation. Harmony of objectives imply the simultaneous fulfillment of organisation's and individual's objectives.
- It is only through the harmonisation of objectives that both the parties will work efficiently for a common goal.
- A sound organisation and a good leadership help in harmonisation of objectives.
- The harmonisation of objectives of the firm and those of employees may be achieved by
  - *(i)* Mutual trust,
  - *(ii)* Cooperation and understanding,
  - *(iii)* Worker's participation in management, and
  - *(iv)* By *balancing* the objectives of the firm with those of individuals (without allowing any conflict to arise between the objectives).

15.10. HIERARCHY OF OBJECTIVES

- The objectives of a company can be structured into a hierarchy. Hierarchy in this sense means *Organised objectives in successive grades.*

  Objectives may be arranged in particular order from the higher to the lower level.
- The objective at the top level provide the basis for setting the objectives at the second level which in turn becomes the basis for objective at the third level and so on.
- For example, a company may have the *overall objective* at the *highest level* to earn a fair rate of return by manufacturing and marketing Numerically Controlled (NC) machine tools.
- If we go down the hierarchy, we shall find that the *major objective* followed by different departments focuses on designing and creating the form of NC machine tools.
- At the *next level,* there may be intermediate objectives concerned with manufacturing and assembling the major components.
- At the *lowest level,* the objective of the individuals consists of performing the detailed work on components.

In this way the objectives at *various levels* in a company are *integrated* and follow a *logical sequence* to achieve the overall objective of the company.

15.11. DIFFERENCE BETWEEN POLICIES, GOALS AND OBJECTIVES

(i) **Policies** are the guidelines for actions. These are means to achieve the objectives. A policy may

be a verbal, written or implied overall guide for decision making. In other words, policies provide guidelines and limits for decision making. As an example, a firm may have the *policy* of selling goods only against cash or no employee will accept any outside job, etc.

- Policy may be taken as an expression of intentions of Top Management and is long lasting.
- Policies are valuable because they allow lower levels of management to handle problems without going to top management for a decision every time.
- Policies provide a broad guide as to how the *objectives* of a firm are to be achieved.

(ii) **Objectives are the ends towards which the activities of the enterprise are aimed.**

- *Objectives may be classified as* :-
  - *(a) External e.g.* to supply goods of good quality at reasonable prices.
  - *(b) Internal e.g.* maximum profitability, good labour relations, job satisfaction and security.
  - *(c) Short term e.g.,* Production and sales targets for a period of three to six months.
  - *(d) Medium term e.g.,* for a period from one to five years.
  - *(e) Long term* objectives *e.g.,* for a period from five to twenty years.
  - *(f) Economic e.g.,* increase in profit by 10%.
  - *(g) Non-economic e.g.,* bringing job satisfaction, improving employer-employee relations etc.
  - *(h) Major objectives,* applicable for the entire organisation *e.g.,* product diversification.
  - *(i) Derived or Minor objectives i.e.* derived from major objectives. They are sectional or departmental objectives.

(iii) **Difference between policies and objectives**

(a) *Objective* decide *What to do.*

Policies decide *How to do*

(b) *Objectives* are the *targets* and *aims* of planning. *Policies* are the *means* and *manner* of *achieving* objectives.

(c) *Objectives* are determined by the top management. *Policies* are even decided at departmental level.

(d) *Objectives* are *fixed* in nature.

Discretion may be used in the implementation of *policies.*

(iv) **Goals**

- A *goal* is any achievement of an end point that is stated in quantitative terms, an example of which is the achievement of a certain amount of profit for a specified time period.
- *Goals* represent the desired future conditions, which the organization strives to achieve.
- A goal may be a specific accomplishment, such as manufacturing 1000 automobiles during a given time period.
- Goal refers to a future state or condition which when realized contributes to the fulfillment of the mission.

(v) **Difference between mission, goal and objective**

- A goal is relatively more concrete and specific than a *mission*, yet not as concrete or specific as an objective.
- Goals can also be thought of as relatively *long-run* targets.
- *Objectives* are derived from goals and are ordinarily *short-run, specific* milestones towards goals.
- As *goals* are derived from the organisation's *mission*, so are its *objectives* derived from the goals.

- The word *mission* provides general term to describe the company's over-all reason for existence. The mission expresses the objective of the entire enterprise and is based on top management's knowledge of broad economic needs and the competitive resources of the firm. *Mission* refers to the broad purpose that society expects the organization to serve.
- *An example of mission is*

  'To protect and promote the health and welfare of the citizens of the commonwealth'.
- *An example of goal is*

  'The eradication of tuberculosis as a health hazard by the end of 1995'.
- *An example of objective is*

  'To reduce the incidence of tuberculosis from 6 per 10,000 to 4 per 10,000 by the end of current year'.
- The development of a coherent set of missions, goals and objectives defines the scope and direction of the organisation's activities.

15.12. EVOLUTION AND DEVELOPMENT OF MANAGEMENT THOUGHT

(*a*) General

- Management in one or the other form has existed in every nook and corner of the world since the dawn of civilization.
- The origin of management can be traced back to the days when man started living in groups.
- History reveals that strong men organised the masses into groups (according to their intelligence, physical and mental capabilities) and became their *leaders*.
- Management took the form of leadership which was essential to coordinate the efforts of group members in order to arrange the necessaries of life.
- Evidence of the use of *principles of management* is to be found in the organizations of public life in ancient *Greece*, the organisations of the *Roman* catholic church and the organisation of *military forces*. They were not much used in the business world so long as the structure of organisation was simple.
- With the onset of Industrial Revolution (Around 1750) the position underwent a radical change. The structure of industry became extremely complex and new problems generated for industrialists. At this stage, the development of a formal theory of management—both of work and the workers—became absolutely necessary. It was against this background that the foundations of *modern management* were laid.

(*b*) Management in antiquity

(1) *Egypt*

- The Egyption skill in planning and organising the construction of public edifices, is evident in their pyramids.
- The Babylonian empire developing along the Tigris and Euphrates also gives us many examples of early managerial practices.

(2) *China*

- Some fifteen hundred and more years ago there flourished in China a diverse and complex civilization in which business and enterprise and the art of government had been developed to a high degree.
- The need for methodological means of employee selection and staffing was also recognized by ancient Chinese philosophers.

(3) *India*

– Around 320 B.C., subjects such as organisation and management of trade and commerce, law and law courts, municipal government, taxation and revenue, agriculture, factories etc., were covered by *Kautilya* also named *Vishnugupta.*

(4) *Greece*

– Greece provides us with the most extensive documentation of management principles, employee selection, delegation of authority etc.

(5) *Rome*

– In ancient Rome, craft and trading groups developed early in the Latian villages of the Seven Hills. These groups operated under the personal leadership of strong or skilled individual leaders.

– As Rome became a city and spread by growth and conquest, her industries became large and numerous, ranging from the making of armor through dress-making and the pickling of olives to mining of metals and salt.

– Personal leadership persisted as the general pattern, even to organisation of guilds of craftsmen and traders.

– Gradually there emerged in Rome, a group of *leaders* that we can classify as *managers.* These managers developed largely as a result of the method employed by the Roman government to accomplish much of its work.

– These managers employed staff assistance, such as accountants and scribes, bought slaves and developed organizations to accomplish the missions of the owners.

(c) **Period of Managerial Awakening**

– Around 1750, England entered a period referred to as the *Industrial Revolution.*

– The industrial revolution brought great impetus to the growth and diversification of business enterprises.

Replacement of human and animal power by machines, new inventions, increased demand led to the expansion of commercial undertakings and the establishment of holdings in colonies in foreign countries.

– With the advent of industrial revolution the *factory system*, as it is known today, became a dominant feature of economy. Under this system land/building, hired labour and capital are made available to the entrepreneur, who strives to combine these factors for achieving a particular goal.

– During the period following the industrial revolution, certain pioneers challanged the traditional character of management by introducing new ideas and approaches. Their contributions are discussed below :-

(1) *Robert Owen (1771-1858)*

– Robert Owen believed that the worker's performance was influenced by the shop floor working conditions, working hours, housing facilities, training of workers, provision of canteen, rest places, kind treatment etc. He can thus be called as the forerunner of *Personnel Mangement.*

– Robert Owen is well-known as the promoter of cooperative and trade union movement in England.

(2) *Charles Babbage (1792-1871)*

– Whereas Owen challanged the inhuman conditions of the factories, Charles Babbage tried to advance technology. He advocated the use of *Science* and *Mathematics, investigations* and *accurate data* to run the factories which were, at that time, using traditional methods, opinions

and rule of thumb.

- Babbage suggested division of work into mental and physical efforts, determining precise cost for every process, paying of bonus, profit-sharing etc.
- Babbage invented the *analytical engine* which was the fore-runner of the modern computer.

(3) *James Watt Jr. (1796-1848) and Robinson Boulton (1770-1842)*

- Both, Watt Junior and Robinson were sons of James Watt, the inventor of steam engine.
- In their factory at Soho (Birmingham), they used the following management techniques:-
  - (*i*) Forecasting-market research.
  - (*ii*) Planned machine layout.
  - (*iii*) Production planning.
  - (*iv*) Standardization of parts.
  - (*v*) Elaborate statistical records.
  - (*vi*) Welfare of workers, etc.

15.13. ORIGIN OF PRINCIPLES OF MANAGEMENT

Date : B.C.	*People*	*Management Principles*
1958-1916	Babylonians	Minimum wage rate
1644	Chinese	Division of labour
993-953	Hebrews	Industrial organisation
605-562	Babylonians	Material control
400	Chinese	Labour turnover
	Chaldeans	Incentive wage plan
384-382	Greeks	Transfer of skill

In more recent centuries :-

1591	–	Recognition of the principle of overhead and establishment charges.
1682	–	Standard practice Institutions
		Stock control
		Expense control
		Job specifications
		Instructions for packing for shipment
		Instructions for time keeping
		Material specifications.
1710	–	Employee welfare
		Pension plan
		Industrial physician.
1776	–	Statement of the principle of the division of labour.
1795	–	Example of costing each product and the use of department profit and loss accounts.
1832	–	Suggestion that Industrial Management was a matter of general principles
		Analysis of process costs
		Suggestion of time study

1800-1848	Production planning
	Standardization of parts
	Welfare of workers etc.

15.14. THE BEGINNING OF SCIENTIFIC MANAGEMENT

– Owen, Babbage, Watt and Boulton were, no doubt, pioneers of *management thought*, but their impact on industry as a whole was meagre. The real beginning of the science of management did not occur until the last decades of the nineteenth century. A group of persons such as F.W.Taylor, Henri Fayol, H.L.Gantt, Emerson, Gilbreth, Carl Barth and others contributed towards the process of the development of the science of management.

15.15. CONTRIBUTIONS OF F.W. TAYLOR

– *Fredrick Winslow Taylor* is known as the founder of *Scientific Management.*

– Taylor laid the foundation for modern scientific management between 1880 and 1890.

– He began his carrier in 1871 as an apprentice machinist and turner at the Cramp Shipyard at Philadelphia, U.S.A. After three years he joined the Midvale Steel Works as a machine shop-worker. By dint of his hard labour, he progressed rapidly to become machinist, gang boss, foreman and finally Chief Engineer in 1884. He served Company till 1889.

– To satisfy his hunger for technical know-how, Taylor joined the Stevens Institute and obtained the Master's Degree in Engineering.

– Then he joined the Bethlehem Steel Company, where he served from 1898 to 1901.

– During his carrier as a machinist and foreman, Taylor saw much disorder and wastage of human and other resources at work-places. The workers did not produce more than one third of a day's work. The workmen did not want the management to know how much work they could do. Because they feared that their wages would be cut. Moreover, the management did not had any idea about the capacity of the workers and further, management did not want to pay more to workers.

– Taylor tried to work out some system whereby the interests of management and the workers might be the same.

– *The various contributions of Taylor were as follows:-*

(1) He developed the *principle of breaking a task* (job) into elements for timing the same.

(2) He kept himself involved in *exploring the causes of inefficiency and labour difficulties in the industry*. Through Time studies he experimented to recognise *losses of efficiency* in Industrial operations.

(3) He evolved certain principles of–– Investigating work on scientific basis, selecting the best worker for a task and training him further to acquire desired skill, developing co-operative spirit between management and workers, almost equal division of work between workers and management, etc., –which led to the concept of *Scientific Management.*

(4) Another concept connected with the name of Taylor is *A Fair Day's Task.* While working on it, Taylor undertook studies on fatigue *incurred by the workers and the time necessary* to complete a task.

Taylor suggested that for increasing production rate, the work of each person should be planned at least one day in advance and he shall be allotted a definite work to complete by a given time using a pre-explained method.

(5) Taylor developed Functional Organisation in which one foreman was made incharge for each function.

(6) Taylor devoted his maximum attention towards Time studies and he established work standards.

(7) Taylor introduced and operated various costing systems.

(8) Taylor suggested a *Wage Incentive Scheme* known as Taylor's *Differential Piece Rate Plan.*

15.16. SCIENTIFIC MANAGEMENT

Introduction

The early decades of this century witnessed the emergence of *Scientific Management.* This school of thought attempted to introduce a *rational, systematic approach to work and to the management of work.*

- In his early writings F. W. Taylor referred to his ideas as *Task Management.* In 1910 Louis Brandeis coined the word *Scientific Management.*
- F. W. Taylor got recognition as the *Father of Scientific Management.* He wrote a book on 'The Principles of Management' in the year 1911.
- The primary *emphasis of scientific management* was on planning, standardizing and improving human effort at the operative level in order to maximize output with minimum input.
- Taylor believed that managing should be based on objective assessment of facts, on measurement and not on guess work.
- Scientific Management is the result of applying scientific knowledge and the scientific methods to the various aspects of management and the problems that arise from them.
- Taylor thought that by maximizing the productive efficiency of each worker, scientific management would also maximize the earnings of the employees and employers.
- The upshot of the scientific management movement was a mechanistic view of the transformation process as well as a mechanistic view of the worker's role in the system.
- Scientific Management could be summarized as:-
  - (*i*) Science, not rule of thumb,
  - (*ii*) Harmony, not discord,
  - (*iii*) Cooperation, not individualism,
  - (*iv*) Maximum output, in place of restricted output, and
  - (*v*) The development of each worker to his greatest efficiency and prosperity.

Opposition to Scientific Management

- *Scientific Management* was an innovation and, as such, received *tremendous opposition.* During Taylor's life time and in spite of support of other pioneers in the field such as Louis Brandeis, James Dodge, and Henry Towne, *opposition to this change retarded the spread of the basic idea of scientific management in the beginning.*
- *Primary resistence*, instead from workers community, *came from management* itself which was not prepared to discard old *rules of thumb* in favour of scientific approach (*i.e.*, scientific management). An other cause for opposition was the feeling that scientific management treated workers like cogs in a well-oiled machine and that the system destroyed humanistic practices in industry.
- Later on when, with the use of scientific management, greater efficiency was achieved in industrial operations and productivity increased, principles of scientific management started spreading rapidly throughout the industry.

Basic Approach of Scientific Management

(*i*) *Analyse work scientifically.* Investigate all aspects of work on a scientific basis rather than using rules of thumb.

(*ii*) Provide specific guidelines for worker performance.

(*iii*) Develop one best way of doing a job (using Time and Motion Studies).

(*iv*) Select workers best suited to perform the specific tasks.

(*v*) Train and develop each workman in the most efficient method for doing the job.

(*vi*) Divide the work so that workmen and management share almost equally in the daily performance of each task; workers do their jobs as per the standards laid down and Management does planning and makes sure that all aspects are ready at the right time so that the resultant efficiency is high.

(*vii*) Achieve support and cooperation from workmen by arranging conditions, services, guidance and by giving them greater economic rewards which in turn are obtained through increased efficiency and productivity.

- Scientific Management removed the worker's discretion in planning, organising and controlling of his own task performance.
- Rather, Scientific management required that, management should plan, organise and control task performance.

Management should

(*i*) Standardize methods,

(*ii*) adopt best implements and working conditions, and

(*iii*) obtain cooperation from workmen (by paying them extra) so that work can be done faster.

15.17. CONTRIBUTIONS OF HENRI FAYOL (1841-1925)

- Henri Fayol, the father of Principles of Management was born in 1841 in France and graduated as a mining engineer in 1860 from the National School of Mining at St. Etienne.

In 1860, he joined the famous French Combine in the mining and metallurgical field—the Commantry–Fourchambault Company—as an engineer. After a couple of years he was promoted as the Manager of the collieries and continued as such for twenty-two years.

In 1888, the condition of the combine became precarious. Due to heavy losses the firm was nearly bankrupt. At this time Fayol was appointed as General Manager. When he retired thirty years later, the company had expanded into a large Coal-Steel combine with a strong financial position and a long record of profits and dividends.

- During his long and successful career as an Industrial Manager, Fayol tried to probe into the bottom of the principles of administration and management.
- In contrast to *Taylor's* emphasis on first-line supervision in production areas, Fayol's work was concerned with the higher levels of the organisation.
- Fayol analysed the process of management as he had observed it first-hand. His conclusion was that all the work done in business enterprises can be divided into six groups :

1. *Technical activities* (production, manufacture, adaptation).
2. *Commercial activities* (buying, selling, exchange).
3. *Financial activities* (search for optimum use of capital).
4. *Security activities* (protection of property and persons).
5. *Accounting activities* (stock taking, balance sheet, costs, statistics).
6. *Managerial* (administrative) activites (planning, organization, command, coordination and control).

Fayol believed that if any kind of business was to operate successfully, these six functions had to be performed. If any one was neglected, the enterprise would suffer accordingly.

- Fayol devoted most of his attention to the managerial activities. In doing so he enunciated certain *principles* which hold ground (with suitable modifications) to this day. The principles laid down by him were:-
  1. Division of work.
  2. Authority and responsibility.
  3. Discipline
  4. Unity of command.

5. Units of direction
6. Subordination of individual to general interest
7. Remuneration
8. Centralisation of authority
9. Scalar chain
10. Order
11. Equity of treatment
12. Stability
13. Initiative
14. Esprit de corps.

– Fayol also spelt out the *functions* of management. The present pattern of management functions follows broadly the lines set by him. *The functions of a Manager* (at the top level) enumerated by him were:-

1. Forecasting and planning
2. Organising
3. Command
4. Coordination, and
5. Control.

– In addition to his over-all concept of management, Fayol singled out and described with clarity and understanding – principles of the unity of command and direction.

– He emphasized the importance of *non-financial incentives.*

– There are two modifications to be made in Fayol's concept:-

(*i*) Fayol saw management as one of six basic activities; that is, technical, commercial, financial, security, accounting and managerial activities. However, our concept of management should be modified to say, in Fayol's terms that *management is the planning, organising, command, coordination and control of technical, financial, security and accounting activities.*

(*ii*) A second modification is also necessary. In terms of our understanding of what makes people work at maximum productivity, we should substitute *motivation for command.* It is true that a manager must direct, command and order to get things done. But he also encourages, communicates, develops, and stimulates. He knows enough of the mainsprings of the motives of men to be able to motivate them to highest endeavor.

15.18. CONTRIBUTIONS OF ELTON MAYO (1880-1949)

– Born in Australia and trained in psychology, Elton Mayo is generally recognized as the *'Father of Human Relations Approach'.*

– Mayo led the team which conducted the study at Western Electric's Hawthorne Plant (1927-32) to evaluate the attitudes and psychological reactions of workers in on-the-job situations.

– Mayo's idea was that logical factors were far less important than emotional factors in determining production efficiency.

– Mayo concluded that work arrangements in addition to meeting the objective requirements of production must at the same time satisfy the employee's subjective requirement of social satisfaction at his work place.

– Mayo was of the opinion that the cause of increase in *productivity* of the workers is not a single factor like changing working hours or rest pauses, but a combination of these and several other factors such as less restrictive methods of supervision, giving autonomy to the workers, allowing the formation of small cohesive groups of workers, cooperation between workers and management, opportunity to be heard, participation in decision making etc.

15.19. CONTRIBUTIONS OF GILBRETH

Gilbreth joined Whidden and Co., in 1885 at the age of 17 as a junior apprentice and took to bricklaying. He soon discovered that the person teaching him (*i.e.*, instructor) used a certain set of motions while working slowly, another (set of motions), when working fast and a different set of motions while teaching to apprentices. Moreover, he found that no two brick-layers adopted the same technique of

brick-laying. Gilbreth started studying the motions of different persons and tried to analyse them. Ultimately he got succeeded in reducing from 18 motions involved in laying each brick to five per brick only.

(1) Frank and Lillian Gilbreth did a lot of work in order to improve work methods and thus to discover one best way of accomplishing a task. Their main field of interest was Motion Study.

(2) In 1917, Gilbreth suggested the first definition of *Motion Study*. He defined motion study "as the science of eliminating wastefulness resulting from unnecessary, ill directed and inefficient motions". According to Gilbreth the purpose of motion study was to discover and establish the scheme of least waste methods of labour.

(3) Gilbreth evolved the Principles of Motion Economy.

(4) While concentrating on the economical motions for doing a job, Gilbreth felt the necessity of charting the activities to be analysed, because a chart could provide the overall picture as well as the importance of everything involved. In 1921, Gilbreth introduced *Process chart*.

(5) Gilbreth identified *Therbligs*—the fundamental motions involved in doing an activity.

(6) He developed Micromotion study and *Simo* chart.

(7) Gilbreth invented Microchronometer, Cyclegraph, Chronocyclegraph, and flow diagram.

(8) Gilbreth applied motion analysis to office procedures (mailing of letters) as well.

(9) While serving U.S. Army, Gilbreth used Motion Study to find the best method to assemble and dissemble the weapons.

(10) Frank and Lillian Gilbreth carried out studies on fatigue and its elimination. They concluded that fatigue could be considerably reduced by lightening the load, spacing the work and by introducing rest periods.

15.20. CONTRIBUTIONS OF GANTT

- Henry L. Gantt worked under Taylor and was his close associate.
- Gantt had a *humanistic* approach. He was more concerned with the *man* behind the machine.
- He improved upon *Taylor's differential piece rate* system and brought out his *task and bonus plan*. Taylor's differential piece rate system was an incentive plan whereby the worker was paid on the basis of his daily *output*. Gantt's task and bonus plan was so structured that the worker received a day's wage even if he did not complete the task. But if he completed the task in less than the prescribed time, he received a bonus.
- Gantt developed the *daily balance chart*, now known as the *Gantt chart*. The chart shows output on one axis with units of time on the other. This proved to be revolutionary in the area of production planning and control. The Gantt chart is still being used and is the fore runner of some of the commercial scheduling techniques.
- Gantt pleaded for wider recognition of the human factor in management. He was of the view that financial incentives influence employee behaviour.
- Gantt also pleaded for a policy of preaching and teaching workmen to do their work rather than using the policy of driving and cajoling the workers like cattle.
- Gantt was of the opinion that emphasis should be placed on *service* rather than on *profits*. Gantt introduced the concept of industrial responsibility.
- Gantt's contributions were more in the nature of refinements rather than fundamental concepts.

15.21. REVIEW OF DIFFERENT SCHOOLS OF THOUGHT

- The various *approaches* to the study of management as propounded by *specialists* such as Taylor, Fayol, Mayo etc., from different disciplines have come to be called the *Schools of Management Thought*.

– Major *schools of Management Theory or Thoughts in Management* may be *classified* as follows:-

(*a*) Management Process School.

(*b*) Empirical School.

(*c*) Human Behaviour or Human Relation School.

(*d*) Social School.

(*e*) Decision Theory School.

(*f*) Mathematical or Quantitative Management School.

(*g*) Systems Management School.

(*h*) Contingency School.

(a) Management Process School

– Henri *Fayol* is known as the father of this School of Thought.

– Other *contributors* to it are:

J.D.Mooney, A.C. Railey, Lyndall Urwick, Harold Koontz, Newman, Summers and McFarland.

– According to this school, management can best be studied in terms of the *process* that it involves.

– *The management process* consisting of *five* broad categories of functions, viz. *planning, organising, staffing, directing* and *controlling* is evident in all managerial situations.

– Following this, this school evolved some universal *principles of management* as listed on page 15-13.

These principles of management could be equally well applied to *business, government*, or any other type of organisation.

– *The main features of the Management Process School or the Operational Approach School are:-*

1. Management is the study of *functions* of managers.

2. The *functions* of managers are the same irrespective of the type of organisation.

3. The conceptual frame work of management can be built through an analysis of the processes of management and identification of principles.

4. The functions of management, *viz.*, planning, organising, staffing, directing and controlling are the core of management.

– *Limitations of Management Process School*

1. The various operational theorists do not agree about the functions of management.

2. The so-called universal principles of management do not always stand the test of emperical scrutiny.

3. Organisations function under dynamic conditions and, therefore, searching for universal principles may not always be a fruitful exercise.

(b) The Empirical School or the Management by Customs School

– The main *contributors* to this school of thought are the Harvard Business school, Ernest Dale, Mooney, Urwick, Railey and American Management Association.

– This school of thought considers management as the study of *experience.* Analysing the *experiences* of successful managers or the mistakes of poor managers from *case studies* one somehow learns how to manage.

– *The main features of this school are:-*

1. Management is the study of managerial experiences.

2. The managerial experiences can be passed over to the practitioners and students.

3. The techniques used in successful cases can be used by future managers.

4. Theoretical researches can be combined with practical experiences.

- This *case study* method is best for imparting management education; it contributes to the development of managerial skills.
- *Limitations of the Empirical School :-*

  This school depends heavily on the *historical* methods of study. It goes mainly by *precedents.* It does not realize that a manager has to work under *dynamic conditions* and that *history* does not exactly repeats itself. The situations in the past may not have been exactly the same as of the present.

In the words of *Harold Koontz* "Management unlike law is not a science based on precedents and situations in the future exactly comparable to the past are exceedingly unlikely to occur. There is a positive danger in relying too much on past experience and on undistilled history of managerial problem solving for the simple reason that the *technique* or approach found right in the past may not fit a situation of the future."

(c) The Human Relations or the Human Behaviour School

- The main contributors to this school of thought are Elton Mayo, Roethlisberger, McGregor and Keith Davis. This school has also been benefitted from the contributions of psychologists like Maslow, Argyris, Herzberg etc.
- This school had its origins in a series of experiments conducted by Mayo and his associates at the Harvard School of Business at the Western Electric Company's Hawthorne Works, near Chicago. These studies brought out for the first time the important relationships between social factors and productivity.
- *The main features of this school are :-*

1. The school draws its concept from psychology, sociology, human relations, inter-personnal relationships, satisfaction of worker's needs etc.

2. Since management is getting things done through people, the managers must have a basic understanding of human behaviour and human relations in all its aspects, particularly in the context of work groups and organisations.

3. Management must study inter-personnel relations among people.

4. Greater production and higher motivation can be achieved only through good human relations.

5. Motivation, leadership, communication, participative management and group dynamics are the core of this school of thought.

- *Various limitations of this School of Thought are :-*

1. This appraoch talks about organisation and organisational behaviour in vague terms.

2. If the study of management were to be confined to human behaviour or human relations, it would be unduly restricting the scope of technical aspects of job etc., which are equally important.

(d) The Social System School

- The main pioneers and contributors to this school of thought are Max Weber, Moreno, Simon and Rensis Likert.
- This school of thought is closely related to the Human Relations School of thought.
- *The main features of this school of thought are:-*

1. Management is a social system, a system of *Cultural relationships.*

2. Formal organisations represent cultural relationships of the social groups working within the organisation.

People working together in groups have their own norms and values which have a bearing on the contribution that they are likely to make towards the goals of the organisation.

3. Cooperation and team spirit among the group members is necessary for the achievement of organisational objectives.

4. Mangement has to direct its efforts towards establishing *harmony* between the goals of the organisation and those of the working groups.

Uses and Limitations:-

- This school of thought is very *useful* for the practising managers. All the managers operate in a social system and the organisation is likely to prosper most if the social demands of the society in which it operates are fully recognised.
- This school attaches maximum importance to the study of sociology and thus tends to overlook many management concepts, principles and techniques which are also important to practising managers.

(e) Decision Theory School

- The main contributors and thinkers belonging to this school of thought are Chester Bernard, James March, Herbert Simon, Forrester and Richard Cyert.
- According to this school, the essence of management lies in decision making. Whatever a manager does is the outcome of a decision made by him through rational choice from among different alternatives available to him.
- By expanding the view point well beyond the process of evaluating alternatives, many use the theory to examine the nature of organisation structure; the psychological and social reactions of individuals and groups, the development of basic information for decisions and the analysis of value considerations with respect to goals, communication networks and incentives.
- **Main features of this school of thought are:-**

1. Management is essentially decision-making.

2. The members of any organisation are essentially decision-makers and problem solvers. Hence management is the study of the process of decision making and the personalities and behaviour of decision-makers.

3. The quality of decisions is a prime factor for increasing the efficiency of the organisation.

4. Management information system and the process and technique of decision making form the subject matter of the study of management.

- **The uses and limitations of this school are:-**

  This school though contributes a lot towards the sharpening of managerial tools especially for making suitable decisions in the organisation, the question still remains to be answered is whether the decision theory school can do justice to the various aspects of management which include besides decision making such important functions as coordination, organising and implementation of decisions.

(f) The Mathematical School

- The prominent contributors to this school are Taylor, Gilbreth, Gantt, Joel Dean, Newmann, Ackoff and Hicks.
- This school believes that if management is a logical process, it can be expressed in terms of mathematical symbols and relationships.

  Effective solution to the problems of management can be achieved through application of suitable simulation and the use of analytic and synthetic mathematical techniques.

The contributors of this school have been using mathematical and quantitative techniques in developing models of the various kinds of decisions and problems involved in managing organisations.

- Dr. Koontz had defined the mathematical school as an *Operations Research School.*

  Operations Research usually requires computer technology to analyse alternatives. Gaming theory, Queuing theory and linear programming are some of its techniques.

- *The essential features of this school are :*

1. Management is concerned with problem solving and it must make use of mathematical tools and techniques for the purpose.

2. The different factors involved in management can be quantified and expressed in the form of models *i.e.,* in the form of equations which can be solved with the help of mathematical techniques.

3. Management problems can be described in mathematical models.

4. Operations Research, Mathematical tools, simulation and model building are the basic methodologies developed by this school of thought.

Uses

Mathematical approach has helped management in systematising thinking and has lent a certain measure of precision to the management discipline.

Limitations

1. The mathematical models cannot be considered as a substitute for sound judgement.

2. There are certain phases of the management process which cannot be expressed in mathematical symbols and formulae.

(g) The Systems Approach School

- The systems approach school is of recent origin having developed in late 1960's.
- The prominent contributors to this school of thought are Kenneth, Boulding, Johnson, Cast Rosen Zweig and Churchman. Another notable contributor is Martin particularly in the field of management audit system.
- A *system* is composed of elements or sub-systems that are related and dependent upon each other to form the *whole.*

The main features of this school of thought are:-

1. A system has a number of sub-systems, parts and subparts.

2. All the subsystems, parts and subparts are mutually related to each other. This relationship is in the context of the whole and is very complex. A change in one part will effect changes in others.

3. The systems approach emphasises the study of the various parts in their inter-relationships rather than in isolation from each other.

4. The system approach to management brings out the complexity of a real life management problem much more sharply than any of the other approaches.

Uses

- The systems approach has been used in studying the function of complex organisations and as the base for new kinds of organisation like the project management organisation.
- The systems approach has an edge over the other approaches in so far as its closeness to reality is concerned.

Limitations

The problem with the systems approach is its utter complexity particularly when it comes to a study of large and complex organisations.

(h) The Contingency Approach School of Management

- The major contributors to this school of thought are Joan Woodward, Fiedler, Lorsch and Lawrence.
- Theorists of the process school, quantitative, behavioural and systems schools often assume that their concepts and techniques have *universal applicability*, which is not so. These concepts may work in some situations and not in others.
- The *Contingency Approach* to management is based upon the fact that there is no one best way to handle any of the management problems. The applications of management principles and practices should be *contingent* upon the *existing* circumstances. Process, behavioural, quantitative and systems tools of management should be applied *situationally.*
- There are three major parts of the overall conceptual framework for contingency management:
  - (*i*) Environment
  - (*ii*) Management concepts, principles and techniques.
  - (*iii*) Contingent relationship between (*i*) & (*ii*) above.

  The environmental variables are *independent.*

  Management variables (process, quantitative, behavioural and systems tools) are *dependent.*

  Every manager has to apply the various schools of thought (approaches) to management according to the demands of the situation.
- It is the basic function of managers to analyse and understand the *environments* in which they function, before adopting any techniques, processes and practices. The choice of approaches and also their effectiveness is contingent on the behaviour and dynamics of situational variables. There is no universally valid one best way of doing things.
- Contingency thinking helps managers in several ways in performing their functions of planning, organising, direction and control. It widens their horizons beyound the theory of management, its concepts, principles, techniques and methods. It leads them to be sensitive, alert and adaptive to situation-behavioural variables, while tailoring their approaches and styles.
- Contingency thinking enlarges the area of freedom of operation of managers. They are not handicapped by having to apply the same approach to diverse situations. They can even think of a *blend* of known approaches as demanded by the existing situations.
- The contingency approach seems to hold a great deal of promise for the future development of management theory and practice.

15.22. PRINCIPLES OF MANAGEMENT

- 'Principles of Management' implies a list of current management practices.
- Though F.W. Taylor developed principles of management, credit goes to Henri Fayol, a French management theorist for advocating and publicizing certain principles (or laws) for the soundness and good working of the management.
- Henri Fayol warned that the principles of management should be,
  - (*i*) Flexible and not absolute—must be usable regardless of changing conditions,
  - (*ii*) Used with intelligence and with a sense of proportion, etc.
- Henri Fayol listed 14 principles, that grew out of his experience; they are briefed as under.

1. Division of Work (or Labour)

- Division of work means dividing the work on the principle that different workers (and different places) are best fitted for different jobs (or things) depending upon influences arising from geography, natural conditions, personal aptitude and skills.

- Division of work leads to specialization.
- Concept of division of labour can be applied to all kinds of work, managerial as well as technical.

Advantages of Division of labour. Since the same worker does the same work repeatedly.

(*i*) he gains proficiency and skill on the jobs,

(*ii*) rate of production increases,

(*iii*) product quality improves,

(*iv*) he is in a position to suggest changes in products, processing or methods of doing that work.

Disadvantages of Division of Labour

(*i*) Division of labour gives rise to loss of craftsmanship; workers become machine-minders and no more.

(*ii*) With the passage of time, the same job becomes dull and monotonous.

(*iii*) Workers do not remain all-round and one cannot work in place of another if he is absent.

2. Authority and Responsibility

- Authority and responsibility should go together, hand-in-hand and must be related.
- An executive can do justice with his responsibility only when he has the proper authority.
- Responsibility without Authority or *vice versa* is meaningless.

[For details refer Chapter 3].

3. Discipline

- Discipline is absolutely necessary for efficient functioning of all enterprises.
- Discipline may be described as—respect for agreements that are directed at achieving obedience, application, and the outward marks of respect.

[For details refer Chapter 20].

4. Unity of Command

- Unity of command means, employees should receive orders and instructions from one boss (or supervisor) only. In other words a worker should not be under the control of more than one supervisors.
- Unity of command avoids confusion, mistakes and delays in getting the work done.

5. Unity of Direction

- It is a broader concept than the unity of command.
- Unlike unity of command which concerns itself with the personnel, unity of direction deals with the functioning of the body corporate.
- Unity of direction implies that there should be one plan and one head for each group of activities having the same objective.

In other words, there should be one common plan for an enterprise as a whole.

6. Subordination of Individual to General Interest

- The interests of an individual person should not be permitted to supersede or prevail upon the general interests of the enterprise.
- This is necessary to maintain unity and to avoid friction among the employees.

7. Remuneration

- Remuneration is the price paid to the employees for the services rendered by them for the enterprise.

- Remuneration should
  - (*i*) be fair, and
  - (*ii*) bring maximum satisfaction to both employees and the employer.

8. Centralisation of Authority

- Centralisation of authority means that the authority is in the hands of center, *i.e.*, the authority is not dispersed among different sections.
- In a business organisation, authority should be centralised only to that degree or extent which is essential for the best overall performance.
- The degree of centralization is decided by keeping in view the nature, size and complexity of the (business) enterprise.

9. Scalar Chain

- Managers may be regarded as a *chain of superiors*. There should be an unbroken line of authority and command through all levels from the highest (*i.e.*, general manager) to the lowest ranks (employee).
- The chain of superiors should be short-circuited, when following it strictly will be detrimental to performance.

10. Order

- This promotes the idea that everything (*e.g.*, materials) and everyone (human being) has his place in the organisation.
- Materials and human beings should be arranged such that right material (thing)/person is in the right place.

11. Equity of Treatment

- Manager should have fairness in treatment for all his subordinates.
- Manager should deal with his subordinates with kindness and justice.
- This will make employees more loyal and devoted towards the management/enterprise.

12. Stability

Stable and secure work force is an asset to the enterprise, because unnecessary labour turnover is costly.

- An average employee who stays with the concern is much better than outstanding employees who merely come and go.
- Instability is the result of bad management.

13. Initiative

- Initiative is one of the keenest satisfactions for an intelligent employee.
- Managers should sacrifice their personal vanity in order to permit their subordinates to exercise their own initiative.
- A manager should encourage his subordinates to take initiative.

14. Esprit de Corps

- This principle of management emphasizes the need for teamwork (harmony, and proper understanding) among the employees and shows the importance of communications in obtaining such team-work.

15.23. PRINCIPLE OF EXCEPTION

- The distinguishing features of this approach are frequent measurement and evaluation of actual progress and comparison with the appropriate target figures.

Management is called upon to make a decision on future action only if this comparison reveals an actual or expected divergence or variance.

- According to principle of exception, one reports only those things and at that time when they (things) require an action by the management. It is assumed that unreported events are going as per the schedule.
- In practice, then, control by exception means, comparing

(*a*) actual performance with expected performance and

(*b*) actual costs with target costs, in such a way that suitable corrective action can be taken if things go wrong.

- The principle of exception consists of a number of related parts which may be summarised as follows:-

(*a*) Each person performs the work alloted to him in the prescribed manner without infringement on the work of others.

(*b*) The work is carried out with minimum amount of instruction and supervision. As a corollary of this, a subordinate should only consult his superior when there are unusual occurrences or emergencies.

(*c*) Matters which are not proceeding according to plan are reported upon so that corrective action can be taken. This allows managers to concentrate on important matters and disregard any others.

- Control by exception depends for its effectiveness upon a number of factors, for example:

(1) The validity of the target figures.

(2) Both targets and actual results must be linked with managerial responsibilities – otherwise it will be difficult to make corrective action effective.

(3) Control reports must be issued sufficiently quickly and frequently to enable corrective action to be taken before it is too late.

15.24. PROCESS OF MANAGEMENT

- *The Process of management* involves the determination of *objectives*, putting them into action and achieving the desired goals.
- *Management process* is the methodology of getting the things done. The process, in general, is defined as a series of actions or operations (functions) conducting to an end.
- The logic of the management process is that particular *functions* are performed in a sequence through time.
- Whatever functions are performed by a manager and the sequence in which they are performed, is designated as *Management Process.*
- Management process involves,
  1. Planning
  2. Organising
  3. Actuating, and
  4. Controlling, for achieving business goals.

1. Planning

- Planning involves the formulation of *what* is to be done, *how, when* and *where* it is to be done, who is to do it and what results are to be evaluated.
- Planning means looking ahead, it is mental work, it is selecting from among many choices following the procedure given below:-

i. Lay down the company *objectives*/ targets.

ii. Collect and classify the *information* relating to company objectives.

iii. Develop *alternative* course of action to do the things.

iv. Compare the alternatives in terms of objectives, feasibility and consequences.

v. Select the optimum course of action yielding maximum benefit/gain.

vi. Establish policies, procedures, methods, schedules, programmes, systems, standards and budgets for the optimum course of action selected.

2. Organising

- After determining the course and make-up of action, the next step, in order to accomplish the task, is to distribute the necessary work among the working groups.
- *The process of organising involves:-*

i. Divide the *work* into Component activities.

ii. Assign *people* to task (component activities).

iii. Define *responsibilities.*

iv. Delegate *authority.*

v. Establish structural relationship (*i.e., organisation structure*) to secure coordination.

3. Actuating (move to action)

- Actuating means *carrying out physically* the activities resulting from planning and organising.
- *The process of actuating involves:-*

i. Provide effective *leadership*.

ii. Integrate people and tasks and convince them to assist in the achievement of the overall objectives.

iii. Ensure effective communication.

iv. Provide climate for subordinates' development.

4. Controlling

- Controlling means checking up (or follow up) to ensure that the planned work is progressing as per schedule and if not, then to apply corrective action to achieve the pre-determined objectives.
- *The Process of controlling involves:-*

i. Observe continuously and study the periodic results of performance.

ii. Compare this performance with the present standards.

iii. Pinpoint deviations if any.

iv. Ascertain the exact causes of deviations.

v. Initiate and implement the corrective action.

15.25. FUNCTIONS OF MANAGEMENT

- One way to look at the process of management is to identify the (basic) functions which together make up the process.
- Since some functions are basic to managerial activities at all levels from the foreman to the manager, they are applicable to all business enterprises.
- Though Fayol, Urwick, Davis, Koontz and O'Donnel have specified different number of management functions, the author feels that the following eight functions may be used to describe the job of management.

1. Forecasting.
2. Planning.
3. Organising.
4. Staffing.
5. Directing
   - Leadership
   - Communication
   - Motivation
   - Supervision
6. Coordinating.
7. Controlling.
8. Decision making.

– The above list of the functions of management is a useful analytical device for stressing the basic elements inherent in the job of management.

1. Forecasting

– Forecasting is a necessary preliminary to planning.

– Forecasting estimates the future work or what should be done in future; may be as regards Sales or Production or any other aspect of business activities.

– Forecasting begins with the sales forecast and is followed by production forecast and forecasts for costs, finance, purchase, profit or loss, etc.

2. Planning

– Planning all aspects of production, selling, etc., are essential in order to minimise intangibles.

– Planning is a process by which a manager anticipates the future and discovers alternative courses of action open to him.

– Planning is a rational, economic, systematic way of making decisions today which will affect the future *e.g.*, what will be done in future, who will do it and where it will be done.

– In fact, every managerial act, whether it be mental or physical, is inexorably intertwined with planning.

– Without proper planning, the activities of an enterprise may become confused, haphazard and ineffective; for example if a refrigerator making concern does not plan in advance—how many refrigerators and of what capacities are to be made before the summer starts and thus it does not procure necessary material, tools, supplies and personnel in time, it cannot reach the production targets and hence may not run profitably.

– Prior planning is very essential for utilizing the available facilities (men, materials, machines etc.) to the best of advantage.

3. Organising

– Organising is the process by which the structure and allocation of jobs is determined.

– Organising involves determining activities required to achieve the established company objectives, grouping these activities in a logical basis for handling by subordinate (persons), managers, and finally, assigning persons to the job designed. In carrying out the above, the manager will delegate necessary authority to his subordinates (persons) and they, in turn, will take the necessary responsibility.

– Organising means, organising people, materials, jobs, time etc., and establishing a framework in which responsibilities are defined and authorities are laid down.

4. Staffing

- Staffing is the process by which managers select, train, promote and retire their subordinates.
- Staffing involves the developing and placing of qualified people in the various jobs in the organisation.
- Staffing is a continuous process. The aim is to have appropriate persons to move into vacated positions or positions newly created in the enterprise.

5. Directing

- Directing is the process by which actual performance of subordinates is guided towards common goals of the enterprise.
- Directing involves motivating, guiding and supervising subordinates towards company objectives.
- Directing thus includes:

(*i*) Giving instructions to subordinates.

(*ii*) Guiding the subordinates to do the work.

(*iii*) Supervising the subordinates to make certain that the work done by them is as per the plans established.

- Directing involves functions such as

(*a*) Leadership, (*b*) Communication,

(*c*) Motivation, and (*d*) Supervision.

(a) Leadership

- Leadership is the quality of the behaviour of the persons (Managers) whereby they inspire confidence and trust in their subordinates, get maximum cooperation from them and guide their activities in organized effort.
- Leadership is more than personal ability and skill.

(b) Communication

- Communicating is the process by which ideas are transmitted, received and understood by others for the purpose of effecting desired results.
- Communication may be verbal or written orders, reports, instruction, etc.
- A manager communicates to his subordinates as what they should do.
- An ineffective communication leads to confusion, misunderstanding, dissatisfaction and sometimes even strikes.

(c) Motivation

- Motivating means inspiring the subordinates to do a work or to achieve company objectives effectively and efficiently.

(d) Supervision

- Supervision is necessary in order to ensure,

(*i*) that the work is going on as per the plan established, and

(*ii*) that the workers are doing as they were directed to do.

6. Coordinating

- Coordinating means achieving harmony of individual effort towards the accomplishment of company objectives.

In other words, the dovetailing and harmonising of all the company assets and employees into a coherent whole is known as *coordination*.

- Ineffective coordination between different functions of a business enterprise (such as production, sales, administration, etc.) can ruin the enterprise.
- Coordination involves making plans that coordinate the activities of subordinates, regulate their activities on the job and regulate their communications.
- Besides other factors, informal relationships within an organization also tend to facilitate coordination, because workers who like each other outside the factory, prefer to work together on the job also.

(7) Controlling

- Controlling is the process that measures current performance and guides it towards some predetermined goal.
- Controlling involves :
  - (*i*) the monitoring of programme activities to make sure that end objectives are being met.
  - (*ii*) the initiation of corrective action as required to over-come problems, if any, hindering the accomplishment of objectives.
- Checks and examinations are required on a periodic basis to ensure that the things are proceeding as per plans established.
- Controlling is necessary to ensure that orders are not misunderstood, rules are not violated and objectives have not been unknowingly shifted. Control means control of persons and other things.
- Controlling is a continuous process which measures the progress of operations, (compares) verifies their conformity with the predetermined plan and takes corrective action, if required.
- As explained above, controlling, process

(*i*) Sets standards,

(*ii*) Measures job performance, and

(*iii*) Takes corrective action, if required.

8. Decision Making

- Decision making is the process by which a course of action is consciously chosen from available alternatives for the purpose of achieving desired results.
- An outstanding quality of a successful manager is his ability to make sound and logical decisions.
- Management decisions range from establishing consumer operational development needs to the selection of a preferred system design configuration to many other aspects of a business enterprise.

15.26. LEVELS OF MANAGEMENT

Management/Industrial Management has got the following activity levels.

1. Top Management.
2. Upper Middle Management.
3. Middle Management.
4. Lower Management (Foremen etc.)
5. Operating force or Rank and File workman.

1. Top Management

- *Top Management includes*

(*a*) Board of Directors.

(*b*) Managing Directors.
(*c*) Chief Executives.
(*d*) General Managers.
(*e*) Owners.
(*f*) Share-holders/Financiers.

– *Top Management Functions are*
(*a*) Setting basic goals and objectives.
(*b*) Expanding or contracting activities.
(*c*) Establishing policies.
(*d*) Monitoring performance.
(*e*) Designing/Redesigning organization system.
(*f*) Shouldering financial responsibilities, etc.

2. Upper Middle Management

– *Upper Middle Management includes*
(*a*) Sales executive (Manager).
(*b*) Production executive.
(*c*) Finance executive.
(*d*) Accounts executive.
(*e*) R & D executive.

–*Upper Middle Management Functions are*
(*a*) Establishment of the organization.
(*b*) Selection of staff for lower levels of management.
(*c*) Installing different departments.
(*d*) Designing operating policies and routines.
(*e*) Assigning duties to their subordinates, etc.

3. Middle Management

– *Middle Management includes*
(*a*) Superintendents.
(*b*) Branch Managers.
(*c*) General Foremen, etc.

– *Middle Management Functions are*
(*a*) To cooperate to run organization smoothly.
(*b*) To understand interlocking of departments in major policies.
(*c*) To achieve coordination between different parts of the organization.
(*d*) To conduct training for employee development.
(*e*) To build an efficient company team spirit.

4. Lower Management

– *Lower Management includes*
(*a*) Foremen.

(*b*) Supervisors or charge-hands.

(*c*) Office superintendent.

(*d*) Inspectors, etc.

– *Lower Management Functions are*

(*a*) Direct supervision of workers and their work.

(*b*) Developing and improving work methods and operations.

(*c*) Inspection function.

(*d*) Imparting instructions to workers.

(*e*) To give finishing touch to the plans and policies of top management.

(*f*) To act as a link between top management and the operating force (*i.e.*, workers).

(*g*) To communicate the feelings of workers to the top management.

5. Operating Force

– *Operating Force includes*

(*a*) Workers, rank and file workman, skilled, semi-skilled and unskilled.

– *Operating Force Functions are*

(*a*) To do work on machines or manually, using tools, etc.

(*b*) To work independently (in case of skilled worker) or under the guidance of supervisor.

15.27. INDUSTRIAL MANAGEMENT

– Industrial Management involves guidance, leadership and control or efforts of a group of individuals toward some common goals of the industry.

– The Industrial Manager must

(*i*) design products that will find acceptance in competitive markets;

(*ii*) devise methods of producing such products efficiently;

(*iii*) explore reliable sources for obtaining materials and supplies;

(*iv*) attract funds;

(*v*) build plants, recruit and train employees with a wide variety of talents;

(*vi*) devise systems for coordinated efforts; and

(*vii*) inspire confidence and activate all the resources (facilities) into a viable *going* concern.

– The job of Industrial Manager becomes still more difficult due to

(*i*) change in market;

(*ii*) change in technology;

(*iii*) change in attitude and feeling of people; and

(*iv*) change in government regulations, etc.

15.28. TYPES OF MANAGEMENT

1. Development Management. It includes research into materials, machines, processes, etc.

2. Distribution Management. It includes marketing, merchandising, advertising, sales, etc.

3. Financial Management. It includes economic forecasting, costing, accounting, budgetary control, insurance and actuarial work, etc.

4. Maintenance Management. It includes upkeep of buildings, equipment, estate work, etc.

5. Purchase Management. It includes tendering, buying, contract work, store keeping, store and stock control.

6. Production Management. It includes work analysis, planning, scheduling, routing, quality control and work study.

7. Transport Management. It includes transportation by rail, road, air and water, packing, warehousing, etc.

8. Personnel Management. It includes employee selection, placement, training, transfer, promotion, discharge, industrial relations, safety, health and welfare services, etc.

9. Office Management. It includes planning and control of offices, keeping records, etc.

15.29. MANAGEMENT (STRUCTURE) CHART FOR A MEDIUM INDUSTRY

- Fig 15.2 Shows the management structure (chart) for a small to medium size company (manufacturing industry).
- **Duties of**

1. *Company Secretary*
   To attend meetings of board of directors.
   To take up legal matters.
   To handle budgetary control, etc.
2. *Office Manager*
   To handle correspondence.
   To keep records, etc.
3. *Chief Accountant*
   To handle accounts (cost accounting)
   To deal with wages.
   To deal with sales, etc.
4. *Controller of Production*
   To plan and control production.
   To load and schedule the production facilities.
   To conduct work study, etc.
5. *Design Officer*
   To design or redesign the component parts.
6. *Research Officer*
   To carry out Materials Research.
   To carry out Engineering Research, etc.
7. *Despatch Officer*
   To take care of packaging of products.
   To take care of external transportation.
8. *Sales Officer*
   To float enquiries.
   To call quotations(tenders).
   To attend orders.
9. *Publicity Officer*
   To advertise company products.
   To explore new markets for company products.

N.B. : Rest all terms of Fig 15.1 are self-explanatory.

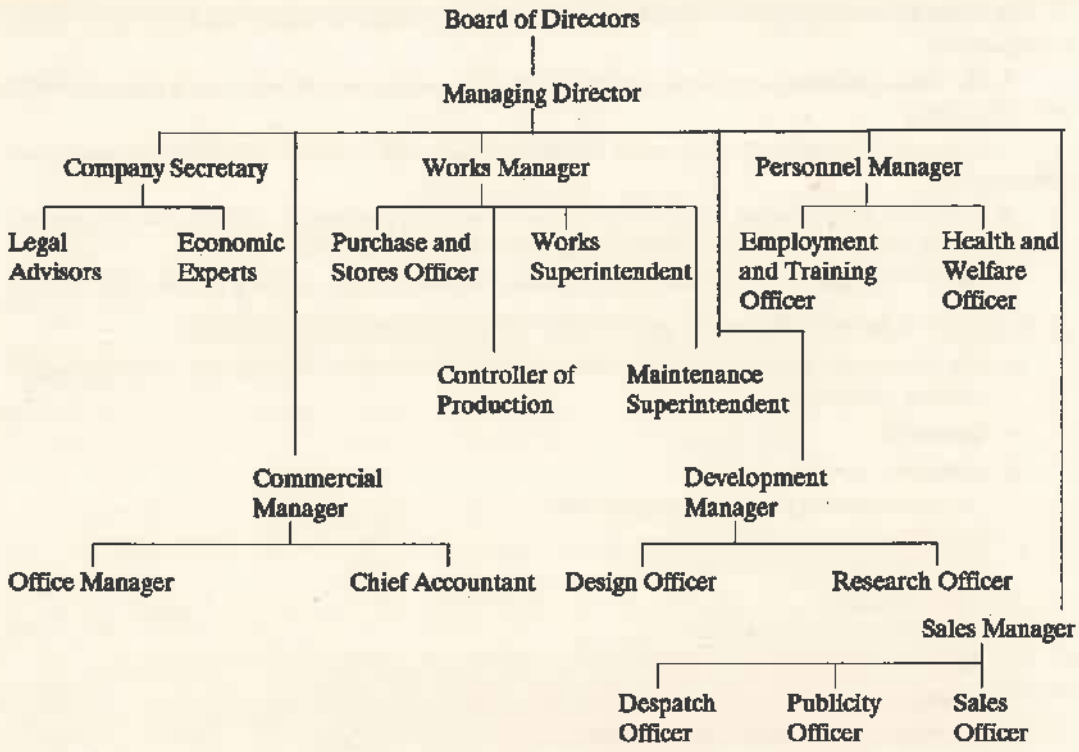


Fig. 15.2. Management Structure (Chart).

15.30. NEED AND USEFULNESS OF MANAGEMENT THEORY

- *Theory* is a systematic grouping of interrelated principles. Its task is to tie together significant knowledge, to give it a framework.
- Theory of management involves a systematic synthesis of the concepts and principles of management.
- The need for a clear concept of management and for a framework of related *theory* and principles was recognised many years ago by such early practical scholars of management as Henri Fayol, Chester Barnard, and Alvin Brown. This need has been increasingly recognised by intelligent managers as time has gone on.
- When management *theory*, principles and techniques can be developed, proved and used, *managerial efficiency* will inevitably improve. Then the conscientious manager can become more effective by using established guidelines to help solve problems, without engaging in original laborious research or the risky practice of trial and error.
- Lack of understanding of the *theory* and principles of management makes it difficult to *analyze* the *managerial job* and *to train managers*.
- Development of management theory would unquestionably have a revolutionary impact on the cultural level of society.

15.31. MANAGEMENT DEVELOPMENT

Concept

Management development is a planned and organised process and programme of training and growth whereby an individual manager or executive (at each level of management hierarchy) gains knowl-

edge, skills and attitude to manage workers and work organizations effectively.

Objectives

1. To ensure the availability of Competent managers to achieve the goals of the organization.
2. To ensure optimum utilisation of human capital.
3. To prepare present employees for higher assignments.
4. To replace retiring executives with younger talents.
5. And as a result, to promote progress, productivity and profits of the enterprise.

Importance

In the words of *Peter Drucker*—An institution that cannot produce its own managers will die. Hence, the ability of an institution to produce managers is more important than its ability to produce goods efficiently and cheeply.

No modern business can grow and succeed without planned attention towards the development of certain attitudes, skills, knowledge and insights in its employees.

Techniques

Management development techniques may be classified as:-

(i) On the job experience and teaching techniques

(*a*) Coaching and assigning challenging tasks.
(*b*) Rotational assignments *e.g.*, rotation among managerial training positions, creation of 'Assistant to.....', positions etc.
(*c*) Multiple management, *e.g.*, Committees, junior boards etc.
(*d*) Conference programmes and problem solving committees.
(*e*) Understudy for management succession.
(*f*) Management workshop programmes.
(*g*) Temporary promotions.
(*h*) Planned reading programmes.

(ii) Off-the-job teaching techniques

(*a*) Lectures and programmed instructions.
(*b*) Case study and case problems.
(*c*) Role playing.
(*d*) Business games.
(*e*) Conference, seminars, etc.
(*f*) Project study.
(*g*) Brain-storming method.
(*h*) Observations tours and visits abroad, etc.

Junior managers/executive development programme

(*a*) *Observation assignments*—to work under a number of managers to observe as how they perform managerial functions.

(*b*) *Assignment to managerial positions*—the trainee is appointed to a supervisory job so that he learns to get things done through others.

(*c*) *Job rotation among different managerial positions* to gain actual experience in managing.

(*d*) *Serving on committees*—Committee experience will warn the young executive against believing that this point of view is always the right one to have, and it will show him the importance of having an open mind towards any problem.

Senior managers/executive development programmes

(*a*) *Lecturing*—The lecture method followed by discussions is the best method to pass on ideas, concept, information and knowledge.

(*b*) *Brain-storming*—A problem is posed and ideas are invited which are critically examined.

(*c*) *Case studies*—It is a real life situation for studying a problem. Case studies are widely used in teaching, Law, personnel management, labour relations etc.

(*d*) *Conferences*—The conference leader makes a preliminary statement indicating the scope of the subject and submits issues for discussion. He puts questions and induces other members of the group to participate in the discussion.

This method is very useful for the development of conceptual knowledge and also for the creation and modification of attitudes.

(*e*) *Role playing*—It is spontaneous acting of a realistic situation involving two or more persons under class-room situation. Typical examples of role playing are (*i*) A medical representative presenting a sales talk on a medicine to a doctor, (*ii*) A finance officer conducting a budget meeting etc.

Role playing involves action, doing and practice.

(*f*) *Project method*—A special project—such as marketing of a new product—may be given to an individual executive who will work on the project, collect data, carry out analysis and offer his recommendations.

(*g*) *Management games*—It is a classroom simulation excercise in which trainee teams compete against each other to achieve given objectives.

(*h*) *Sensitivity training*—It involves face-to-face contact with a small group for a couple of weaks. The learning takes place not on an intellectual level but on a *feeling* level, since the individual is actually experiencing events rather than talking about them.

Performance appraisal

- Appraisal is the basis of all development programmes.
- Managerial appraisal is the process of judging the effectiveness of executives.
- Performance appraisal shows-how much effective the management development programme was.
- Performance appraisal methods may be divided into two groups :-

(*i*) Appraisal of employees according to their traits, attributes and general behaviour on the job, known as *Trait Approach.*

(*ii*) *Appraisal by results*

(*i*) *Trait Approach*—Different techniques under this approach are :-

(*a*) *Rankine Method*—One employee is compared with all other employees and then he is placed in a simple rank order. In doing so, the appraiser considers the employee and his performance as an entity.

(*b*) *Grading Method*—Certain categories of worth are established in advance and are carefully defined, such as—outstanding, satisfactory and unsatisfactory. Employee performance is then compared with these grade definitions and the person is allocated a grade which best describes his performance.

(*c*) *Forced Choice Method*—In this method, the rating elements are *sets* of four phrases pertaining to the proficiency or personal qualification of the employees, such as

(1) He is hardworking.

(2) He gives very clear instructions to his subordinates.

(3) He is not loyal to the institution.

(4) He is indifferent.

The rater indicates which of these four is most characteristics of the ratee, and which is least characteristic; and repeats this selection for each of the sets included.

(ii) Appraisal by results

- *Performance* in itself is the most reliable indicator of the potential and quality of an employee.
- In this approach, the manager observes the performance of the subordinate against specific predetermined goals.

Conclusions are based on observation and evidence of performance rather than the superior's opinions of the subordinates.

15.32. PROJECT MANAGEMENT

A Project

- If there is one single quality which sets a project apart from routine commercial or industrial operations, it is its *novelty*.
- No two projects are ever exactly alike. A project is always a journey into the unknown, fraught with risk.
- Projects typically demand the use of resources that are scarce or expensive, but which have to be deployed over a most complex frame work of tasks.

Project Management

The purpose of project management is to minimize, contain or counter the risks, and organize and direct the resources so that the project is finished in time, within budgeted costs and with the functional or other design objectives fulfilled.

Types of projects

(1) *Manufacturing Projects*—where the final result is a vehicle, ship, aircraft, a piece of machinery etc.

(2) *Construction projects*—resulting in the erection of buildings, bridges, roads, tunnels etc. Mining and petro-chemical projects can be included in this group.

(3) *Management projects*—which include the organization or reorganization of work without necessarily producing a tangible result. Examples would be the design and testing of a new computer software package, relocation of a company's headquarters or the production of a stage show.

(4) *Research Projects*—in which the objectives may be difficult to establish, and where the results are unpredictable.

Project Objectives

A project usually has three objectives :-

(*i*) *Function or performance*—the final result must satisfy the requirements of the end user. Considering a project to develop a racing car, the objectives must be to produce a vehicle that satisfies specified standards for performance, reliability and safety.

(2) *Containment of expenditure within budget* is another criterion for project success. Continuing with the racing car development example, if the development costs were to exceed those planned, then their recovery from car sales could result in the selling price having

to be increased too far above prices charged by competitors for their rival products. Projects must, therefore, be completed within their budgeted costs.

(3) *Time scale* is the third factor. In the motor car example, the car should be fully developed and proven in time for launch at the motor show.

Project definition and specification

- If the purpose of project management is to meet the functional, cost and timescale objectives, then clearly these objectives must be properly defined from the out set.
- The technical or performance specification usually originates from a customer's stated requirements.

There must be in clear text the scope and technical performance of the project, supported by whatever drawings are necessary.

Since any eventual contract between the customer and the contractor will be based on this specification, it is important that no significant element of the project is omitted.

After contract award, the sales specification becomes the definitive project specification.

- Project definition is a process which continues after contract award, right up to the final stages of commissioing.

Project Organisation

- Obviously the person at the head of the project (project manager) should, ideally, be technically experienced and qualified in the type of work involved.
- Note that there may be more than one project manager working on the same project. This has been seen in large projects with more than one participating contractor, or where subcontractors are employed.

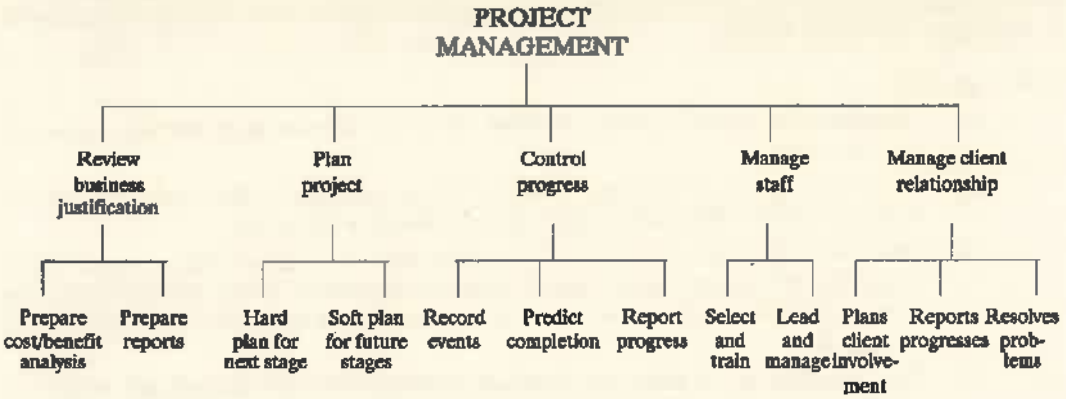


Fig. 15.3 Role of a project Manager.

Qualities of a Project Manager

A project manager should be :

(1) Technically competent—familiar with project management techniques
(2) Effective planner
(3) Organizationally powerful
(4) A persuasive communicator
(5) A good controller
(6) Sensitive to the problems of change

(7) An effective manager of teams
(8) A good project trainer
(9) Perceptive (able to spot potential problems early)
(10) Questioning
(11) Active and mobile
(12) A good motivator of people.

– *For details of project organisation refer chapter 3.*

Cost Estimating and Budgeting

Once the scope of a project has been defined clearly in a sales specification, it is necessary to estimate the likely costs of fulfilling all the work. *Cost estimates* form the basis of subsequent *budgets* for management control. They also provide a foundation for *pricing.*

Planning and scheduling

- Every project must be controlled from a plan of working.
- Ideally the promised project delivery or completion date will have resulted from careful *planning.*
- Large projects must be broken down in smaller packages or groups of tasks for the purpose of planning and control. This procedure should result in the identification of sub-projects that can be delegated to the responsibility of managers with relevant experience.
- The next stage in project planning is to assemble all the tasks in a practical working sequence. This is possible for small projects using a *Bar chart* (chapter 7) or with a *Critical Path Network diagram* (chapter 10). The critical path method provides an excellent notation for the purpose.
- The addition of estimates for the *duration* of each task enables the planner to add up all the expected durations in the work sequence to arrive at a planned project completion date.
- A plan of action is not complete until the use of resources has been taken into account. This is the process *of resource scheduling. Critical Path Analysis* (refer chapter 10) is a most powerful tool in this respect, because it allows a degree of criticality (float) to be assigned to each activity.

Controlling progress and Costs

- From time to time it is necessary to gauge *Progress* in terms of the *value* (cost) of work achieved.
- The contractor is required to submit regular report of progress to his client.
- Regular *meetings* may take place to review *progress*. The purpose of such meet is to short-circuit the usual communication routes in an organization and get key people together so that progress data can be reviewed, disputes debated, and agreements reached on the spot.
- An essential in *Cost control* is to start with an approved budget, related item by item to each job or purchase, and with the timing of expenditure calculated to agree with the project work schedules.

When a project proceeds as per schedule, the costs will tend to take care of themselves. But if a project runs late, total costs will also overrun and there may also be expensive contractual penalties. Time is money !

15.33. MANAGEMENT INFORMATION SYSTEMS (MIS)

Definition

- Management information system may be defined as a formal method of making available to management the accurate and timely information necessary to facilitate the decision-making process and enable the organisation's planning, control, and operational functions to be carried out effectively.

- The system provides information on the past, present and projected future and on related events inside and outside the organisation.
- The *purpose* of MIS is to aid decision making and not to automate the decision making process itself. Secondly MIS should focus only on those decisions whose benefit/cost ratio is attractive.

The Evolution of MIS

- Organisations have always had some kind of management information system, even if it was not recognised as such. In the past, these systems were of a highly informal nature in their setup and utilization.
- Not until the advent of Computers, with their ability to process and condense large quantities of data, did the design of MIS become a formal process and field of study.
- When computers were first introduced into organisations, they were used mainly to process data for a few organisational functions—usually accounting and billing. As the speed and ease of processing data grew, other data processing and information management tasks were computerized.
- The growth of EDP departments spurred managers to plan their organization information systems more rationally. These efforts led to the emergence of the concept of computer-based information systems (CBIS), which became better known as computer based MIS-or simply MIS.
- Recent advances in computers have made it possible for EDP/MIS experts, and then for managers, to gain *on-line* or *real-time* access to the data bases in CBISs.
- The near future will witness the widespread use of *expert systems* using artificial intelligence to diagnose problems, recommend strategies to avert or solve these problems, offer a rationale for these recommendations, and *learn* from each experience. In effect, the *expert* system acts like a human expert in analyzing unstructured situations.

Objectives of MIS

1. To provide the desired information available in the right form at the right time.
2. To supply the desired information at a reasonable cost.
3. To keep the information up to date.
4. To store important and confidential information properly.

Management Information categories

- *Information* applies to facts that are gathered in any way, as by reading, observation, hearsay etc.
- Management information can be conveniently categorized into three main areas :-

1. Strategic planning information
2. Management control information
3. Operational information

(1) *Strategic planning information* relates to the top management tasks of deciding on objectives of the organization, on the levels and the kinds of resources required to attain the objectives and on the policies that govern the acquisition, use and disposition of resources.

Strategic planning depends heavily upon information external to a specific organization. When this is combined with internal data, management can make estimates of expected results. The specifics of this information are often unique and tailor-made to particular strategic problems.

(2) *Management Control information* sheds light on goal congruence; it keeps managers to take those actions which are in the best interests of the organization; it enables managers to see that resources are being used efficiently and effectively in meeting the organizational goals.

– Robert Anthony pinpoints three types of information needed for management control :

Costs by responsibility centers,

Direct program costs and

Full program costs (including allocations for indirect costs)

– Management control information is often interdepartmental.

(3) *Operational information* pertains to the day-to-day activities of the organization and helps assure that specific tasks are performed effectively and efficiently.

It also includes the production of routine and necessary information, such as financial accounting, payrolls, personnel rosters, equipment inventories and logistics. *Operational information* can be well defined and easily reduced to a routine of a series of instructions, whereas *strategic information* is difficult to define; *control information* falls in between.

Designing Information Systems

– Much of the literature on design emphasizes the development of mechanized systems. Electronic computers have fostered the design of sophisticated systems of information flow. But the analysis involved is applicable to information systems of all kinds-computerized or not.

– A hazard in designing information systems is that of attempting to develop as much data as possible for use in the system. Voluminous data of many types might be collected and stored in case they are needed at some point in time. It is easy to see that massive amounts of useless data might result.

– The best approach is oriented to decision making. It minimizes the development of useless information because only data likely to be meaningful at various points are collected. The object is development of better information systems for management.

– Three stages in a continuous process of design and implementation for computerized information systems can be described as follows :-

Stage-1 *Systems specification*...includes the design of all of the aspects of a management information system that are important to the users. It includes principally the basic decisions as to what information should be provided by the system.

Stage-2 *Data Processing Implementation*...is concerned with those things that are important to the processing of the data. The purpose in this stage is to design a data processing system that will most efficiently implement the systems specified in stage-1.

Stage-3 *Programming*...starts with the systems flow charts and ends when the program is running on the computer.

Applications of MIS

To name a few :-

1. Reservation systems being operated in Airlines.
2. In health maintenance and diagnosis centres.
3. Forecasting.
4. Inventory Management.
5. Scheduling problems.
6. In Banking.
7. In Judicial system for court scheduling etc.

16

Industrial Ownership

16.1. INTRODUCTION

- 'Industrial Ownership', 'Business organisation', 'Forms of Ownership of Industry','Types of Organisation in Industry', 'Business Enterprises', 'Types of Ownership', etc., all convey the same meaning.
- To start a business enterprise the most important thing required is the capital.
- If the capital is provided by single individual, it is known as *Individual ownership, Individual entrepreneur organisation, Single ownership or Individual proprietorship,* etc.
- If the capital is supplied by two or more persons, it refers to *partnership* organisation.
- If the capital is provided by many persons in the form of shares to an institute with a legal entity, it is called a *Joint Stock Company.*
- There are other forms of ownership also, but they are merely outgrowths of the three types mentioned above.

16.2. TYPES OF OWNERSHIP

The different types of ownership are

1. Single ownership (Private Undertaking).
2. Partnership.
3. Joint Stock Companies.
4. Cooperative organisation.
5. State and central Government owned.

16.3. SINGLE OWNERSHIP

Concept

- Ownership when applied to an industrial enterprise means title to and possession of the assets of the enterprise, the power to determine the policies of operation, and the right to receive and dispose of the proceeds.
- It is called a single ownership when an individual exercises and enjoys these rights in his own interest.
- A business owned by one man is called single ownership.
- Single ownership does well for those enterprises which require little capital and lend themselves readily to control by one person.
- Examples of enterprises run by single owner are printing press, auto repair shop, wood working plant, a small fabrication shop, etc., *i.e.,* retail trades, service industries and small engineering firms.
- In single ownership, one person contributes the original assets to start the business, maintains and controls business operations, reaps full benefit in terms of profit and is fully liable for all

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debts associated with the business.

Advantages

1. Easy to establish as it does not require to complete any legal formality.
2. Simplicity of organization.
3. The expenses in starting the business are minimal.
4. Owner is free to make all decisions.
5. This type of ownership is simple, easy to operate and extremely flexible.
6. The owner enjoys all the profits, thus,
7. There is a great deal of personal motivation and incentive to succeed.
8. Minimum legal restrictions are associated with this form of ownership.
9. Owner can keep secrecy as regards the raw materials used, method of manufacture, etc.
10. Single ownership associates with it the great ease with which the business can be discontinued.

Disadvantages

1. The owner is liable for all obligations and debts of the business.

2. The business may not be successful if the owner has limited money, lacks ability and necessary experience to run the business.

3. Because of relatively unstable nature of the business, it is difficult to raise capital for expanding the business.

4. If the business fails, creditors can take the personal property as well as the business property of the (single) owner to settle their claims. This means single ownership involves unlimited liability for debts and losses.

5. There is limited opportunity for employees as regards monetary rewards (*e.g.,* profit sharing, bonuses, etc.) and promotions.

6. Generally, single ownership firm has limited life, *i.e.* the firm may cease to exist with the death of the proprietor. This is the cause of unstable nature of the firm (refer 3 above).

Applications. Single ownership is suitable

1. For retail trades, service concerns and small engineering firms which require relatively small capital to start with and to run.

2. For those businesses which do not involve high risks of failure.

3. When the business can be taken care by one person.

16.4. PARTNERSHIP

Concept

- A single owner becomes inadequate as the size of the business enterprise grows. He may not be in a position to do away with all the duties and responsibilities of the grown business.
- At this stage, the individual owner may wish to associate with him more persons who have either capital to invest, or possess special skill and knowledge to make the existing business still more profitable
- Such a combination of individual traders is called *Partnership.*
- *Partnership* may be defined as the relation between persons who have agreed to share the profits of a business carried on by all or any of them acting for all.

Individuals with common purposes join as partners and they put together their property, ability, skill, knowledge, etc., for the purpose of making profits.

- In brief, partnership is an association of two or more (up to 20) persons to carry on as co-owners of a business for profit.
- Partnerships are based upon a partnership agreement which is generally reduced to writing.

It should cover all areas of disagreement among the partners. It should define the authority, rights and duties of each partner.

It should specify—how profits and losses will be divided among the partners, etc.

Kinds of Partners

(*i*) *Active Partners* who take active part in the management of the business enterprise.

(*ii*) *Sleeping Partners* who do not take any active part in the conduct of the business.

Both Active and Sleeping partners are responsible for the debts of the Partnership.

General Duties of Partners

Partners should

(*i*) Be just and faithful to one another.

(*ii*) Render true accounts and full information about every thing that affects any partner.

(*iii*) Cooperate and accommodate each other.

(*iv*) Have confidence in each other and better mutual understanding.

(*v*) Respect the views of one-another.

Types of Partnership

(*i*) General Partnership.

(*ii*) Limited Partnership.

(*i*) General Partnership

Whatever has been discussed above so far pertains to General Partnership ; besides that

- In a general partnership, each partner has full agency powers and may bind the partnership by any act, *i.e*, each partner may act as though he were an individual proprietor. General partnership differs from single ownership in that the actions of any partner not only affect himself but they affect other partners also.
- As the partnership grows or personnel changes occur, additional partners can be had with the consent of all old partners.

Advantages

(*i*) Large capital is available to the firm.

(*ii*) The firm possesses much better talents, judgement and skills.

(*iii*) General partnership is easy to form and is relatively inexpensive in terms of organization cost.

(*iv*) Incentive for success is high.

(*v*) There is a definite legal status of the firm.

(*vi*) Partners have full control of the business and possess full rights to all profits.

(*vii*) Partnership associates tax advantages with it.

(*viii*) Partnership firms can borrow money quite easily from the banks.

(*ix*) For all losses, there are more than one person to share them.

Applications. General Partnership does very well in

Law firms,
Retail trade organisation,
Medical clinics,
Small engineering firms, etc.

Disadvantages

(*i*) Each partner has unlimited liability for the debts of the firm.

(*ii*) Danger of disagreement and distrust among the partners.

(*iii*) Authority being divided among the partners.

(*iv*) Partnership lacks permanence and stability ; it has limited life. Partnership may dissolve if a partner dies.

(*v*) Investors and lenders hesitate to provide money because of the lack of stability of a partnership firm.

(*vi*) All partners suffer because of the wrong steps taken by one partner.

(*ii*) Limited Partnership

- Limited partnership type of ownership overcomes the two main disadvantages [*e.g.* number (*i*) and (*v*) mentioned above] of general partnership.
- Limited partnership is an association of one or more general partners who manage the business and one or more limited partners whose liability is limited to the capital they have invested in the business.
- Limited partners share the profit but they do not participate or interfere with the control or management of the firm. Moreover limited partners have their liabilities limited to the amount of their investment.
- Thus, those investors and lenders who used to hesitate investing in the venture can do so without much risk.
- Limited partnership type of ownership is easy and less costly to form, and personal incentive to succeed is retained.
- A disadvantage associated with limited partnership is that the limited partner, though he invests in the business, has no voice in the management.

16.5. JOINT STOCK COMPANY

Concept

- Joint Stock Company overcomes many of the disadvantages associated with *Partnership* types of industrial ownership, such as :

(*i*) Difficulties in raising capital,

(*ii*) Easy disruption,

(*iii*) Lack of facility for centralised management, and

(*iv*) Unlimited liability, etc.

- A joint stock company is an Association of individuals, called shareholders, who join together for profit and agree to supply capital divided into shares that are transferable for carrying on a specific business.
- Death, insolvency, disablement or lunacy of the shareholders does not affect the joint stock company.
- A joint stock company consists of more than twenty persons for carrying any business other than

the banking business.

- These persons give a name to the company, mention the purpose for which it is formed, and state the nature and the amount of capital (shares) to be issued, etc., and submit the proposal to the Registrar of Companies. As the registrar issues a certificate in this connection, the company starts operating.
- The managing body of a joint stock company is the *Board of Directors* elected by the share holders. The Board of Directors

(*i*) makes policies ;

(*ii*) takes decisions ; and

(*iii*) runs the company efficiently.

- The liability of the members (or shareholders) of a joint stock company is limited to that capital only of which they hold the shares.
- Finance is raised by issuing shares, debentures, bank loans, loans from industrial and finance corporations.

Types of Joint Stock Company. There are two types of joint stock companies :

(*a*) Private limited company,

(*b*) Public limited company.

(*a*) Private Limited Company

(*i*) The capital is collected from the private partners ; some of them may be active while others being sleeping.

(*ii*) Private limited company restricts the right to transfer shares, avoids public to take up shares or debentures.

(*iii*) The number of members is between 2 and 50, excluding employee and ex-employee shareholders.

(*iv*) The company need not file documents such as consent of directors, list of directors, etc., with the Registrar of Joint Stock Companies.

(*v*) The company need not obtain from the Registrar, a certificate of commencement of business.

(*vi*) The company need not circulate the Balance Sheet, Profit and Loss Account, etc., among its members ; but it should hold its annual general meeting and place such financial statements in the meeting.

(*vii*) A private company must get its accounts audited.

(*viii*) A private company has to send a certificate along with the *annual return* to the Registrar of Joint Stock Companies stating that it does not have shareholders more than fifty excluding the employee and ex-employee shareholders.

Actually, a private joint stock company resembles much with partnership and has the advantage that big capital can be collected, than could be done so in partnership.

(*b*) Public Limited Company

(*i*) In Public limited company, the capital is collected from the public by issuing shares having small face value (Rs. 50, 20, 10).

(*ii*) The number of shareholders should not be less than seven, but there is no limit to their maximum number.

(*iii*) A public limited company has to file with the Registrar of Joint Stock Companies, documents such as consent of the directors, list of directors, director's contract, etc., along with the memorandum of

association and articles of association.

(*iv*) A public company has to issue a prospectus to the public.

(*v*) It has to allot shares within 180 days from the date of prospectus.

(*vi*) It can start only after receiving the *certificate to commence business.*

(*vii*) It has to hold a Statutory Meeting and to issue a Statutory Report to all members and also to the Registrar within a certain period.

(*viii*) There is no restriction on the transfer of shares.

(*ix*) Directors of the company are subject to rotation.

(*x*) The public company must get its account audited every year by registered auditors.

(*xi*) It has to send financial statements to all members and to the Registrar.

(*xii*) It has to hold a general meeting every year.

(*xiii*) The Managing Agent gets a fixed percentage of net profit as remuneration.

Advantages of Joint Stock Companies

(*i*) A huge sum of money can be raised.

(*ii*) It associates limited liability with it.

(*iii*) Shares are transferable.

(*iv*) Company's life is not affected by the life (death) of shareholders.

(*v*) Services of specialists can be obtained.

(*vi*) Risk of loss is divided among many shareholders.

(*vii*) The company associates with it stability, efficiency and flexibility of management.

Disadvantages of Joint Stock Companies

(*i*) A good deal of legal formalities is required for the formation of a joint stock company.

(*ii*) Company is managed by big shareholders only.

(*iii*) High paid officials manage the whole shows; they cannot have as high interests in the company as the proprietors can have.

(*iv*) People can commit frauds with the company.

(*v*) Board of directors and managers who remain familiar with the financial position of the company may sell or purchase shares for their personal profits.

(*vi*) It is difficult to maintain secrecy as in partnership.

(*vii*) The team spirit with which partnership works, is lacking in a joint stock company.

(*viii*) Divided responsibility.

Applications of Joint Stock Companies

(*i*) Steel mills,

(*ii*) Fertiliser factories, and

(*iii*) Engineering concerns, etc.

16.6. COOPERATIVE ORGANISATION (OR SOCIETIES)

Concept

— It is a form of private ownership which contains features of large partnership as well as some features of the corporation.

- The main aim of the cooperative is to eliminate profit and provide goods and services to the members of the cooperative at cost.
- Members pay fees or buy shares of the cooperative, and profits are periodically redistributed to them.
- Since each member has only one vote (unlike in joint stock companies), this avoids the concentration of control in a few hands.
- In a cooperative, there are shareholders, a board of directors and the elected officers similar to the corporation.
- There are periodic meetings of shareholders, also.
- Special laws deal with the formation and taxation of cooperatives.
- Cooperative organisation is a kind of voluntary, democratic ownership formed by some motivated individuals for obtaining necessities of everyday life at rates less than those of the market. The principle behind the cooperative is that of cooperation and self-help.

Forms of Cooperative Enterprises

(*i*) *Consumer's Cooperatives,* in retail trade and services.

(*ii*) *Producer Cooperatives,* for group buying and selling such items as dairy products, grain, fruit, etc.

(*iii*) *Cooperative farming* for more and good quality yield from the farms.

(*iv*) *Cooperative housing* for constructing and providing houses to the members of the association at relatively lesser rates.

(*v*) *Cooperative credit society*, to provide loans to the needy individuals.

Advantages

(*i*) Daily necessities of life can be made available at lower rates.

(*ii*) It is the democratic form of ownership.

(*iii*) Overheads are reduced as members of the cooperative may render honorary services.

(*iv*) It promotes cooperation, mutual assistance and the idea of self-help.

(*v*) The chances of large stock-holding (hoarding) and black marketing are eliminated.

(*vi*) No one person can make huge profits.

(*vii*) Common man is benefited by cooperatives.

(*viii*) Monetary help can be secured from government.

(*ix*) Goods required can be purchased directly from the manufacturers and therefore can be sold at less rates.

Disadvantages

(*i*) Since the members of the cooperative manage the whole show, they may not be competent enough to make it a good success.

(*ii*) Finance being limited, specialist's services cannot be taken.

(*iii*) Conflict may arise among the members on the issue of sharing responsibility and enjoying authorities.

(*iv*) Members who are in position may try to take personal advantages.

(*v*) Members being in services may not be able to devote necessary attention and adequate time for supervising the works of the cooperative enterprise.

16.7. PUBLIC SECTOR

Concept of Public Sector

- A public enterprise is one that is
  - (1) Owned by the state,
  - (2) Managed by the state, or
  - (3) Owned and managed by the state.
- The sector of public enterprises is popularly known as the *Public Sector.*
- Public enterprises are controlled and operated by the Government either solely or in association with private enterprises.
- Public enterprises are controlled and operated by the Government to produce and supply goods and services required by the society.
- Ultimate control of public enterprises remains with the state and the state runs it with a service motto.
- Its sphere embraces all units, irrespective of risks involved and profit expected.
- There is no dearth of capital in public sector and business expansion is not difficult.
- Public sector prevents concentration and unbalanced growth of industries.
- Public sectors are accountable in terms of their results to Parliament and State Legislature.
- A public enterprise is seldom as efficient as a private enterprise ; wastage and inefficiency can seldom be reduced to a minimum.

Evolution of Public Sector

- The Industrial Revolution gave rise to many bitter social evils. It also gave birth to private capitalism. Consumers and workers were exploited and, therefore, there arose the need of State Intervention in industrial field. The intervention led to evolution of public sector/enterprises.
- The evolution of public sector in India is recent. Prior to 1947, there was virtually no public sector barring the field of transport and communication, *i.e.*, Railways, Posts and Telegraphs etc., are being managed by the Central Government since pre-independence period.
- Since independence, a large number of public enterprises have been established both by Central and State Governments. The Hindustan Shipyard, The Hindustan Steels, the Hindustan Machine Tools, The Bharat Heavy Electricals, Indian Telephone Industries, Indian Airlines, Life Insurance Corporation are a few examples of public sector.

Objectives of Public Sector

(1) To provide basic infrastructure facilities for the growth of economy.

(2) To promote rapid economic development.

(3) To undertake economic activity strategically important for the growth of the country, which if left to private initiative would distort the national objective.

(4) To have balanced regional development and even dispersal of economic activity throughout the country.

(5) To avoid concentration of economic power in a few hands.

(6) To create employment opportunities on an increasing scale.

(7) To earn foreign exchange in order to export commodities not available in the country *e.g.*, petroleum oil, sophisticated weapon systems etc.

(8) To look after well-being and welfare of public.

(9) To minimize exploitation of workers and consumers.

Merits of Public Sector

(1) Public sector helps in the growth of those industries which require huge amount of capital and which cannot flourish under the private sector.

(2) Public sector helps in the implementation of the economic plans and enables them to reach the target of achievement within a prescribed period by taking initiative in the establishment of industries of its own accord.

(3) Due to the absence of project motive in the public sector, the consumers are benefitted by greater, better and cheaper products.

(4) Public enterprise prevents the concentration of wealth in the hands of a few and paves the way for equitable distribution of wealth among different sections of community.

(5) Public enterprise encourages industrial growth of under-developed regions in the country.

(6) Profits earned by public sector may be used for the general welfare of the community.

(7) Public sector offers equitable employment opportunities to all ; there is no discrimination, as may be in a private sector.

(8) Capital, raw material, fuel, power and transport are easily made available to them.

Demerits of Public Sector

(1) Public sector can rarely attain the efficiency of a private enterprise ; wastage and inefficiency can seldom be reduced to a minimum.

(2) Due to heavy administrative expenses, state enterprises are mostly run at a loss leading to additional burden of taxation on the people.

(3) There is too much interference by the Government and Politicians in the internal affairs of the public enterprises. As a result inefficiency increases.

(4 Delay in decisions is a very common phenomena in public enterprises.

(5 Incompetent persons may occupy high levels.

(6) Workers (unlike in private concerns) shirk work.

16.8. PRIVATE SECTOR

Concept

- Private sector serves personal interests and is a non-government sector.
- Profit (rather than service) is the main objective.
- Private sector constitutes mainly consumer's goods industries where profit possibilities are high.
- Private sector does not undertake risky ventures or those having low-profit margin.
- Private enterprises are run by businessmen, capital is collected from the private partners.

Merits

(*i*) The magnitude of profits incurred is high.

(*ii*) The efficiency of the private enterprise is high.

(*iii*) Wastage of material and labour is minimum.

(*iv*) Decision-making is very prompt.

(*v*) There is no interference in its internal affairs by politicians or Government.

(*vi*) Competent persons occupy high levels.

Demerits

(*i*) There is exploitation motive, the workers and the consumers may not receive fair deal.

(*ii*) There is dearth of capital to expand the business.

(*iii*) Private enterprise leads to concentration of wealth in the hands of a few.

(*iv*) Private enterprises lead to unbalanced growth of industries.

17

Supervisory and Leadership

17.1. INTRODUCTION

- A *Foreman* generally designated by *Supervisor* (in most of the industries) is a person incharge of, and coordinator of, the activities of a group of workers engaged in one type of task.
- A Foreman/supervisor is a vital link between the management and the workers.
- A foreman is the person who actually gives practical shape to the policies of the enterprise, with the help of workmen.
- Information, both vertically upwards or downwards passes through the foreman.
- A foreman is concerned with the direct supervision of the workers.

17.2. DUTIES AND RESPONSIBILITIES OF A FOREMAN/THE SUPERVISOR'S JOB

1. Towards Management

- To transmit management policies to workers.
- To accept full responsibility for all the work in his department.
- To transmit worker's feelings to management.
- To keep management informed of the work-progress.
- To get the required production out in time.
- Refer promptly the matters to management which need their attention.
- To take up cases of promotion, transfer and dismissal of workers with the management.
- To make plans and devise methods to boost productive efficiency and product quality.
- Devise ways to minimize waste and scrap.
- To keep records for future action.
- To render reports to management as desired.

2. Towards Workers

- To instruct workers about,

(*i*) Company policies and procedures.

(*ii*) The right method of doing the job.

(*iii*) The job ahead.

- To listen patiently the workers, their suggestions and complaints.
- To maintain discipline.
- To develop a sense of belonging in the workers.
- To maintain neat, clean and safe working conditions.
- Divide work among workers in accordance with their capacity and skill.
- To represent workers to management.
- Encourage and train workers to take responsibilities.
- To promote and transfer workers in an impartial manner.
- Develop harmony, cooperation and team work.
- To rate workers for determining their wage rates.
- To train the workers on the job.
- Develop worker's initiative and interest in the job and to motivate them.
- Setting good example in punctuality, temperament, leadership, efficiency, etc.

3. Towards Fellow Supervisors

- To cooperate with them in making company policies a success.
- To give respect to suggestions of fellow supervisors.
- To coordinate work with other departments.
- Passing any information pertaining to other associates, to them.
- Sitting together with other colleagues to solve common problems.
- Encouraging interchange of good workers through promotion and transfer, etc.
- To avoid the creation of ill-feeling among fellow supervisors.

4. Towards Work

- To plan the work.
- To make sure that the material is available for the work.
- To make sure that the necessary equipment and tools are also available.
- To lay out each job.
- To distribute work to workforce as per individual capabilities.
- To see that the work is being accomplished as per the scheduled plan.
- To ensure proper material handling.
- To ensure smooth flow of work.
- To coordinate work of different sections.

- To check the work as regards quantity and quality.
- To keep abreast with the modern developments in his own field of work.

17.3. QUALIFICATIONS OF A FOREMAN

(*i*) Suitable engineering qualification to understand the technical aspects of the job, production processes, equipments, etc.

(*ii*) Skill to meet the demands of the job.

(*iii*) Mechanical ability.

(*iv*) Skill in imparting instructions to the workers.

(*v*) Familiarity with

Production control
Quality control
Safety practices
Machine management
Record keeping
Merit rating
Costing and Estimating, etc.

(*vi*) Ability to train workers.

(*vii*) Ability to handle (*i.e.* supervise and control) workers properly.

(*viii*) Elementary knowledge of labour psychology.

(*ix*) Familiarity with modern developments in the field, etc.

17.4. QUALITIES OF A FOREMAN

(*i*) Democratic leadership.

(*ii*) Result consciousness.

(*iii*) Judgement and decision making in an existing situation.

(*iv*) Full knowledge of men, materials and machines.

(*v*) Versatility and ingenuity.

(*vi*) A cooperative sympathetic and helpful attitude towards others.

(*vii*) Just, fair and impartial attitude towards all his subordinates.

(*viii*) Self-control and firmness.

(*ix*) Ability to develop an organisation.

(*x*) Ability to plan and control work.

(*xi*) Wilful acceptance of responsibility.

(*xii*) Constructive and independent thinking, etc.

17.5. LEADERSHIP

Definition and concept

- Leadership is the knack of getting other people to follow you and to do willingly the things you want them to do.
- Leadership means to inspire confidence and trust so that there is maximum cooperation from the employees within the control of a manager.
- Leadership is the ability to persuade others to seek defined objectives enthusiastically. It is the

human factor which binds a group together and motivates it toward goals.

– Leadership may also be defined as the process of influencing a group in a particular situation at a given point of time and in a specific set of circumstances that stimulate people to strive willingly to attain company objectives.

Styles (Types) of Leadership

The three relatively distinct leadership styles are

1. Authoritarian,
2. Democratic, and
3. Laissez-Faire.

1. Authoritarian Leadership

– It is felt that this technique is old-fashioned, but it works well in many cases.

– The leader makes all the decisions (no matter it is right or not) and demands obedience from the people he supervises.

– All policies are determined by the leader without consulting the subordinates.

– The leader dictates to the subordinates, the techniques and activity steps, he tells them what to do next, he does not inform them about future plans and thus future steps always remain uncertain to a large degree.

– The leader decides the particular work task for a person and the work companion of each person (worker).

– The leader tends to be *personal* in his praise and criticism of the work of each member (worker).

– The leader remains aloof from active group participation except when demonstrating.

– Authoritarian leadership is negative because the subordinates remain uninformed, they feel insecure and remain afraid of the leader.

– In authoritarian leadership, there is a tighter control and supervision over the persons (*i.e.* subordinates).

– Authoritarian leadership succeeds where

(*i*) Subordinates shirk work but want security.

(*ii*) Subordinates do not want to take initiative.

– The advantages of Authoritarian leadership is that

(*i*) Decisions can be taken quickly.

(*ii*) Some people who simply work for fear of punishment remain disciplined and devoted towards the tasks given to them.

2. Democratic Leadership

– Democratic leadership is most popular today.

– The leader discusses and consults his subordinates. He draws ideas from them, supervises and lets them help set policy.

- A democratic leader promotes participation of subordinates and develops strong team work.
- All policies come out of group discussions, the subordinates being constantly encouraged and assisted by the leader.
- The leader gives decision only after consulting his subordinates. Actually the decision emerges out of the subordinate group itself.
- Subordinates know the long term plans on which they are supposed to work, thus they are kept well informed.
- Division of tasks is left upon the group; individuals are free to work with whomsoever they choose.
- A democratic leader is *objective* or *fact-minded* in his praise and criticism; he tries to be a regular group member in spirit without doing too much of the work.
- *Democratic leadership*

(*i*) Motivates subordinates to work, and improves their attitude towards work.

(*ii*) Promotes healthier relations between workers and management.

(*iii*) Minimizes employee-grievances.

(*iv*) Raises the employee-morale.

- Democratic leadership works very well if the subordinates (also) feel their responsibility, tend to be reasonable and do not take undue advantage of the democratic leadership.

3. Free Rein or Laissez-Faire Leadership

- This is the most difficult to use type of leadership.
- The leader acts as an information centre and exercises minimum of control.
- The leader depends upon subordinate's sense of responsibility and good judgement to get the work done.
- There is a complete freedom for group or individual decision, with a minimum of leader participation
- The leader supplies various materials, gives information when asked but takes no other part in work discussion.
- The leader makes no attempt to appraise or regulate the course of events.
- Actually, a Free Rein leader does not lead the subordinates but leaves them entirely to themselves; the responsibility for accomplishing most of the work lies on the shoulders of the subordinates.
- The subordinate group establishes its own goals and solves its own problems.
- The leader is simply a contact man, he ignores leader's contribution, he intervenes least and avoids power.
- Free Rein leadership can work only if the subordinates are highly educated, brilliant and they possess good sense of responsibility.

17.6. QUALITIES OF (GOOD) LEADERSHIP

1. **A sense of mission.** A devotion to the people and the organisation in which one serves.
2. **Accomplishment.** Effective use of time in meeting company goals and objectives.
3. **Education : broad as well as technical.**
4. **Acceptability.** From the subordinates ; respect from and confidence of others.
5. **Self-denial.** A willingness to forgo self-indulgences and the ability to bear the headaches the job entails.
6. **Acuteness.** A leader remains mentally alert and readily comprehends instructions, explanations and unusual circumstances.
7. **High intelligence.** A leader should be able to come down to the level necessary for the subordinates he is leading.
8. **High character.** Includes honesty, sincerity, and the courage to face hard facts, unpleasant situations, etc.
9. **Administration.** Ability to plan and organise the work, delegation of responsibility and authority, controlling position activities, etc.
10. **Maturity.** In coping with situations and making decisions, emotionally stable and unlikely to break down with frustration.
11. **Job Competence.** A leader knows well the job he supervises.
12. **Analysis and Judgement.** A leader performs critical evaluation of potential current problem areas ; he possesses wisdom to look into future.
13. **Initiative and drive.** Self-starting to achieve both personal and company objectives.
14. **Energy.** Good health, good nerves and boundless energy make even tough jobs easier.
15. **Attitude.** Enthusiastic, Optimistic, and Loyal attitude towards the organization.
16. **Personal compliance.** Degree to which leader does what is expected of him, such as setting good example by being punctual, honest, just etc.
17. **Constructive, creative and independent thinking.** Ability to originate and develop ideas intelligently and to make constructive suggestions and improvements.
18. **Dependability.** A leader meets schedules and dead lines and adheres to company policies.
19. **Group Spirit.**
20. **Flexibility.** A leader is adaptable, and quickly adjusts to changing conditions.
21. **Knowledge of Industrial psychology and human relations.** A leader understands personnel interactions, has feel for individuals and recognises their problems; is considerate towards others; can motivate and get people to work together.
22. **Approachability.** The extent, to which he is willing to sit and talk with his subordinates and to which they are willing to talk things over with him.
23. **Open-mindedness.** A leader has open-mind and makes decisions without the influence of personal or emotional interests.
24. **Self-confidence.** Self assurance; self-reliance; inner security, etc.
25. **Cheerfulness and Socialness.** A leader remains always cheerful, he makes friends easily and has sincere interest in people.
26. **Verbal ability and communication.** Articulate; communicative and is generally understood by people at different organizational levels.
27. **Good poise and bearing.**
28. **Vision.** Possesses foresight, sees new trends and opportunities; anticipates future events, etc.

18

Decision Making

18.1. INTRODUCTION AND DEFINITION

- A *decision* is the conclusion of *a process* by which one chooses between two or more available alternative courses of action for the purpose of attaining a goal(s). The process is called *decision making. Managerial decision making* is synonymous with the whole process of management. To illustrate the idea, let us examine the important managerial function of *planning.* Planning involves a *series of decisions* such as : what should be done? When ? How ? Where ? By Whom ? Hence planning implies decision making. Other functions of management such as organizing and controlling can also be viewed as composed of making decisions.

- A decision is an act of *choice* wherein a manager forms a *conclusion* about what must be done under a given situation. A decision represents a course of behaviour chosen from a number of possible *alternatives.*

  Decision making involves two or more alternatives because if there is only one alternative, there is no decision to be made.

- A decision is a course of action or inaction selected to meet the requirements of a solution (*i.e.,* problem).

- Decision may also be conceived as a conclusion that a manager has reached so as to know what he (or others) should do in future (or later on). The future must be seen at least in generality, if the decision is to be properly oriented in terms of goals.

- Decision making is an intellectual activity, because it calls for both judgement and imagination to select one from among many alternatives.

- Decision with regard to future course of action for the organisation, over short or long terms, may be directed in every conceivable physical and organizational area, for example, there are

  (*i*) Inventory control decisions.

  (*ii*) Marketing decisions.

18.2. IMPORTANCE OF DECISION MAKING

- Throughout the business cycle, it is required to supply, financial, technical or other information as an input to help making decisions at higher management levels, for achieving maximum return on the assets of the business enterprise.

- Decisions are usually made to attain the objectives of the business.

- In business, whether the enterprise is big or small, changes in condition occur, shifts in personnel take place, unforeseen contingencies arise. Moreover, just to get wheels started and to keep them moving, decisions must be made.

- Every aspect of management functions, such as planning, organizing, and control is determined by decisions, the result of which is the performance in the organization.

– Decision making is vital to all management activities. It helps set definite objectives, prepare plans of action, determine organizational structure, motivate personnel and introduce innovations.

18.3. DECISION MAKING AND PROBLEM SOLVING

– A major premise of management science is *decision making*, regardless of the situation involved, which can be considered as a general *process*, consisting of the steps : (1) defining the problem (2) searching for alternative courses of action (3) evaluating the alternatives (4) selecting one alternative.

– Much confusion exists between the terms *decision making* and *problem solving*. One way to distinguish between the two is to consider the entire process (steps 1-4 above) as *problem solving* ; the specific step of making the choice (step 4 above) is the *decision* or the *solution* to the problem.

18.4. TYPES OF DECISIONS

Decisions may be of different types. Some of the important types of managerial decisions are explained below :

1. Programmed and Non-programmed decisions.
2. Major and Minor decisions.
3. Routine and Strategic decisions.
4. Organizational and personal decisions.
5. Individual and group decisions.
6. Policy and operation decisions.
7. Long-term, departmental and Non-economic decisions.

1. Programmed and Non-programmed decisions

(*a*) *Programmed decisions* are those made in accordance with some habit, *rule* or *procedure*. Every organisation has written or unwritten *policies* that simplify decision making in recurring situations by limiting or excluding alternatives. For example, we would not usually have to worry about what to pay to a newly hired employee; organizations generally have an established salary scale for all positions. Routine procedures exist for dealing with routine problems.

– Routine problems are not necessarily simple ones; programmed decisions are used for dealing with complex as well as with uncomplicated issues.

– To some extent, of course, programmed decisions limit our freedom, because the organization rather than the individual decides what to do. However, the policies, rules or procedures by which we make decisions free us of the time needed to work out new solutions to old problems, thus allowing us to devote attention to other, more important activities in the organization.

(*b*) *Non-programmed decisions* are those that deal with unusual or exceptional problems.

– If a problem has not come up often enough to be covered by a policy or is so important that it deserves special treatment, it must be handled by a non-programmed decision.

– Such problems as (1) how to allocate an organisation's resources (2) what to do about a failing product line, (3) how community relations should be improved will usually require non-programmed decisions. As one moves up in the organizational hierarchy, the ability to make non-programmed decisions becomes more important because progressively more of the decisions made are non-programmed.

2. **Major and Minor Decisions**

A decision related to the purchase of a CNC machine costing several lakhs is a major decision and purchase of a few reams of typing paper is a minor (matter or) decision.

3. **Routine and strategic decisions**

- *Routine decisions* are of repetitive nature, do not require much analysis and evaluation, are in the context of day-to-day operations of the enterprise and can be made quickly at middle management level. An example is, sending samples of a food product to the Government investigation centre.
- *Strategic decisions* relate to policy matter, are taken at higher levels of management after careful analysis and evaluation of various alternatives, involve large expenditure of funds and a slight mistake in decision making is injurious to the enterprise. Examples of strategic decisions are– capital expenditure decisions, decisions related to pricing, expansion and change in product line etc.

4. **Organizational and personal decisions**

- A manager makes *organizational decisions* in the capacity of a company officer. Such decisions reflect the basic policy of the company. They can be delegated to others.
- *Personal decisions* relate the manager as an *individual* and not as a member of an organization. Such decisions cannot be delegated.

5. **Individual and Group decisions**

- *Individual decisions* are taken by a single *individual* in context of routine decisions where guidelines are already provided.
- *Group decisions* are taken by a *committee* constituted for this specific purpose. Such decisions are very important for the organisation.

6. **Policy and operative decisions**

- *Policy decisions* are very important, they are taken by top management, they have a long-term impact and mostly relate to basic policies.
- *Operative decisions* relate to day-to-day operations of the enterprise and are taken at lower or middle management level.

Whether to give bonus to employees is a policy decision but calculating bonus for each employee is an operative decision.

7. **Long-term departmental and non-economic decisions**

- In case of *long term decisions,* the time period covered is long and the risk involved is more.
- *Departmental decisions* relate to a particular department only and are taken by departmental head.
- *Non-economic decisions* relate to factors such as technical values, moral behaviour etc.

18.5. THEORIES OF DECISION MAKING

The major theories of decision-making are :

1. The Intuition or the Traditional Theory.

2. The Classical Theory.
3. The Behavioural Theory.

1. The Intuition Theory

Decisions are taken by *intuition* or *hunch* without really considering carefully all the alternatives. A person just decides a particular course of action because he feels that, that course is the best one.

2. The Classical Theory

This is just opposite to Intuition Theory. Here the decision is made rationally, after a careful probing into all the alternatives. It is essentially a theory of decision making under conditions of certainty which is, of course, a rare phenomenon.

3. The Behavioural Theory

Decisions are made on the basis of a limited, approximate model of the real situation.

18.6. TECHNIQUES OF DECISION MAKING

Type of decision	*Decision-Making Techniques*	
	Traditional	*Modern*
1. *Programmed* Routine, repetitive decisions Organization develops specific processes for handling them	(1) Habit (2) Clerical routine standard operating Procedures (3) Organization structure : Common expectations A system of subgoals Well defined informational channels	(1) Operations Research Mathematical analysis, Models, Computer simulation (2) Data processing
2. *Non-programmed :* Non-routine, one shot, ill structured, novel policy decisions Handled by general problem-solving processes	(1) Judgement, intuition, and creativity (2) Rule of thumb (3) Selection and training of executives	Heuristic problem solving technique applied to : (*a*) Training human decision makers (*b*) Constructing heuristic computer programs.

18.7. DECISION MAKING PROCESS

– Decision making has following distinct phases :

(1) Defining the problem.
(2) Analysing the problem.
(3) Developing alternative solutions.
(4) Deciding upon the best solution.
(5) Converting the decision into effective action.
(6) Implementing and verifying the decisions.

(1) Defining the problem

- Management may see a clash of personalities ; the real problem may well be poor organization structure. Management may see a problem of manufacturing costs and start a cost-reduction drive ; the real problem may well be poor engineering design or poor sales planning. Similarly, management may see an organizational problem ; the real problem may well be lack of clear objectives.

- In the light of above, the first job in decision making is therefore to find the real problem and to define it.

- *Symptomatic diagnosis*—the method used by most managers is no solution. It is based upon experience rather than upon analysis, which alone rules it out for the business manager who cannot systematically acquire this experience.

- To arrive at the *definition* of the problem, the manager must begin by finding the *critical factor.* This is the element(s) in the situation that has to be changed before anything else can be changed, moved, acted upon.

- To find the critical factor by straight analysis of the problem is not always easy. Often *two* subsidiary approaches have to be used.

  One approach assumes that nothing whatever will change and asks : what will then happen in time ?

  The other approach projects backward and asks: what, that could have been done or left undone at the time this problem first appeared, would have materially affected the present situation?

- The second step in the definition of the problem is to determine the conditions for its solution.

  The *objectives* for the solution must be thought through.

  The objectives should always reflect the objectives of the business, should always be focused ultimately on business performance and business results. They should always balance and harmonize the immediate and the long range future. They should always take into account both the business as a whole and the activities needed to run it.

- At the same time the *rules* that limit the solution must be thought through.

  What are the principles, policies and rules of conduct that have to be followed ? It may be a rule of the company never to borrow more than half its capital needs. It may be a principle never to hire a man from outside without first considering all inside managers carefully, etc. To spell out the rules is necessary because in many cases the right decision will require to change accepted policies or practices.

(2) Analysing the problem

- Analysing the problem means *classifying* it and finding the *facts.*

- It is necessary to *classify* the problem in order to know who must make the decision, who must be consulted in making it and who must be informed.

  Classification alone can show who has to do what in order to convert the decision into effective action.

- There are *four principles* of classification.

(1) The futurity of the decision (the time-span for which it commits the business to a course of action and the speed with which the decision can be reversed.)

(2) The impact of the decision on other areas and functions.

(3) The number of qualitative considerations that enter into it, and

(4) The uniqueness or periodicity of the decision.

This classification can alone ensure that a decision really contributes to the whole business rather than solves an immediate or local problem at the expense of the whole.

– In *getting the facts* the manager has to ask (*i*) What information does he need for this particular decision ? (*ii*) He has to decide how relevant and how valid are the data in his possession. (*iii*) He has to determine what additional information he needs and do whatever is necessary to get it. These are not mechanical jobs. The information itself needs skillful and imaginative analysis.

To make a sound decision, it is not necessary to have all the facts ; but it is necessary to know what information is *lacking* in order to judge how much of a risk the decision involves, as well as the degree of precision and rigidity that the proposed course of action can afford. The manager must know where lack of information has forced him to guess. He must define the unknown.

(3) Developing alternative solutions

– It should be an invariable rule to develop several alternative solutions for every problem. Otherwise there is the danger of falling into the trap of the false *either-or*.

– Taking an example : an old plant of a small plumbing equipment manufacturer had become obsolete and threatened the company with the total loss of market position in a highly competitive and price-conscious industry. Management rightly concluded that it had to move out of the plant. But because it did not force itself to *develop alternative* solutions, it decided that it had to build a new plant. And this decision bankrupted the company. Actually there were plenty of alternative courses of action, (*i*) to sub-contract the plant (*ii*) to become a distributor for another manufacturer not yet represented in the territory etc.

The above and many such cases reveal how limited most of us are in our imagination. We tend to see one pattern and consider it right.

Alternative solutions are the only means of bringing our basic assumptions up to the conscious level, forcing ourselves to examine them and test their validity. Alternative solutions are no guarantee of wisdom or of the right decision. But at least they prevent our making, what we would have known to be the wrong decision had we but thought the problem through.

What the alternatives are, will vary with the problem.

– It is rare for alternatives to be lacking for any course of action ; indeed, a sound adage for the manager is that if there seems to be only one way of doing a thing, that way is probably wrong. In such a case, the manager, probably has not forced himself to consider other ways, which is necessary if the decision is to be the best possible.

– The ability to develop alternatives is often as important as selecting correctly from among them. On the other hand, ingenuity, research and perspicacity will often unearth so many choices that they cannot be adequately evaluated. The decision maker needs help in this situation, and this, as well as assistance in choosing the best alternative, may be found in the concept of the strategic factor.

– A *limiting factor* is one which stands in the way of accomplishing a desired factor. If these factors are clearly recognized, managers will confine their search for alternatives to those which will overcome the limiting factors. A limiting factor in a manufacturing enterprise may be lack of cash.

(4) Deciding upon the best solution

– In choosing from among alternatives, the more an individual can recognize and solve for those factors which are limiting or critical to the attainment of the desired goal, the more clearly and accurately he can select the most favourable alternative.

– There are *four criteria for picking the best from among the possible alternative solutions :*

(*i*) *The risk.* The manager has to weigh the risks of each alternative solution against the expected gains.

(*ii*) *Economy of effort.* Which of the possible alternative solutions will give the greatest results with the least effort. Far too many managers pick an elephant gun to chase sparrows. Too many others use sling-shots against forty-ton tanks.

(*iii*) *Timing.* If the situation has great urgency, the preferable course of action is one that dramatizes the decision and serves notice on the organization that something important is happening. If, on the other hand, long consistent effort is needed, a slow start that gathers momentum may be preferable.

(*iv*) *Limitations of resources.* The most important resource whose limitations have to be considered, are the *human beings* who will carry out the decision. No decision can be better than the people who have to carry it out. Their vision, competence, skill and understanding determine what they can and cannot do. Efforts must be made to raise the ability and standard of the people or new people may have to be found for the purpose.

– *In selecting from among alternatives, a manager has three bases* for decision open to him– *experience, experimentation* and *research and analysis.*

(*a*) Reliance on *past experience* probably plays a larger part than it deserves in decision making. This attitude is more pronounced, the more experience a manager has had and the higher in an organisation he has risen.

To some extent, the attitude that experience is the best teacher is justifiable. There is danger, however, in relying on one's past experience as a guide for future action, because future may have new problems and events.

On the other hand, if experience is carefully analyzed rather than blindly followed and if the fundamental reasons for success or failure are distilled from it, it can be useful as a basis for decision analysis.

(*b*) *Experimentation* is another way to help make decisions. An obvious way to decide upon alternatives is to try them and see what happens. Such experimentation is used in scientific inquiry.

Experimentation is likely to be the most expensive of all techniques, but their are many decisions which cannot be made until the best course of action can be ascertained with experiment.

(*c*) *Research and Analysis* is the most generally used and certainly a most effective technique for selecting from alternatives when major decisions are involved.

Research and analysis is much cheaper than experimentation.

The approach entails solving a problem by :

(*i*) Comprehending it. It thus involves a search for relationships between the more critical variables, constraints and premises that bear upon the goal sought. In a real sense it is the pencil and paper (or better, the computer and print out) approach to decision making.

(*ii*) In the second place, the solution of a planning problem requires that it be broken into its component parts and the various tangible and intangible factors studied.

A major characteristic of research and analysis approach is to develop a *model* simulating the problem situation by mathematical terms and relationships. Being thus able to conceptualize a problem is a major step toward its solution.

Process of Evaluation

- Once appropriate alternatives have been isolated, the next step is to evaluate them and select the one which will best contribute to the goal. This is the point of ultimate decision making.
- As we approach the problem of comparing alternatives for achieving an objective, both *quantitative* and *qualitative factors* need to be taken into consideration. *Quantitative factors* are those which can be measured such as various types of fixed and operating costs and the time and cost associated with ancillary services.

  Qualitative or unmeasurable factors are such as quality of labour relations, the risk of technological change or the international political climate. In many cases, even the best of quantitative plans were destroyed by an unforeseen war.
- The *evaluation of alternatives* may utilize the techniques of *marginal analysis,* wherein the additional revenues from additional costs are compared. Marginal analysis can be used in comparing factors other than costs and revenues. For example, to find the optimum output of a machine, one could vary inputs against outputs until the additional input equals the additional output. This would then be the point of maximum efficiency of the machine.
- An *improvement* on traditional marginal analysis is *cost effectiveness* or *cost-benefit analysis.* Cost effectiveness is a technique for choosing from among alternatives to identify a preferred choice when objectives are *far less specific* than those expressed by such clear quantities as sales, costs or profits. For example, *defense objectives* may be so unspecific as those to repel enemy attack, *social objectives* such as reduce air pollution, reduce unemployment, etc.

(5) Making the decision effective

- Finally, any solution has to be made effective in action.
- It is of the essence of a manager's decision that other people must apply it to make it effective. A manager's decision is always a decision concerning what other people should do. They must make it their own.
- To convert a solution into action requires that people understand what change in behaviour is expected of them, and what change to expect in the behaviour of others with whom they work. What they have to learn is the minimum necessary to make them able to act the new way. However, it is poor decision making (to present a decision) if people are required to learn all over again.
- It is better, if the people who have to carry out the decision should always participate in the work of developing alternatives.
- Precisely because the decision affects the work of other people, it must help these people achieve their objectives, assist them in their work, contribute to their performing better, more effectively and with a greater sense of achievement. It cannot be a decision designed merely to help the manager perform better, do his job more easily or obtain greater satisfaction from it.

(6) Implementing and verifying the decision

- Effectiveness of decision in achieving the desired goals depends on its *implementation.* Best decisions are futile if they are not effectively implemented.

– Further, *follow up* is essential to verify the proper implementation of the decision and to modify decisions, if necessary.

Follow-up system will ensure the achievement of objectives.

18.8. THE SCIENTIFIC APPROACH TO THE DECISION PROCESS

– The scientific approach is a formalized reasoning process. It consists of the following steps :

Step-1. The problem for analysis is *defined* and the conditions for observation are determined.

Step-2. *Observations* are made under different conditions to determine the behaviour of the system containing the problem.

Step-3. Based on the observations, a *hypothesis* that describes how the factors involved are thought to interact or what is the best solution to the problem, is conceived.

Step-4. To test the hypothesis, an *experiment* is designed.

Step-5. The experiment is executed and *measurements* are obtained and recorded.

Step-6. The *results* of the experiment are analyzed and the hypothesis is either accepted or rejected.

These six steps of the scientific method can be applied to decision making. For example, the *evaluation* of alternatives is done scientifically through experimentation.

The overall relationship of the scientific approach to the decision making process is shown in Fig. 18.1.

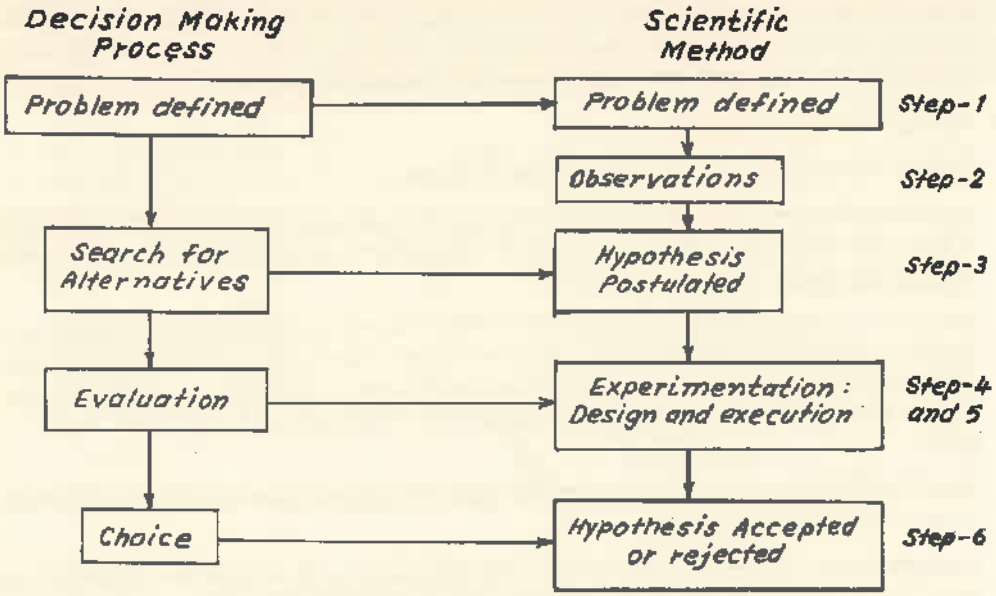


Fig. 18.1. Relationship of the Scientific Approach to the Decision Process.

18.9. GUIDELINES FOR EFFECTIVE DECISION MAKING

The following guidelines may be followed for effective decision making :

1. Define the goals.
2. Ensure that the decision will contribute to the goal.

3. Adopt a diagnostic approach to decision making.
4. Involve subordinates in decision making process.
5. Ensure successful implementation of the decision.
6. Evaluate the results, and
7. Be flexible and revise the decision which does not yield the desired results.

18.10. QUANTITATIVE METHODS IN DECISION MAKING

Introduction

- Regardless of how much difficult the study of mathematics may be to some, the fact remains that the business manager today must deal with *quantitative concepts* in order to run a complex operation effectively.
- The increasing use of *quantitative techniques* has enabled managers to make more intelligent use of the vast amounts of *data* now available to the business organization.

  As a result of the use of the many available quantitative techniques, this *data* can be processed to provide information valuable to the manager in carrying out *planning, decision-making,* and/or *controlling functions.*
- During World War II, certain mathematical techniques were developed to aid in the resolution of complex military problems and in recent years they have been applied to aid managers in their decision making.
- The application of *quantitative techniques* to management decision making can aid greatly in reducing the risk and uncertainty the manager must confront daily. Although some quantitative tools have been used by managers for decades, the emphasis in recent years has been on *Operations Research* (O.R.) a concept which merged during World War II. Used in conjunction with the computer, O.R. is the mathematical application of the scientific method to the solution of business problems.
- At the center of the O.R. is the *mathematical model* – a set of equations representing the actual problem situation. The specific technique used to construct and solve the model depends upon the nature of problem. Some of the O.R. techniques are Linear Programming, Queuing theory, etc.
- **Various quantitative techniques for decision making are :**

1. *Deterministic Models*
   - Break-even Analysis
   - Linear Programming
   - Capital Budgeting
   - Inventory Management
2. *Probabilistic Models*
   - Expected value model
   - Decision tree
   - Simulation
3. *Other techniques*
   - Waiting Line Theory
   - Game models
   - Information theory
   - Utility theory
   - Heuristic problem solving

– **A Deterministic Model** is typically appropriate when a manager can obtain *reliable data.* If a manager knows precisely what revenues are for a particular year, this enables him to solve problems involving revenues.

– **A Probabilistic Model** does not require the exact value of all factors in a problem as a deterministic model needs. Probabilistic models, on the other hand, can be used for solving problems involving *chance* or random *factors.*

Managers rarely, if ever, know with complete certainty how demand will shift as the price of a product is raised. Typically, managers must make decisions under conditions of at least some uncertainty. The function of probabilistic models is to reduce uncertainty.

18.11. MATHEMATICAL PROGRAMMING

– Besides the calculus, there are other management science techniques which can be employed to resolve a variety of decision problems.

– One such technique is *Mathematical Programming* which is useful whenever several factors constrain the choice of strategies.

– Consider the inventory problem. If the objective is simply to minimize total cost, there are no constraints which limit our choice of strategies. If there are constraints, they might limit either the space in which inventory can be placed, the funds which can be spent on inventory, or the maximum number of orders that can be placed by the purchasing department.

This being the case, it would have become a problem in *constrained* minimization and mathematical programming techniques could be used to find a solution.

– The *constraints* create the environment within which decision makers strive to maximize or minimize the objectives to be achieved. This is the essence of mathematical programming: Constrained maximization or minimization. It becomes an intuitively appealing framework for the analysis of many types of business problems. The difficult task, however, is shouldered by the model builder, who must abstract from the environment those important elements that are to be incorporated in the *mathematical model.*

– Linear programming techniques such as *Simplex method, graphical method* etc., make the mathematical models to solve them (refer chapter 11).

18.12. MATHEMATICAL MODELS

Concept

A model is a simplified representation of *reality.* It is usually simplified because reality is too complex to copy exactly and because much of the complexity is actually irrelevant to the specific problem.

Types

Models may be classified as :

(1) Iconic (sale)
(2) Analog
(3) Mathematical

(1) An *iconic model* is a physical replica of a system usually based on a different scale than the original. These may appear in three dimensions such as airplane, car or bridge model to scale. Photographs are another type of iconic model but in only two dimensions.

(2) An *analog* model does not look like the real system but behaves like it. These are usually two

dimensional charts or diagrams, *e.g.*, organisation charts, showing structure, authority and responsibility relationships.

Analog models are more abstract than iconic ones.

(3) Mathematical model

- The complexity of relationships in some systems cannot be represented physically or the physical representation may be cumbersome and take time to construct. Therefore a more abstract model is used with the aid of symbols.
- Most management science analysis is executed with the aid of mathematical models which utilize mathematical symbols. These are general rather than specific and can describe diverse situations. Furthermore they can be manipulated easily for purposes of experimentation and prediction.
- When the concept of a model is extended to the area of *mathematics,* it is useful to know in a quantitative sense how important or how pertinent the variables are in the model with regard to their impact on the solution.
- The *mathematical models* depict explicit relationships and interrelationships among the variables and other factors deemed important in solving problems.

The Structure of Mathematical Models

Mathematical models are typically in the form of equations or other mathematical statements. For example, the relationship between cost, revenue and profit can be expressed as

$$P = R - C \qquad \text{.....}(i)$$

where

P symbolizes profit,

R symbolizes revenues, and

C symbolizes cost.

The *components* of a system, when described by a mathematical model, are expressed in terms of variables (such as C and R above). In general, a distinction is made between independent (cause) and dependent (effect) variables.

Characteristics of Mathematical Models

- To be used successfully in a typical Management Science (MS) project, a *mathematical model must meet the following criteria :*

(*i*) The model should be as *simple* and *understandable* as possible.

(*ii*) The Model should be *reasonable.*

(*iii*) The Model should be *easy to maintain and control.*

(*iv*) The model should be *adaptive.* The parameters and structure of the model should be easy to change as new insights and information evolve.

(*v*) The model should be *complete* on important issues, *i.e.*, all important variables and factors should have been taken into consideration.

Advantages:

- *Use of models* avoids constructing costly plants and warehouses in locations that do not best meet the present and future needs of the customers.
- A model indicates *gaps* that are not immediately apparent, and after testing, the character of the failure might give a clue to the model's deficiencies.
- Models have the advantage of time, since results can be obtained within a relatively short time.
- Because of the constant squeeze on profits, the *cost* and *time* saving that MS models allow make

them decision-making tools of great value to the manager.

Disadvantages :

- A model that oversimplifies may inaccurately reflect the real world situation.
- If the person who builds a model does not know what he is doing, output from the model will be incorrect.
- Models can sometimes prove too expensive to originate when their cost is compared to the expected return from their use.

18.13. COST ANALYSIS (BREAK-EVEN ANALYSIS) FOR DECISION MAKING

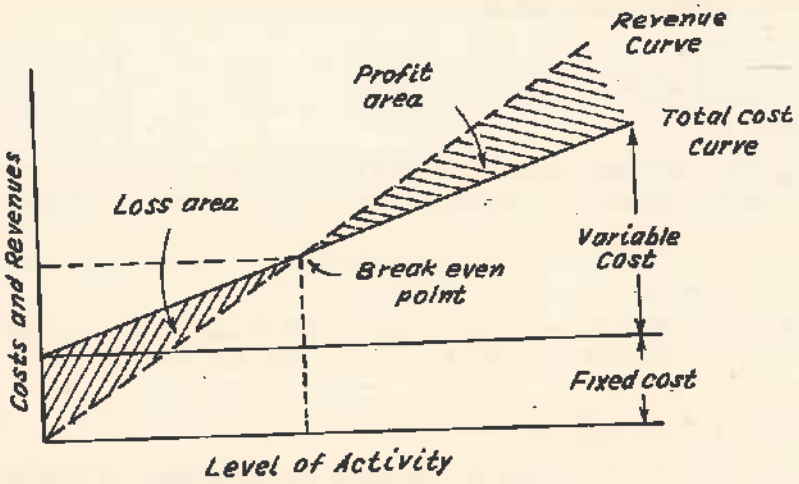
- Managers want to make money.
- The objective of the break-even analysis is to decide the *optimum* break-even point, that is, where profits will be highest.
- In making decisions, managers must pay a great deal of attention to the profit opportunities of alternative courses of action. This obviously requires that the cost implications of those alternatives are assessed.
- An important aspect of such cost analysis is that made between **fixed** and **variable** costs.
- A cost can be classified as being fixed or variable in relation to *changes in the level of activity within a given period.* (In the long run, of course, all costs are variable).
- *Fixed costs* are those which remain fixed irrespective of the volume of production or sales. For example, a managing director's salary will not vary (change) with the volume of goods produced during any year. Road tax payable for a car will not vary with its annual mileage covered. Insurance premiums, rent charges, R & D costs are a few other typical examples of fixed costs.
- *Variable costs* vary or change in response to changes in, say, volume of production or sales or any other similar activity.

  Sales commissions in relation to sales levels, petrol costs in relation to miles travelled and labour costs in relation to hours worked are obvious examples.
- *Mixed costs* are of *hybrid* nature, being partly fixed and partly variable. An example is found in telephone charges - the rental element is a fixed cost, whereas charges for calls made are a variable cost.
- *Separating fixed and variable costs*

  The total cost at any level of operations is the sum of a fixed cost component and a variable cost component.

  The *importance* of separating variable costs from fixed costs stems from the different behaviour patterns of each, which have a significant bearing on their control. Variable Costs must be controlled in relation to the level of activity, whilst fixed costs must be controlled in relation to time. From a *decision-making point of view,* it is also important to know whether or not a particular cost will vary as a result of a given decision.
- By adding graphically *variable cost* to the *fixed cost* for different levels of activity (*e.g.* number of goods produced), a *total cost curve* can be drawn. If a *revenue curve* is super-imposed on the same graph (Fig. 18.2) the result is the *break-even chart* which depicts the profits/loss picture for several possible cost-revenue situations at different levels of activity.

  In particular, *break-even analysis* is useful as a background information device for reviewing overall cost and profit levels, but it can also be used in connection with special *decisions* such as selecting a *channel of distribution* or *make* or *buy decisions.*



Fg. 18.2. A Break-even Chart.

18.14. COST-BENEFIT ANALYSIS

- *Cost-benefit analysis* is a mathematical technique for decision-making.
- It is a quantitative technique used to evaluate the economic costs and the social benefits associated with a particular course of action.
- In this technique, an effort is made to identify all costs and benefits, not only those that may be expressed in rupees, but also the less easily calculated effects of a given decision.
- In general, this technique (which is fairly complicated) is advocated for use in decisions on public projects, in which social costs and social benefits as well as actual out-of-pocket costs should be taken into account.
- What counts as a benefit or loss to *one part* of the economy—to one or more persons or groups—does not necessarily count as a benefit or loss to the economy as a *whole*. And in cost-benefit analysis we are concerned with the economy as a whole, with the welfare of a defined society and not any smaller part of it.
- But cost-benefit analysis may also be applicable to a single company, for in many cases, it is advisable to place a *value* on costs and benefits that are not ordinarily expressed in rupees.

Some what similar to *cost-benefit analysis* is the **cost-effectiveness analysis**, which is analysis to determine the least expensive way of reaching an objective or of obtaining the greatest possible value from a given expenditure.

18.15. OPERATIONS RESEARCH

- One of the most significant sets of tools now available for decision makers is that of O.R. (**Operations Research**). O.R. involves the use of scientific models or conceptual frameworks, to represent real situations. The models utilize mathematical and statistical terms to express the variables involved in a decision. Particular O.R. techniques include *Network Analysis, Risk Analysis,* and *Statistical Decision Theory.* The chief benefits of such techniques are that they assist the analysis of problems and the development of solutions.
- The basic approach of such techniques in decision making is :

(*1*) *Formulate the problem* in the context of the total system concerned.

(*2*) *Construct a mathematical model* of the system.

(3) *Derive a solution* from the model.

(4) *Test the model.*

(5) *Install a feedback mechanism.*

(6) *Implement the solution.*

– The principal advantage of such an approach is that it seeks to define and solve problems in their organizational context. It is important to appreciate that the approach is utilized to *assist* decision making. O.R. techniques in themselves do not implement decisions. What they can do is to provide managers with information and options which can lead to qualitatively better decisions being taken.

– O.R. does have definite *limitations* – the major one being that some aspects of business decisions are simply not quantifiable. But O.R. is still relatively new and its practical applications are numerous.

18.16. LINEAR PROGRAMMING

– Linear programming is a quantitative technique used to determine the optimal mix of limited resources for maximizing profits or minimizing costs.

– Linear programming is an extension of break-even analysis that is very useful in analyzing complex problems.

– Linear programming involves the solution of linear equations and is appropriate when the manager must allocate scarce resources to competing projects.

– For details of linear programming refer chapter 11.

18.17. CAPITAL BUDGETING

– A manager relies heavily on linear programming when he allocates resources to competing projects. Similarly *Capital budgeting* provides a set of techniques a manager can use to evaluate the relative attractiveness of various projects in which a lump payment is made to generate a stream of earnings over a future period. Examples of capital budgeting projects include an investment in a new machine that will increase future profits by reducing costs, an investment of a sum of money into an advertising compaign to increase future sales (and profits) etc.

– In essence, capital budgeting *techniques* provide management with a useful method for analyzing the profitability of potential investments that have dissimilar earnings characteristics. Without these techniques, it would be nearly impossible to weigh the advantages of dissimilar investments.

18.18. CAPITAL INVESTMENT ANALYSIS, CAPITAL INVESTMENT DECISIONS OR CAPITAL EXPENDITURE DECISIONS

Introduction

– Many decision situations which occur during the process design stage require the evaluation and comparison of *capital expenditure* proposals. The purchase of machinery for a new assembly line is one example of this.

– In accounting terminology, any money spent on *fixed assets* is known as *capital expenditure*. The distinguishing feature is the expectation that the assets purchased will be used for producing, selling or other functions, over a period *exceeding* one year. Thus, for example, the cost of a lathe machine to be used in machine shop would be regarded as capital expenditure.

Importance

– Investment decisions have traditionally been at the center of attention. There are, of course, good reasons for this :

(*i*) It is the allocation of capital that starts the process which eventually leads to the commitment of labor and materials.

(*ii*) Once capital has been allocated, the investment is irreversible, and

(*iii*) The usually large magnitude of the capital outlay makes the investment decision a major influence on the future profitability of the firm.

18.19 Methods of

Different methods employed for *comparing alternative investments* and to ascertain the profitability of each project are :

(1) Pay-back method

(2) Return on investment method

(3) Present-value return on investment method

(4) Return on total capital employed

(5) Linear programming model

(6) Simulation technique.

(1) *Pay-back method*

- The method attempts to determine the number of years in which the investment is expected to pay for itself. For example, if a machine is to cost Rs. 100,000 and extra revenue is expected to amount to Rs. 20,000 the first year, Rs. 40,000 the second year and Rs. 40,000 in the third year, then the pay-back period is three years.
- In practice, these calculations may not be so simple. A fixed asset cannot usually be treated as a separate entity. The introduction of a new machine often introduces problems. It may displace an older machine. There may be a rearrangement of duties between workers. Quite likely some costs may be reduced. Therefore, both the costs incurred and the costs saved will have to be taken into account.
- When comparing different alternatives, the one which pays for itself first is the one selected.
- The pay-back method has the *advantage* that it is simple to understand and operate. Furthermore it shows how quickly the investment will be recovered.
- Although this method has many followers, it also has many *critics*. Some accountants have rightly pointed out that the true profitability of investments cannot be determined merely by considering the pay-back period. Indeed, in that period only the recovery of costs is considered. The profit comes after all costs have been recovered and not before. Therefore, much better results would be obtained by considering the full serviceable life of each asset: only then can the total, expected profit be ascertained.

(2) *Return on investment method*

- This method considers the *rate of return* to be obtained from the investment. When comparing alternative courses of action, the investment which shows the highest return is the one normally selected.
- The rate of return may be expressed as a *percentage of the average amount.* A simple method of obtaining the *average amount* is to divide the total investment by two.
- The following illustration will explain how to *calculate rate of return.*

	Year	*Machine, X*	*Machine, Y*
Capital cost		Rs. 60,000	Rs. 72,000
Earnings			
(or *net cash flow*)	1	Rs. 30,000	Rs. 24,000
	2	Rs. 30,000	Rs. 24,000
	3	Nil	Rs. 60,000

Calculating rate of return per Re. 1 invested

	Machine X	*Machine Y*
Earnings	Rs. (30,000 + 30,000) = Rs. 60,000	Rs. (24,000 + 24,000 + 60,000) = Rs. 108,000
Investment	Rs. 60,000	Rs. 72,000
Rate of return per Re. 1 invested	$= \frac{\text{Rs. } 60{,}000}{\text{Rs. } 60{,}000} = 1$	$= \frac{\text{Rs. } 108{,}000}{\text{Rs. } 72{,}000} = 1.5$

This shows the *superiority* of machine *Y* over *X*.

The *weakness* of this method is – the same results would have been shown even if the full earnings of machine *Y* that is Rs. 108,000 would have been only in the third year. In other words, this method *ignores* the timing of the receipts, whereas money received earlier is more valuable.

(3) *Present-value return on investment method*

– A serious limitation of the *pay-back method* was the time factor. Sums of money received at different times in the *future* have to be discounted to *present value*. Otherwise no true comparison of different investments can be made.

The *present-value return method*, discussed below, overcomes this obvious weakness of the pay-back method.

– A person faced with the choice of having Rs. 100 now or after one year, normally like to have it now. If he was offered Rs. 100 now, but Rs. 110 after one year then he may be tempted to wait for Rs. 110. This simple example illustrates the present value concept of money. As above, if 10% is taken to be a normal rate of return for a particular type of investment, the Rs. 100 due in one year is at present worth only Rs. 90.91. If it is necessary to wait two years for Rs. 100, then taking compound interest at 10%, the present value is Rs. 82.64.

– The object of all the methods being described is to arrive at the most profitable investment. The present-value return method is no exception. When this method is used, there are two ways of tackling the problem of calculating profitability. These may be summarised as follows :

(*i*) Trial and error yield method.

(*ii*) Net gain method.

(*i*) *Trial and error yield method,* procedure of :

(*a*) List the annual sales and costs (other than depreciation) and deducting the latter from the former, obtain the net cash flow (or earnings).

(*b*) Obtain the capital cost. Often this will already be at present value because the cash is spent now.

(*c*) Calculate the present value of the net cash flow by using an appropriate rate of interest. This rate is found by trial and error from present value tables. The object is to make the cash flow equal to the capital cost.

(*d*) Carryout this procedure for each project being considered and then rank the projects in order of preference.

(*ii*) *Net gain method*

The net gain method attempts to arrive at the difference between the present value of *receipts* and *payments*. As with previous method, the cash flows should be taken. One of the difficulties of this method is the selection of an appropriate rate of interest. One rate will give different results from another. The principal object should be to assess a *return* which reflects what can be expected from putting the money in alternative investments.

(4) *Return on total capital employed*

This method approaches the problem by ensuring that the total capital employed earns an adequate return. Additional assets purchased should increase, or at least keep constant, the percentage rate of return on total capital employed.

(5) *Linear Programming model*

- When the firm must consider several alternatives, each of which requires cash outflows over many periods, the use of a linear programming model can be an effective way of generating a feasible investment mix.
- In fact this method can be employed whenever factors such as capital, labor and equipment constrain the investment choice.
- In a large firm, with many investment proposals being generated each year, it is not hard to imagine how such a linear programming model could get exceedingly large.

(6) *Simulation technique*

- It was assumed that the data required for the discounted cash flow and linear programming methods was known with certainty. This, however, is rarely true.
- A more general approach to the analysis of investments requires the introduction of the concept of *risk*. The distinguishing feature of models which incorporate this aspect is that they take into account the full range of possible outcomes for each factor rather than just its expected value. Since models of this sort generally become quite complex, *simulation techniques* must be employed.
- It is also easy to see how these simulation models might become quite large. As we introduce more and more variables, the necessity for using a computer becomes apparent.

Building a large-scale simulation model is not very difficult ; what difficult is, justifying the fact that the incremental *benefit* associated with a more complex model is greater than the incremental *cost*.

18.20. INVENTORY MANAGEMENT

- In quest to make money, a manager should employ his resources as efficiently as possible.
- *Inventory management* involves determining and controlling the amount of raw material an organization should keep in stock to operate effectively and efficiently.
- Efficient management of inventory requires balancing several conflicting goals. The first goal is to keep inventories as small as possible to minimize the amount of warehouse space and the

amount of money tied up in inventories. This goal is in conflict with the need to fill all customer requirements, to optimize the number of orders placed, and to take advantage of the economies of long production runs and quantity discounts.

– To solve inventory problems, the mananger can use the *economic order quantity* (EOQ) *model.* This model can be expressed as a mathematical formula. The solution of EOQ formula tells the manager how many items he should purchase, and how often.

18.21. EXPECTED VALUE

– To understand *expected value model,* it is important to comprehend the concept of *probability* which refers to the likelihood that an event will happen. Mathematically, probability is expressed as a fraction or percentage. For example, there is a 30% (or 0.3) probability that it will rain tomorrow.

– Probabilities may be established *empirically,* by observing some phenomenon over time.

– When several courses of action are available and the outcome of each is uncertain, the decision maker can use probabilities to select his final choice.

– *Taking an example :*

The sales of an air-conditioner will depend on how *hot* the summer is. The expected value for any event is the income it would produce times its probability. Adding the expected values of all possible events, yields expected sales, the average level of sales that can be expected over the long run if the given probabilities hold, as shown in table below. For the air-conditioner, expected sales for the summer are Rs. 7,300,000.

Event	*Outcome*	*Sales × Probability*	*Expected Value of each alternative*
Hot summer	Rs. 10,000,000	0.3	Rs. 3,000,000
Normal summer	Rs. 7,000,000	0.5	Rs. 3,500,000
Cool summer	Rs. 4,000,000	0.2	Rs. 800,000
Expected Sales			Rs. 7,300,000

18.22. DECISION TREE

– Another increasingly useful tool for management decision-makers is the so called *decision tree.* This is basically a conceptual map of possible decisions and outcomes in a particular situation. It is useful in cases where a manager is required to make a number of sequential decisions *i.e.,* where earlier decisions will affect later ones. A simple decision tree appears below :

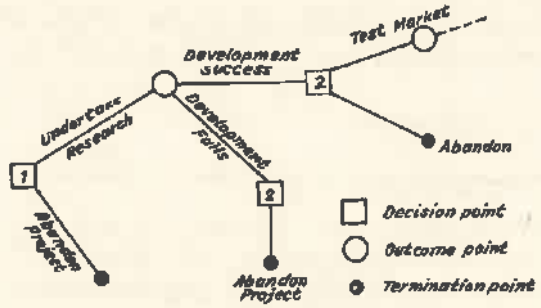


Fig. 18.3. R & D Decision tree.

- The above diagram focuses attention on *outcomes* or consequences as well as *decisions*. These outcomes can be further elaborated in terms of their probability and their anticipated pay off.

  It is also possible to add a time dimension to the whole diagram, so that, for example in Fig. 18.3 the period from decision point 1 to decision point 2 could be one year. These additional features help to make the use of decision trees a salutary exercise for managers.

18.23. SIMULATION

- Simulation techniques are especially applicable to *what if* problems, in which a manager or technician wants to know, *If we do this*, what will happen.

- Simulation can, of course, be conducted by the manipulation of *physical models*. For example, one might have a physical model of a machine and actually keep on increasing its speed to determine at what point it would begin to jam, fly apart or *walk* across the floor.

  With no loss, one may, instead, use a *mathematical model* in which each of the terms represents one of the variables, and observe the effect on the others when different values are given to one or more of the terms. With the help of a *computer*, it is possible to examine what will happen in an enormous number of cases-without spending a prohibitive amount of time.

- Because large electronic computers have become easily accessible in recent years, management can simulate complex situations in order to determine the best course of action.

- Simulation is the process of building, testing and operating models of real-world phenomena through the use of mathematical relationships that exist among critical factors.

- This technique is useful for solving complex problems that cannot be readily solved by other techniques.

- A simulation model can be *deterministic* if the manager knows exactly the value of the factors he employs in the equations.

- However, simulation is essentially probabilistic, since the manager typically must estimate the future values of these factors.

- Simulation is very helpful in engineering and design problems, where the medium may be either the mathematical model or a diagram on a screen (VDU) connected to the computer. In the latter case, the engineer-designer can modify the design by using a *light pen*. The technique is equally *applicable* to management decision-making.

- It is obviously much cheaper, safer and easier to experiment with a mathematical model or diagrammatic simulator than to experiment with real machines or even physical models of machines.

- In some cases, however the *variables* that one manipulates are not exact quantities but probabilities. Then what are known as *Monte Carlo techniques* must be used (refer article 8.24). These make it possible to stretch as far as possible such few actual data as are available to begin with.

18.24. QUEUING OR WAITING LINE THEORY

- Queuing theory is an O.R. technique which aids the manager in making decisions involving the establishment of *service facilities* to meet *irregular demands*.

- Cost problems arise when there are more service facilities available than are needed, or when too few facilities are available and consequently, long waiting lines form.

- For example, in a battery of machines, breakdowns will occur randomly, and whenever the maintenance service falls below that demanded by the breakdowns, a waiting line of unrepaired machines forms. This idle capacity is a cost that has to be balanced against the costs of keeping maintenance services available.

- Queuing theory is applied to any situation producing a need to balance the cost of increasing available service against the cost of letting units wait.

- To arrive at the best number of service facilities, the manager and the O.R. team must first determine (in the example above) the breakdown rate and the time required to service each machine. These data can then be used to construct a *mathematical model* of the problem, which can become extremely complex.

- *Simulation methods* are widely used to solve waiting line problems.

  Simulation is a systematic, trial and error procedure for solving waiting line *problems* that are too *complex* for easy mathematical analysis. Reasonably good solutions may often be obtained by simulating important elements of the problem.

  A widely used method of simulating business problems in which events occur with assigned or computed probabilities is known as the *Monte Carlo* Method. This method utilizes the mathematics of probability, and is often run on the computer.

- For details refer Article 8.24.

18.25. GAME THEORY

- Game theory is a technique of operations research. This provides a basis for determining, under specified conditions, the particular *strategy* that will result in maximum gain or minimum loss, no matter what *opponents* do or do not do. (An opponent would be the enemy general in military application, or a competitor in a business situation etc.)
- The simplest *application* of the game theory is the two-person, zero-sum game, in which there are only two players and one player can gain only at the expense of the other.

  These two conditions are generally fulfilled when two armies are opposing each other.

  In *business* they are fulfilled only in special cases.

  Assume, a company has only one competitor and the *size* of the *market* is *fixed*; thus every gain in sales by one company means an equal loss in sales for the other.
- In an *expanding market*, both the companies could gain, in a declining market, one could gain at the expense of the other.
- Game theory has the greatest *practical usefulness* in planning *sales promotion strategies*.

  A Company who wishes to *increase* its *sales* may do so by using one or more of such *techniques* as :

  (1) a reduction in product price,
  (2) an increase in number of salesmen, and
  (3) a rise in its advertising budget,

  The company must consider what the *rival* can do to nullify the effect of any of these techniques.
- The company therefore asks itself questions like these. Assuming we decide to increase our share of market by cutting prices, what will actually happen if

  (*a*) our rival also cuts prices,

  (*b*) he increases the number of his salesmen,

(*c*) he raises his advertising budget or

(*d*) he uses a combination of all three of these tactics ?

By evaluating each one of these possibilities, the company can ascertain the greatest possible damage the rival can inflict. This will reveal either the minimum gain the company is assured of or the maximum loss it can suffer.

– In *real life*, however, there are more than *two* competitors and the demand for most products is not stable or fixed. If all competitors cut prices, the market for all may be increased and possibly all may gain. Or, if the market remains the same, all may lose. Therefore the losses of one do not necessarily equal the gains of another.

18.26. GAME MODELS

– The next quantitative decision making model consists of *game models* or *competitive strategies.* These models are derived from *game theory* which provides many useful insights into situations involving elements of competition.

– Decision situations are of a game nature when a rational opponent (*e.g.* a competitor in the market) is involved, so that resulting effects are dependent on the specific strategies selected by the decision maker and his opponent. This assumes that the opponent will carefully consider what the decision maker may do before he selects his own strategy.

18.27. INFORMATION THEORY

– A central element in all decision making is the process of obtaining, using and disseminating information.

– Information theory is a rigorous mathematical effort to solve problems in communication engineering.

– Since information theory deals with the flow of information and communication net-works, it has important implications for organization design and for man-machine relationships.

– Information theory provides a means of measuring the information content of both symbolic and verbal languages and relating the characteristics of an efficient communication system to the information content of messages transmitted. This body of theory has been of great use in the design of communication systems and computers.

18.28. PREFERENCE THEORY/UTILITY THEORY

– One of the interesting and practical supplements of modern decision theory is (the work that has been done and) the techniques developed to supplement statistical probabilities with analysis of individual preferences in the assumption or avoidance of risk. While referred to here as *preference* theory, it is more classically denoted *Utility theory.*

– It might seem reasonable that if we had a 60% chance of a decision being the right one, we would take it. But this is not necessarily true, since the risk of being wrong is 40% and a manager might not wish to take this risk, particularly if the penalty for being wrong is severe, whether in terms of monetary losses, reputation or job security.

– If we doubt this, we might ask ourselves whether we would risk, say Rs. 40,000 on the 60% chance that we might make Rs. 100,000. We might readily risk Rs. 4 on a chance of making Rs. 10, and gamblers have been known to risk much more on a lesser chance of success.

- Therefore, in order to give probabilities practical meaning in decision making, we need better understanding of the individual decision maker's aversion to, or acceptance of risk. This varies not only with people but also with the size of the risk, with the level of managers in an organization and according to whether the funds involved are personal or belong to a company.
- Higher level managers are accustomed to taking larger risks than lower-level managers.
- The same top manager who may take a decision involving risks of millions of rupees for a company would not like to do that with his own personal fortune.
- Moreover, the same manager willing to opt for a 75% risk in one case might not be willing to, in another. For example, he may go for a large advertising program where the chances of success are 70%, but might not decide in favour of an investment in plant and machinery unless the probabilities for success were higher. In other words, attitudes toward risk vary with events, as well as with people and positions.
- Most of us are gamblers when small stakes are involved, but soon take on the role of risk averters when the stakes rise.
- Many managers are risk averters and thereby miss opportunities.

18.29. HEURISTIC PROGRAMMING

- *Heuristic programming*, sometimes called heuristic problem solving, is an approach to decision making that has gained increasingly wide usage in recent years.
- It is in fact a branch of simulation model analysis. It is applied to problems in such areas as assembly line balancing, plant layout, job shop scheduling, warehouse location and resource allocation.
- A heuristic is any device or procedure used to reduce problem-solving effort. A *rule-of-thumb* is a commonly used heuristic. For example, the rule that "when there are only ten parts in the bin, reorder the part" or "donot drink liquor and drive a car", are examples of heuristics. Much business behaviour and much in everyday life is guided by this kind of rule.
- When heuristics are combined to solve a problem, a heuristic program is formed. Complex programs require computers for their solution.
- Heuristic programs are used wherever the problem is too large or too complex to solve by mathematical or statistical techniques.
- It is also used to deal with ill-structured problems that cannot be stated in mathematical terms, so that quantitative techniques (such as O.R.) are not suitable for such problems.
- The chief *inputs* in heuristic programming are subjective, based on the managers past experience, the pooling of knowledge and judgements of colleagues, the use of judgement, intuition, creativity, learning processes and other qualitative variables. The decision maker immerses himself in the total problem, and searches by means of *trial and error* for a satisfactory solution in a reasonable time and at a reasonable cost, rather than striving for an optimal solution at all costs.

18.30. MARKOV ANALYSIS

Concept

- Markov analysis is a method of analyzing the *current behaviour* of some variable in an effort to predict the *future* behaviour of the same variable.

- This procedure was developed by the Russian mathematician, Andrei A. Markov early in this century. He first used it to describe and predict the behaviour of particles of gas in a closed container.

- As a *management tool*, Markov analysis has been successfully applied to a wide variety of *decision* situations. Perhaps its widest use is in examining and predicting the behaviour of customers in terms of their *brand loyalty* and their switching from one brand to another.

- Markov processes are a special class of mathematical models which are often applicable to decision problems. In a Markov process, various states are defined. The probability of going to each of the states depends only on the present state and is independent of how we arrived at that state.

A simple Markov process is illustrated in the following example.

Example 18.1

A machine which produces parts may either be *in adjustment* or *out of adjustment*. If the machine is in adjustment, the probability that it will be in adjustment a day later is 0.7, and the probability that it will be out of adjustment a day later is 0.3. If the machine is out of adjustment, the probability that it will be in adjustment a day later is 0.6, and the probability that it will be out of adjustment a day later is 0.4.* If we let state-1 represent the situation in which the machine is in adjustment and let state-2 represent its being out of adjustment, then the probabilities of change are as given in the table below. Note that the sum of the probabilities in any row is equal to one.

Table 18.1

Probabilities of Change

From \ *To*	*In adjustment (State-1)*	*Out of adjustment (State-2)*
In adjustment (State-1)	0.7	0.3
Out of adjustment (State-2)	0.6	0.4

Solution

The process is represented in Fig. 18.4 by two probability trees whose upward branches indicate moving to state-1 and whose downward branches indicate moving to state-2.

- Suppose the machine starts out in state-1 (in adjustment), Table 18.1 and Fig.18.4 show there is a 0.7 probability that the machine will be in state-1 on the second day. Now, consider the state of machine on the third day. The probability that the machine is in state-1 on the third day is 0.49 plus 0.18 or 0.67 (Fig. 18.4).

- The corresponding probability that the machine will be in state-2 on day 3, given that it started in state-1 on day 1, is 0.21 plus 0.12, or 0.33.

- The probability of being in state-1 plus the probability of being in state-2 add to one (0.67 + 0.33 = 1) since there are only two possible states in this example.

- Calculations can similarly be made for next days and are given in Table 18.2 below.

*Assume the machine has a self-adjusting mechanism which functions imperfectly.

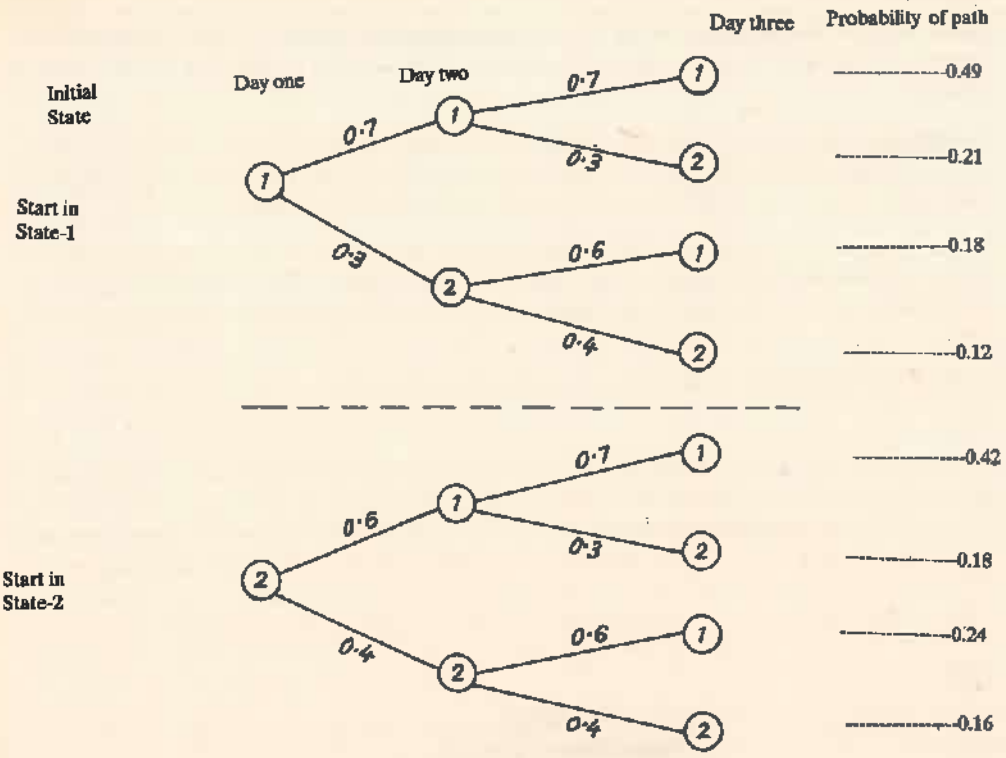


Fig. 18.4. Probability trees.

Table 18.2

Day Number	*Probability of machine being in state-1 on a future day, given that it started in state-1 on day-1*
1	1.0
2	0.7
3	0.67...(2/3)
4	0.667...(2/3)
5	0.6667...(2/3)
6	0.66667...(2/3)

– Refer to Fig. 18.4 (start in State-2)

The probability that the machine will be in state-1 on day 3, given that it started off in state-2 on day 1 is 0.42 plus 0.24 or 0.66, hence the table below.

Table 18.3

Day Number	*Probability of machine being in state-1 on a future day, given that it started off in state-2 on day-1*
1	0.0
2	0.6
3	0.66...(2/3)
4	0.666...(2/3)
5	0.6666...(2/3)
6	0.66666...(2/3)

– Table 18.2 and 18.3 above show that the probability of machine being in state 1 on any future day tends towards 2/3, irrespective of the initial state of the machine on day-1. This probability is called the *steady-state* probability of being in state-1 ; the corresponding probability of being in state-2 (1 – 2/3 = 1/3) is called the *steady-state* probability of being in state-2. The steady state probabilities are often significant for decision purposes. For example, if we were deciding to lease either this machine or some other machine, the steady-state probability of state-2 would indicate the fraction of time the machine would be out of adjustment in the long run, and this fraction (*e.g.* 1/3) would be of interest to us in making the decision.

Applications of Markov Analysis

– Markov analysis has come to be used as a marketing research tool for examining and forecasting the frequency with which customers will remain loyal to one brand or switch to others. It is generally assumed that customers do not shift from one brand to another at random, but instead will choose to buy brands in the future that reflect their choices in the past.

– Other applications that have been found for Markov Analysis include the following models :

A model for manpower planning,
A model for human needs,
A model for assessing the behaviour of stock prices,
A model for scheduling hospital admissions,
A model for analyzing internal manpower supply etc.

18.31. DECISION THEORY

– There are numerous approaches to the general decision making process, ranging from purely *subjective* judgements to highly *quantified* analysis.

Two quantitative approaches are commonly found in the production management literature :

1. Decision Theory,
2. Cost-effectiveness Analysis.

– **Decision Theory** may be defined as a set of general concepts and techniques that assist a decision maker in *choosing among alternatives.*

– Decision theory problems are commonly cast in a standard framework, termed a *decision matrix* which consists of the following components :

Decision Matrix

Strategies(S)	States of nature (N) and Proabilities of occurrence (Pr)				
	N_1 P_{r1}	N_2 P_{r2}	N_3 P_{r3}	....	N_n P_{rn}
S_1	O_{11}	O_{12}	O_{13}	.....	O_{1n}
S_2	O_{21}	O_{22}	O_{23}	.....	O_{2n}
⋮	⋮	⋮	⋮		⋮
S_m	O_{m1}	O_{m2}	O_{m3}	.....	O_{mn}

(1) *Strategies or alternatives (S)*, available to the decision maker. For example *make* and *buy* would be two strategies in a make-or-buy decision problem. Strategies are within the control of the decision maker.

(2) *States of nature (N)*, which are characteristics of the *environment* and are beyond the control of the decision maker. The term derives from the *Weather*, where we might observe, say, three states of nature: sunshine, rain or snow.

In business decisions, states of nature might be various levels of demand for a product, the number of competitors, governmental actions etc.

(3) *Predictions of likelihood* (P_r) or the probability associated with the occurrence of each state of nature. If a particular state of nature is sure to occur ($P_r = 1.0$), the decision situation is termed one of *certainty*.

If the decision maker can assign probability of occurrence to one or more states of nature, with no one state given a value of 1.0, it is termed a *risk situation*.

Finally, if the decision maker has no idea of the probabilities of occurrence of any state of nature, the situation is defined as decision making under *uncertainty*.

Thus in the decision matrix above, there would be an entry for probability if the situation is one of certainty or risk and no entry if it is one of uncertainty.

(4) *Pay offs or outcomes (O)*, which represent the *value* associated with each combination of strategy and state of nature. The *value* may be stated in terms of utility, cost, profit, satisfaction etc.

Solving a decision theory problem obviously requires some choice to be made from among the alternatives, and thus some *rule* or *decision criterion* must be selected for this purpose. For example, in *certainty* situations, the decision criterion is to select the single strategy with the highest pay off. Since only one state of nature is relevant, this entails a simple scanning of the pay off column under the *certain N* and picking the best one.

18.32. DECISION MAKING UNDER CERTAINTY

- *Certainty* implies that all the facts are known for sure. It is assumed that there is complete and accurate knowledge of the consequences of each choice (or of the nature of future conditions).
- It is decision making under certainty if only *one state of nature* is relevant.
- Decision making under certainty occurs when the manager knows the state of nature that will occur with complete certainty, that is, when a probability of 1.0 can be assigned to a specific state of nature.
- The meaning of the term *certainty* is that for each alternative there is one and only one value of the pay off. All we need do then is to find the alternative which has the best pay off and this is the alternative which should be selected. The decision criterion is simply to select the alternative with the best pay off.
- Consider the following *pay off matrix*.

	State of Nature		
Strategies	N_1	N_2	N_3
S_1	Rs. 220,000	Rs. 150,000	Rs. 80,000
S_2	250,000	170,000	100,000
S_3	280,000	190,000	110,000

– A *pay off matrix* is a logical grouping of possible outcomes in a problem. Outcomes can be expressed in rupees (profits, costs etc.), units or some other appropriate measure. In a pay off matrix, the intersection of each row and column gives a specific *outcome i.e.* the consequences of choosing a particular strategy (row), given that a certain state of nature (column) occurs. In other words, the manager's measure of utility or pay-off measure for each outcome is associated with each combination of *strategy* and state of nature. *Strategies* are those variables (controllable) that are within the manager's control, such as appropriate actions to be taken (including the decision to do nothing).

The future events that can occur for the strategies must be identified. These events, which are termed *states of nature,* represent those variables (non-controllable) that are beyond the control of the manager, such as economic conditions or a competitor's actions.

– The pay off matrix above, shows the *profits*. The manager knows with certainty that N_2 state of nature will occur. Therefore, he will select strategy S_3, since it offers the highest return.

The decision criterion for certainty is to select that strategy with the largest payoff based upon a given state of nature.

Example 18.2. An industrial enterprise can sell 500 units of products to another concern at a price of Rs. 40 per unit. If the enterprise has excess capacity, should the order be accepted ?

Solution.

(*i*) The evaluation criterion in this case will be – the maximization of profit.

(*ii*) The alternative courses of action are

(*a*) To accept the order.

(*b*) To reject the order.

Order can be accepted only if it increases the profit, otherwise it will be rejected.

(*iii*) The next step in the process of decision making is to find the incremental expenses of producing 500 units.

The relevant expense model is

$$E = x + 500y.$$

Assume that an additional equipment, worth Rs. 10,000 ($\therefore x = 10{,}000$) is required to be bought for accomplishing the order and the variable cost associated with making one unit is Rs. 30, ($\therefore y = 30$).

Thus the total relevant expenses of filling the order are

$$E = \text{Rs. } 10{,}000 + 500 \times 30 = \text{Rs. } 25{,}000.$$

(*iv*) A comparison of the incremental revenues, *i.e.* [Rs. 40 × 500 (units)] = Rs. 20,000 and incremental expenses, E, *i.e.,* Rs. 25,000 indicate that the *order should not be accepted.*

18.33. DECISION MAKING UNDER RISK

– Decision making under risk refers to situations where there are a number of states of nature, and the manager knows the probability of occurrence for each of these states of nature, (based upon past experience etc.).

– An inventory decision problem for optimum stocking of machinery replacement parts is an example of decision making under risk, because historical data on parts replaced can be compiled for a certain period of time.

– Another example is that of a food processing firm that grows its own crops ; based on the firm's past experience with planting three types of crops in a particular area of the country, the following pay off matrix has resulted, over the past years, for the three states of nature (where N_1 = good

weather, N_2 = variable weather and N_3 = bad weather).

		States of Nature		
		N_1	N_2	N_3
Probability		*0.25*	*0.50*	*0.25*
Strategies	S_1	Rs. 400,000	Rs. 600,000	Rs. 100,000
	S_2	500,000	400,000	150,000
	S_3	600,000	200,000	120,000

In terms of data given for this problem, the strategy with the largest pay off is to be selected.

The equations for computing *expected pay offs for the strategies* (ES) are as follows:

ES_1 = Rs. 400,000 (0.25) + Rs. 600,000 (0.5) + Rs. 100,000 (0.25) = Rs. 425,000

ES_2 = Rs. 500,000 (0.25) + Rs. 400,000 (0.5) + Rs. 150,000 (0.25) = Rs. 362,500.

ES_3 = Rs. 600,000 (0.25) + Rs. 200,000 (0.5) + Rs. 120,000 (0.25) = Rs. 280,000.

Because the expected pay off is greatest for the first strategy, this then is the strategy to select.

18.34. DECISION MAKING (OR PROBLEM SOLVING) UNDER UNCERTAINTY

Introduction

- Whereas in decision making under certainty, only one state of nature is relevant, with decision making under uncertainty, one can expect to enumerate a finite number of states of nature.
- The character of uncertainty is associated with the fact that, one, then acknowledges a total inability to estimate the likelihood of occurrence for each of these states of nature.
- Under uncertainty, the event that will occur (the state of nature) is not known for sure.
- Under uncertainty, the consequences of each choice cannot be defined by a correspondence relationship even within a probabilistic framework.
- Decision making under uncertainty requires that the person responsible for making decisions should use his judgement. He must make sure that which outcomes are more likely than others and combine this knowledge with the consequences associated with the various decisions. Such a process lies behind the familiar willingness to *take a calculated risk.*
- Decision making under uncertainty refers to situations where the probabilities of occurrence for the various states of nature are unknown.
- Business problems of this type arise when no past experience is available for determining the probabilities of occurrence for the various states of nature.
- Problems that deal with new products, increasing plant capacity, and floating new stock issues are examples of decision making under uncertainty.
- The choice of a specific decision criterion under uncertainty is determined by

  The size of the company,

  The company's objectives and policies,

  The feelings of the manager or

  Some other logical basis.

Example 18.3. A business enterprise has a project of making and selling a new product. It associates a fixed cost of Rs. 7000 and a variable cost of producing a unit, as Rs. 40. The product can be sold at the rate of Rs. 60 per piece. The level of sales is *uncertain i.e.*, it is not sure whether 100 units (will be sold) or 350 or 700 units will be sold. Should the enterprise go for the project or reject it ?

Solution.

(*i*) The relevant expense model will be

$$E = 7000 + 40y. \qquad ...(i)$$

(*ii*) Alternatives are

(*a*) To make and sell the product and accept the related profit or loss.

(*b*) To reject the project.

(*iii*) If the product is made and marketed, the profit for each level of sales is

Sales (Units)	*Profit*[1]
100	–Rs. 5000
350	0
700	Rs. 7000

[1. Profit = Incremental revenues – Incremental expenses
= 100 × 60 – (7000 + 40 × 100) = –Rs. 5000 and so on]

(*iv*) Since the level of sales is not certain and different levels of sale involve profit and loss, the decision maker has to act with imperfect information.

– Under such conditions the **Bayes Decision Rule** is extremely useful for making business decisions.

The Bayes decision process is an orderly and consistent technique and a logical way of bringing both the decision maker's judgement and the economic consequences of a given action to bear upon the decision.

As per the procedure of the Bayes decision rule, the decision maker, depending upon his judgement, feelings and experience, assumes probabilities of occurrence of the three levels of sales, *e.g.*, he may feel that

for 100 units the probability is 0.20 ;
for 350 units the probability is 0.30 ; and
for 700 units the probability is 0.50.

– With these probability values, the decision maker constructs the following table :

Table 18.4

Sales (units)	*Probability* (*p*)	*Profit* (*P*)	$p \times P$
100	0.2	–Rs. 5000	–Rs. 1000
350	0.3	0	0
700	0.5	Rs. 7000	Rs. 3500
	1.0		Rs. 2500

– The expected profit for making and marketing the product is Rs. 2500. Thus as per the recommendations of Bayes decision rule the enterprise should go for the project.

18.35. COST EFFECTIVENESS ANALYSIS

– Cost effectiveness analysis is a decision making methodology that ultimately leads to a *compari-*

son of alternatives in terms of their costs and effectiveness in attaining some specific objective.

It differs from conventional economic analysis in that it attempts to devise a quantitative criterion that can simultaneously measure both the quantitative and qualitative elements of a decision problem.

Because its methodology permits analysis of alternatives with widely ranging physical and operational characteristics, it has been *applied* in situations where a general objective can be achieved in many ways.

In addition to *industrial applications*, cost-effectiveness analysis has been applied to problems of :

Health care	Urban planning
Law enforcement,	Defense etc.

– The *procedure* for performing a cost effectiveness analysis typically includes the following *steps :*

(1) Define *objectives* that the systems are to fulfill. For example, objective may be to produce a high-quality newspaper in sufficient quantity to meet daily demand for the next 10 years.

(2) Identify *mission requirements* essential to the attainment of the objectives. There are the individual system's goals, which must be met if the overall objective is to be achieved. In this example they are : Meet a specified demand (of say 100,000 newspapers a day) and print parts of the paper in atleast five colours.

(3) *Develop alternative systems* for accomplishing the system.

(4) Establish basis for *evaluating* alternative systems.

Steps (3) and (4) are shown in *Table 18.5.*

(5) *Formulate effectiveness model*

Evaluation basis variables X_1, X_2, X_3 can be converted to a single measure, E.

E = Salable papers/day = $(X_1)(1-X_2)(1-X_3)$

Effectiveness of CP = (110,000) (1–0.02) (1–0.05) = 102,410

Effectiveness of O = (150,000) (1–0.04) (1–0.10) = 129,600

Effectiveness of C = (175,000) (1–0.03) (1–0.08) = 156,170

Table 18.5

Evaluation bases	*Alternative Systems*		
	Conventional presses (CP)	*Offset presses (O)*	*Computer System (C)*
Maximum output (X_1)	110,000	150,000	175,000
Expected loss due to paper quality (X_2)	0.02	0.04	0.03
Expected loss due to downtime (X_3)	0.05	0.10	0.08
Number of colours that can be printed without additional press runs	4	5	4

(6) *Formulate cost model*

The cost function should reflect the present value of all associated costs for each alternative,

discounted over a 10 year time horizon. The function would be :

$$C_T = C_I + C_P + C_F$$

where C_T = Grand total cost for a proposed plan of action.

C_I = Total cost incurred for initial investment.

C_P = Total cost incurred for production operations over a 10 years time horizon.

C_F = Cost of additional desirable feature(s), for example, colour reproduction capability.

The costs C_P and C_F are new data inputs and C_I came from the decision theory problem. These are used to derive C_T (refer table 18.6).

Table 18.6

Alternatives	C_I	C_P	C_F	C_T
Conventional presses	Rs. 400,000	Rs. 495,500	Rs. 4,500	Rs. 900,000
Offset presses	600,000	250,000	...	850,000
Computer system	750,000	500,000	...	1,250,000

(7) *Select decision criterion.* Several different decision criteria have been employed to rank and select alternatives :

(*a*) Maximize effectiveness divided by cost (max. $E+C$)

(*b*) Maximize effectiveness minus cost (max. $E-C$)

(*c*) Maximize effectiveness given a fixed cost (max. E/C)

(*d*) Minimize cost given a fixed effectiveness (min. C/E)

For this example we will choose number (a), although each has its pros and cons.

(8) *Analyze systems costs versus effectiveness*

Table 18.7 represents the cost, effectiveness value and the $E+C$ ratio for each candidate system.

Table 18.7

Cost effectiveness of three printing systems

System	*Cost*	*Effectiveness*	$E+C$
Conventional	Rs. 900,000	102,410	0.114
Offset	850,000	129,600	0.152
Computer	1,250,000	156,170	0.125

On the basis of the effectiveness ratio criterion, the choice would be the *offset press.* However, before finalizing the decision, the management should also consider the importance of those factors which could not be quantified – for example, management skill in handling several technologies, operator availability and the training required for each alternative, proven capability of each process in other situations etc.

(9) *Perform Sensitivity Analysis*

– In many cost-effectiveness studies, the decision is very *sensitive* to the assumptions.

In this example, it was assumed that demand would be atleast 100,000 papers per day ; however, if demand reaches 120,000 papers per day, the conventional press system under consideration would be inadequate.

Thus a sensitivity analysis might also be made using a variety of conventional press systems.

– Finally, the offset press system requires a better quality paper than the conventional press and in many locales such paper is provided by only a few suppliers. Thus if there is a problem with a supplier, the expected loss due to paper quality might be much higher than the assumed 4% because of having to use a lower-quality paper or having to wait for shipment from a more distant source.

SHEETAL GAUTAM

19

Industrial Psychology

19.1. DEFINITION AND CONCEPT OF INDUSTRIAL PSYCHOLOGY

- Industrial psychology is the study of men at work as individuals and in groups and of the relationship between individuals and groups.
- Industrial psychology is concerned with the study of human behaviour in different aspects of industry and business, *e.g.*, production, distribution and use of the goods and services of the civilization.
- Industrial psychology studies human behaviour in order to obtain information that can be applied to the very practical objectives of helping to resolve industrial problems.

19.2. INDUSTRIAL PSYCHOLOGY *VERSUS* PERSONNEL MANAGEMENT

- Both, Industrial psychology and Personnel management cover the entire process of management's dealing with men at work.
- However, industrial psychology differs from personnel management in the sense that it emphasizes the scientific and research aspects of men at work and omits many of the routine administrative details.

19.3. AIMS AND OBJECTIVES OF INDUSTRIAL PSYCHOLOGY

1. To improve the situation on the job.
2. To affect high morale and enthusiasm at work.
3. To restore the mental health of upset and confused individuals.
4. To remove risks to healths or threats to safety.
5. To increase efficiency of people at work.
6. To increase productivity and hence the profits.

19.4. SCOPE OF INDUSTRIAL PSYCHOLOGY

In industry, psychology is applied :

1. To understand the culture-pattern of a working group or the commonly accepted attitudes and standards to which the individual must conform if he is to be accepted as a member.

2. In connection with human problems associated with aspects of human work, including

- Employee selection and placement.
- Employee training and development.
- Attitude, Morale and Motivation.
- Supervision and evaluation.
- Measurement of various kinds of human ability.

3. To related problems of organizations.

– Financial remuneration.

– Working conditions (environments).

– Equipment design.

4. In connection with market research, sales and advertising.

5. To organizational behaviour.

6. In connection with Programme Development (research) and individual evaluation (consulting).

7. To find facts about existing methods and the development of better methods, *e.g.*, new interviewing methods, different application blanks, etc.

19.5. INDIVIDUAL AND GROUP

– An individual is one whose performance is affected solely by his own characteristics such as brain, abilities, qualifications, motivation, adjustment, etc.

– Every individual is different from the other and each individual possesses a unique hierarchy of motives and a unique way of behaving.

– Individuals collect and form groups within which they live.

– Groups may be classed as

(*i*) *Primary groups,* where individuals are in face-to-face relationships with each other, where they interact directly and have some liberty of action in interpreting the roles required of them.

(*ii*) *Secondary groups,* where the relationships are more of contractual nature and where the roles must be played out in a more impersonal and stereotyped manner.

Industries normally require secondary grouping of their employees which are not always satisfying to the individual.

19.6. INDIVIDUAL DIFFERENCES IN BEHAVIOUR

– Individuals differ from one another in dozens of ways. Differences are present as regards physical appearance, abilities, education, aptitude, etc.

– Individuals differ and therefore, in industry, they are paid at different rates. One learns with little efforts and practice whereas another is not able to pick up so fast.

– The differences in individuals reflect in their performance and behaviour at work.

– Individual differences in behaviour, if (they are) identified and measured, help much in right selection, placement and imparting proper training to the individuals.

– Action or a peculiar behaviour of an individual to a particular situation is seldom spontaneous ; it does have a cause behind.

– Research in behaviour in industry aims at discovering

(*i*) – causes of behaviour, or

(*ii*) the factors which are correlated with behaviour even though they are not causative.

– For any given aspect of individual behaviour, there may be many contributing factors.

– If any aspect, factor or variable of individuals is subjected to measurement and plotted, the

measured trait (*e.g.*, ability, muscular coordination, work performance, etc.) forms a distribution resembling a *Normal Distribution* and individuals fall at different points along the performance continuum (*i.e.*, the X-axis). Fig. 19.1 shows a normal distribution curve.

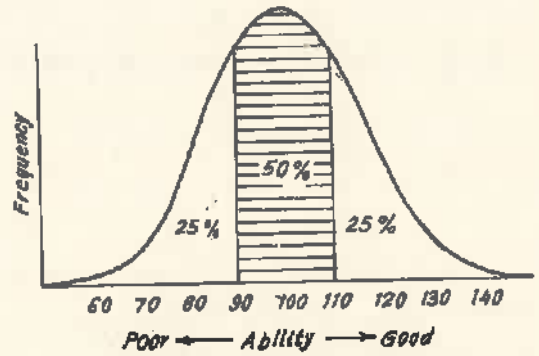


Fig. 19.1. Distribution of employees abilities.

- Fig. 19.1 shows that about 50% individuals are near average in ability. It is these employees that a supervisor is most likely to understand and it is their performance that creates in the supervisor the notion of what he can expect in the form of a day's work.
- 25% individuals below average in ability are problemous because either they complete less than what is expected of them or, if under supervisor's urge they tend to produce more, they do it at the cost of quality or safety.
- 25% individuals above average in ability also create problems sometimes as it is difficult to keep them busy ; they may finish a day's work soon and refuse to do more work and thus cause difficulties for the supervisor by keeping themselves free (*i.e.*, without work) for the rest of the day.
- The individuals differ from each other in certain aspects which are termed as *Individual Variables*. Individual variables play a major role and influence the performance of an employee at work. Individuals variables are :

1. *Physical characteristics*

Heredity would seem to be of most importance in determining physical characteristics such as height, weight and strength.

2. *Intellectual factors*

- By intelligence is meant ability to learn.
- Differences in intelligence, also, are distributed as the Normal Distribution.

3. *Interest and motivation*

- An individual interested in a particular job will accomplish it in a better manner.
- Therefore, selection and placement of the employee should depend in part on his interests.
- OR the job may be modified to fit his interests.
- OR the employee should be motivated (financially or otherwise) to do that job.

4. *Temperament*

– By temperament is meant excitability of response—the degree to which an individual responds with emotion.

5. *Character*

– Character implies honesty-resistance to stealing, to lying and to cheating where money is involved.

6. *Aptitude*
7. *Personality characteristics*
8. *Education*
9. *Experience*
10. *Age*
11. *Sex*

– Besides individual variables, there are some *Situational Variables* also which influence the performance (behaviour) of an employee on a given job. Situational variables are :

(*a*) *Physical and job variables*

1. Physical environment.
2. Work space and layout.
3. Design and condition of work equipment.
4. Methods of work.

(*b*) *Organizational and social variables*

1. Character of organization.
2. Kind of training and supervision.
3. Types of incentives.
4. Social environment.

19.7. GROUP DYNAMICS—HUMAN BEHAVIOUR UNDER GROUP INFLUENCE—GROUP BEHAVIOUR

– Many jobs in industries, *e.g.*, riveting, forging, maintenance work, etc., require a collective effort on the part of employees to achieve the goals of the organisation. This leads to the formation of *Formal Groups* in the industry and such groups are set up by the organisation itself.

– Besides formal groups, individuals because of their social needs, common interests, security and some psychological factors tend to collect themselves in what are known as Informal Groups.

– *Characteristics of Group Behaviour*

(*i*) It has been observed that an employee behaves differently, when acting as an individual, than when as a member of a group.

(*ii*) Group influences and changes the attitude and behaviour of an individual towards work and towards the organisation.

(*iii*) Every group has its characteristics *culture-pattern* to which the individual must conform if he is to remain a member.

(*iv*) Groups differ in their degree of cohesiveness. Some are loosely bound, they slowly

disintegrate and vanish whereas other groups are strong, effective and possess active support of most members.

(*v*) In case of difference in opinion in a group, the extremists face pressure to change or modify their opinions.

This pressure is more effective in *high-cohesive* groups.

The extremists either modify their views or leave the group.

(*vi*) In a group, the persons who try hardest to influence others, are generally most willing to accept the opinions of others.

The understanding of *group characteristics* as explained above and otherwise is very essential for the management to maintain good human relations.

– **Group behaviour** may be beneficial as well as detrimental for the organisation and management.

Group may influence the behaviour of those in the group as regards absenteeism, restriction of work output, etc., such restrictions being invisibile, unwritten and informal.

The possibility of group influence being contrary to the interests of management has tended to cause the managements of some enterprises to view dimly the development of strong, integrated groups within the organisation.

Group Dynamics

– Group dynamics is an expression that describes the situation in which persons working together in a group accomplish certain things, either positively or negatively, in a way that cannot be explained adequately in terms of the individual acting separately.

– Group dynamics describes the interaction between members within a work group and the concurrent changes of their attitudes, behaviour and relationships ; similarly, the interaction - and changing attitudes, behaviour and relationships—between an employee work group and others outside the group, in particular the supervisor/foreman.

– The term *Group dynamics* is applied to the forces brought to bear by individuals, singly or collectively, in a group activity. The work *dynamics* implies *change.*

– Group dynamics emphasizes the influence of groups, group behaviour and inter-group conflict.

– The Lewin *group dynamics* analysis has been influential in shaping modern administrative theory. It has emphasized the persistent development and influence of informal organization, it has highlighted the role of group norms of behaviour and has suggested the importance of these variables in the working environment in so far as they contribute to the individual's feeling of security and the assurance with which he can predict the behaviour of associates.

– Group dynamics focuses a team work—team spirit which has an extensive history in military units and among athletic teams but has fairly recent applications in industry. Members of group remain in constant touch with each other, mutually discuss and furnish suggestions in order to achieve the company goals effectively. The group has common objectives to reach at.

– A Group

(*i*) provides security to its members from outside pressure ;

(*ii*) provides companionship at or after the work ;

(*iii*) provides norms (guides) for behaviour ;

(*iv*) provides a personal touch or relationship ;

(*v*) provides identity to its members and builds up their morale ; and

(*vi*) imparts job satisfaction to its members.

19.8. THEORY X AND Y

(*a*) Theory-X

According to theory-X put forward by Douglas McGregor, the traditional framework for management thinking is based upon certain assumptions about human nature and human behaviour. It is an essentially negative approach to human relations in which a supervisor presumes that

1. The average person does not like to work and will avoid it if he can.

2. For this reason, most persons must be coerced, controlled, directed or threatened with punishment so that they start putting efforts to achieve goals of the organization.

3. The average human being prefers to be directed, wishes to avoid responsibility, has relatively little ambition and wants security above all. Therefore, employees must be pushed constantly and threatened with loss of security and other punishments when they do not produce.

(*b*) Theory-Y

- Theory-Y bases itself on recently accumulated knowledge about human behaviour.
- Theory-Y is an essentially positive approach to human relations in which the supervisor integrates the needs of his subordinates with the needs of his department. He presumes that the assumptions made in Theory-X do not portray the correct human nature and behaviour.
- Theory-Y emphasizes on satisfying the needs of employees so that they willingly commit to the goals of the organization.
- Theory-Y promotes good human relations and an atmosphere of good mutual understanding and cooperation.
- The assumptions of theory-Y as given by D. McGregor are as follows :
  1. The expenditure of physical and mental effort in work is as natural as in play or rest. The average human beings do not dislike work, given meaningful work, they will try hard to achieve.
  2. External control and threat of punishment are not the only means to bring about efforts towards organizational goals. Satisfied persons will themselves exert self-control in seeking to attain them.
  3. Commitment to organizational goals depends upon the rewards associated with their achievement. The most important rewards being those which satisfy needs for self-respect and personal improvement.
  4. The average man learns, under proper conditions, not only to accept but also to seek responsibility.
  5. The capacity to exercise a relatively high degree of imagination, ingenuity and creativity in the solution of organizational problems is widely (not narrowly) distributed in the population (people).
  6. Under the conditions of modern industrial life, the intellectual potentialities of the average men are only partially utilized.

19.9. HAWTHORNE EXPERIMENT

- The most famous of all human relations movement and research were the Hawthorne experiments (so named because they were carried on in the Hawthorne plant of Western Electric

Company of Chicago, U.S.A.)

- Dr. Elton Mayo led a team from Harvard University which cooperated with the Western Electric Co., in the period 1927-1936 to carry out Hawthorne experiments.

- The Hawthorne experiments :
  1. Recognised the importance of employee-attitudes—such as understanding, voluntary co-operation, and willing dedication—in the accomplishment of organizational goals.
  2. Found that employee performance is very much influenced by his attitude towards his job, associates and management.
  3. Proved that the organization/firm can gain only when its employees are satisfied and contented in their jobs.
  4. Pointed out that any change to be made should be explained and its meaning should be made clear to the employees.

     The fact that a change is logical is not enough, because the employees may not appreciate the logic.
  5. Explored much of the information on group behaviour.
  6. Thus, have provided the basis for much of what we know about getting along with all, problem employees in particular.

19.10. MORALE

Definition and Concept

- Interest in industrial morale developed rapidly after the Second World War, though this word (*i.e.*, morale) was in widespread use even long before.

- It is a measure of extent (or level as either high or low) of voluntary cooperation demonstrated by an individual or a work group and of the intensity of the desire to attain common goals.

- Morale is a mental condition or attitude of (individuals and) groups which determines their willingness to cooperate.

- Morale may also be defined as the extent to which an individual's needs are satisfied and the extent to which the individual perceives satisfaction as stemming from his total job situation.

- Morale is made up of two sets of elements—one set containing those which help to make a person satisfied with his job and a second set containing those (elements) which when, lacking, make him feel dissatisfied.

- The word morale generally has an implication of group reactions, *i.e.*, what motivation does to the individual, morale does to the work group. Morale is an individual attitude in a group endeavour and a group attitude towards the goals of an organization.

- In other words, morale of a group depends on the interactions among individuals in the group such as a hockey team, military unit or a riveting gang.

- *High morale* is the confident spirit of whole-hearted cooperation in a common effort.

High morale implies

(1) Perseverance at work.

(2) Loyalty to organization and its leadership.

(3) Good discipline or the voluntary conformance to rules, regulations and orders.

(4) Strong organizational stamina.
(5) A high degree of employee interest in the job.
(6) Reasonable employee initiative.
(7) Pride in the organization.
(8) Team spirit.
(9) Zest or enthusiasm.
(10) Resistance to frustration.
(11) Staying quality.

– **Low morale.** Morale may be depressed by
  (*i*) Too fine division of authority and responsibility.
  (*ii*) Wrong or improper selection of employees.
  (*iii*) Too small a number of real executives.
  (*iv*) Too many foremen or supervisors.
  (*v*) Over-reliance on organization charts.

  Low morale results in
  (*i*) A higher rate of absenteeism and labour turnover.
  (*ii*) Friction, Jealousy and frustration among workers.
  (*iii*) More complaints and employee grievances.
  (*iv*) Enemity towards management.

– Many large organisations conduct morale surveys to explore how the workers feel about their working conditions, jobs, supervisors, and the company itself and such surveys generally lead to improved morale of the employees.

Factors Affecting Morale

Factors which tend to lower or improve the employee morale are :

1. *Job Factors*
– Nature of job.
– Fatigue and boredom associated with the job.
– Employees interest in the job.
– Job satisfaction.
– Confidence on individual members of the group.
– Confidence of different members of the group in the leadership at all levels.
– Nature of leadership and supervision, *i.e.*, whether the leader/supervisor is just, impartial, helpful, social minded etc.?
– Working and environmental conditions, *i.e.*, whether they are good and wholesome ?
– Condition of working equipment.

2. *Personal Factors*, such as
– Background
– Age
– Sex
– Mental and emotional condition of employee
– Intelligence
– Skill and proficiency
– Training
– Experience, etc.

3. *Other Factors*

- Organisational efficiency, *i.e.,*
  - (*i*) The way the organization is set up, the way the orders are given, the way information is passed up and down, the way things are provided, etc.
  - (*ii*) The way the informal organizations decide and think and work.
- Objects of the organization, *i.e.,* whether they are clear or they confuse the employees.
- Unfair selections and promotions.
- Frustrations resulting from lack of recognition, *i.e.,* attaching more importance to junior persons and neglecting seniors.
- Rewards and Incentives.

Methods to Measure Morale

Level of morale may be measured by,

(*A*) The attitude questionnaire.

(*B*) In-group versus out-group choices.

(*C*) Other criteria.

A. The *attitude questionnaire* is the method most used to measure the morale of employees. From a general survey, questions relevant to the group conditions are used to develop a morale index by assigning values to alternative answers. The questions may look like, *e.g.,*

Q. 1. Do you feel that you are really a part of your work group ? (Check one).

- Really a part of my work group.
- Included in most ways.
- Included in some ways, but not in others.
- Do not feel I really belong.

Q. 2. How do you rate your company with others as a place to work with.

- Very worst.
- Worse than average.
- Just average.
- Better than average.
- Very best.

B. In-group versus out-group choices technique determines the ratio of in-group choices to out-group choices or in terms of the percent of in-group choices to choices available. The purpose of the method is to know whether an individual would like to work with the persons of his own group or with those of another group. A number of questions such as follows may be asked to ascertain the preference of an individual.

Q. 1. With whom would you prefer to work ?

Q. 2. Who would make a good supervisor ?

C. Other criteria used to measure morale are :

(*a*) Comparison of earlier and present value of productivity and waste (scrap) rate.

(*b*) Comparison of earlier and present rates of absenteeism and labour turn-over.

(*c*) Output and product quality.

(*d*) Complaints and grievances records.

Methods to Improve Morale

A number of methods employed for improving morale of employees are :

(1) Introduction of *profit sharing scheme* in which the employees in addition to their wages share a definite percentage of profits.

(2) Giving proper status and recognition to all concerned.

(3) Consulting the group on the matters related to work to be done by them.

(4) Basing decisions on the concept of Democratic Leadership.

(5) An effective two-way communication between the workers and the management.

(6) Suitable Suggestion System.

(7) Adequate grievance handling procedure.

(8) Periodic conferences between workers and management to discuss employee-problems and difficulties.

(9) Informal talks between individual workers and the management.

(10) Adequate welfare schemes for the employees and their families.

(11) Recreational facilities and social get-together programmes for the employees and their families.

19.11. MOTIVATION

Definition and Need of

- Certain workers generally come late, take more sick leaves or produce low quality products—perhaps they are less motivated or not motivated at all as compared to other workers.
- *Motivation* is the means or inducements which inspire or impel a person (to behave in a certain manner and) to intensify his willingness to use his capabilities and potentialities for achieving goals of the organisation in which he works.
- Behind *Motivation* (or the *will to do/achieve*) is mainly the psychological force ; physical or physiological factors exert comparatively lesser influence.
- What morale does to work-group, motivation does to an individual.

  Motivation moves an individual into action and urges him to work with sincerity and loyalty.
- Motivation of workers is very important when a supervisor wants to get things accomplished by them at right time, in right quantity and of right quality.

  Workers not properly motivated may not mentally accept the orders or directions with the result that the company goals may not be achieved effectively and efficiently.

Motive

- A detective or police seeks the motive (or reason) for crime, *i.e.*, why the accused did the crime. Once the motive for crime has been uncovered, it provides an explanation for the crime.
- Therefore *Motive* is a reason for the expression of a particular ability.
- Motive is an idea or emotion which prompts an individual to take a certain course of action. Motive influences the behaviour of an individual.

- Motives are based on physiological drives such as the innate tissue conditions of the organism to avoid pain, to need food, water, sleep, etc.
- Besides those based on physiological drives, there are social motives also, *e.g.,* self-respect, social approval or recognition, etc.

Internal and External Motives

- Internal motives motivate people internally. Internal motivation starts from the ego needs of an individual.
- Examples of internal motives are :
  - (*i*) The need to get the job of one's choice.
  - (*ii*) The illusion of self-determination and freedom.
  - (*iii*) A sense of accomplishment in doing a job well.
- External motivation is stimulated by pay, incentives, praise or punishment.

Positive and Negative Motivation

- Positive motivation adds to an individual's existing set of satisfactions, *e.g.,*
  A Better and more responsible job.
  Higher wages, etc.
- Negative motivation influences the behaviour of an individual through a threatened loss *e.g.,*
  Fear of losing one's present job.
  Reduced wages, etc.

Factors Affecting Motivation

(*a*) *Factors leading primarily towards motivation*

1. *Achievement.* Personal satisfaction in job completion and problem solving.
2. *Advancement.* Promotion to the higher job/level.
3. *Growth.* Learning new skills which will offer greater possibility for advancement.
4. *Recognition.* Acknowledgement of a job done well.
5. *Responsibility and Authority* in relation to one's job.
6. *Work itself.* Actual job content and its positive or negative effect on the worker.

(*b*) *Factors leading primarily towards dissatisfaction*

1. *Company Policy and Administration.* Feelings about the inadequacy of company organization and management, policies and procedures.
2. *Job Security.* Tenure, company stability or instability.
3. *Interpersonal Relations.* Relations with supervisors, subordinates and peers.
4. *Salary.* Pay and fringe benefits.
5. *Status. e.g.,* size of office, private secretary, air-conditioner, etc.
6. *Supervision.* Competency or technical ability of supervision.
7. *Working Conditions.* Physical environment associated with the job.
8. *Personal Life.* Personal factors (*e.g.,* family problems) which affect the job.

Motivational Techniques

1. Praise the workers and give them credit for all good work done by them.

2. Take a sincere interest in subordinates as individual persons.

3. Promote healthy competition among the individual employees.

4. Find ways to develop and utilise the appeal of pride in or about the workplace. Let the subordinates feel pride in work or in job accomplishment.

5. Delegate a substantial amount of responsibility to the subordinates.

6. Fix fair wages and monetary individual or group incentives for the employees.

7. Formulate a suitable suggestion system.

8. If possible permit the employee's participation in management matters.

9. Provide opportunities for growth and promotion.

10. Promote good and satisfying interpersonal relationships at work and outside.

11. Promote good working conditions.

12. Formulate fair, clear, firm and consistant management policies.

Besides the above-mentioned *positive* motivating tools, there are a few *negative* motivational techniques also, *e.g.,*

1. Reprimand
2. Fines
3. Demotion
4. Lay off
5. Discharge

The proper proportioning of these two motivational *techniques* (*i.e.*, Positive and Negative) is the mark of the skilful Manager, Executive or Supervisor.

19.12. WORKING, ENVIRONMENTAL CONDITIONS

Introduction

- Human work behaviour to a great extent can be influenced by the working environments or working conditions.

- *Working conditions* may be classed as follows :

1. Working conditions of physical nature, e.g.

- Illumination (Lighting),
- Heating,
- Ventilating,
- Air-conditioning, and
- Noise, etc.

Improper working conditions of physcial nature increase fatigue and reduce output and product quality. (For details refer Chapter 4)

2. Working conditions related to time, e.g.

- Hours of work (8-hours day and 40-hours week are probably best in terms of efficiency and absenteeism).

- Rest pauses. Rest pauses such as tea and coffee breaks or otherwise are necessary to prevent excessive physiological and mental fatigue.

Scheduled rest pauses during the day were found to reduce unauthorized rest pauses and they increased the speed of work.

In the case of monitoring tasks (in which the attention demands are high) rest periods should be provided at 20- or 30-minute intervals.

In case of heavy physical works or those carried out in hot environments rest pauses should be fairly frequent.

As a general practice, rest pause should be provided before the build up of a substantial level of fatigue.

3. *Working conditions related to social situation within which individual works, e.g.*

- Community attitude towards the objectives of the organisation.
- Acceptance of company employees by the community.
- Social welfare, etc.

19.13. INDUSTRIAL FATIGUE

Definition and Concept

- Working conditions of physical nature and those related to time, influence employee fatigue to a considerable extent.
- For practical purposes, *fatigue* may be *defined* as
  - (*i*) Negative appetite for activity ; and
  - (*ii*) A reduction in the ability to do work as a consequence of previous work.

Nature of Fatigue

- Fatigue includes both mental and physical reactions as well as the phenomenon of monotony and boredom.

  Monotony is a state of mind caused by performing repetitive tasks.

  Boredom or lack of interest, is characterised by depression and a desire for change of work or activity.
- Fatigue occurs owing to variety of causes ranging from chemical to psychological. Fatigue associates with it three aspects, namely

1. Reduction in quantity of work for a given amount of effort.
2. A feeling of tiredness.
3. Physiological change, *e.g.,* the accumulation of lactic acid in the blood caused by the breaking down of glycogen, or sugar, in the blood.

Effects of Fatigue. Fatigue,

1. affects badly the muscles, nerves and mind of the workers ;
2. decreases a worker's capacity to do more (further) work ;
3. results in loss of worker's efficiency ;
4. introduces a feeling of tiredness and weakness ;
5. creates disinterest in the work ;
6. disturbs chemical, psychological and physiological equilibrium ;
7. gives rise to monotony and boredom ;

8. increases tendency towards making accidents; and
9. increases absenteeism and labour turn-over rate.

Causes and Elimination of Fatigue

The various factors affecting fatigue and the methods to eliminate fatigue are briefed below :

1. Hours of work

In general, the highest productivity per hour and less fatigue is achieved with small number of working hours per day. Perhaps an eight-hour day with a lunch break of 45 to 60 minutes is a good solution.

2. Working days of a week

A five day week with 40 working hours (total) showed the highest hourly output.

3. Nature of work

- Complex muscular work may preferably be done with the help of suitable material handling devices.
- Minute and precise work imparts more fatigue.
- Mental task requiring continuous attention adds to fatigue rapidly.
- Work involving standing and abnormal posture tend to increase fatigue fast.

4. Working conditions

Improper working conditions such as

- Improper light (illumination)
- Too cold or too hot atmosphere,
- Insufficient ventilation,
- Presence of bad smell, fumes, dust, smoke and flash,
- Noise,
- Heavy protective clothings, etc., add to the fatigue of the worker.

Besides the above listed working conditions of physical nature, the surrounding social situations also add to fatigue.

5. Rest pauses

- Suitable and well planned rest pauses/tea-coffee breaks within the work-hours tend to reduce the build-up of fatigue.
- In general, the duration of rest pause should be anywhere from 5 to 20 minutes, with heavier work requiring the upper limit.

20

Personnel Management

20.1. DEFINITION AND CONCEPT

- Management in industry inevitably sub-divides itself into a series of functions such as sales, production, finance, etc. *Personnel* is one of these functions.
- The personnel function exists in every enterprise regardless of its size and irrespective of the fact that whether or not there is a personnel department.
- In a small concern, the personnel function is carried on by the owner itself whereas as soon as the organisation reaches a certain size, the personnel function like other functions is given a separate organizational status.
- The *personnel function* is concerned with all of the human relationships among workers as people.
- The essentials of Personnel Management were first exemplified by the work of Robert Owen (1771-1858). He recognized the immense importance of the human factor in industry and he put efforts to apply this knowledge.
- Any industry depends upon human beings; it has to acquire workers and it creates an acceptable environment and a rule-of-practice to encourage the greatest degree of participation from its employees.
- Personnel Management, Personnel Administration or Industrial Relations in an enterprise tends to attain maximum individual (employee) development, desirable working relationships between employees and employers and between groups of employees and effective moulding of human resources as contrasted with physical resources.
- *Personnel Management* may be defined as the Planning, Organising, Directing and Controlling of the Procurement, Development, Compensation, Integration and Maintenance of people (*i.e.*, employees) for the purpose of contributing to the organizational goals.

The different words used in the above definition are explained below :

(*i*) *Planning.* It means determination in advance of a personnel programme. It involves ability to think, analyze and to reach decisions.

(*ii*) *Organizing.* It means (after determining a course of action) establishing an organization by designing the structure of relationships among jobs, personnel and physical factors to attain the company objectives.

(*iii*) *Directing, Motivation or Actuation* means getting employees to go to work willingly and effectively.

(*iv*) *Controlling.* It concerns with regulating activities in accordance with the personnel plan (formulated on the basis of organizational goals).

(*v*) *Procurement* means obtaining proper kind and size of personnel necessary to achieve company goals.

(*vi*) *Development* involves increasing of employee's skill, through training, that is necessary for proper job performance.

(*vii*) *Compensation* means (adequate and equitable) remuneration of personnel for their contribution to achieve organizational goals.

(*viii*) *Integration* is concerned with the attempt to effect a resonable reconciliation of individual and organizational interest.

(*ix*) *Maintenance* means sustaining and improving the conditions (*e.g.*, health and safety measures, employee service programme, etc.), that have been established.

20.2. AIMS, OBJECTIVES OR FUNCTIONS OF PERSONNEL MANAGEMENT OR PERSONNEL DEPARTMENT

– Being used upon the definition of Personnel Management given in section 20.1, it is generally recognized that the following areas of the work situation in an industry are the province of the Personnel Department, *i.e.*, Personnel Manager and the staff of his department.

(*a*) *Procurement and Maintenance of adequate work-force (employees) as regards to both --number and quality of personnel.*

- Recruitment
- Interviewing
- Testing
- Induction
- Placement
- Follow up of new employees for adjustment
- Merit rating
- Promotion, transfer and discharge
- Employment records.

(*b*) *Education and training of present employees*

- Job instruction : Apprentice training vestibule schools
- Economic education
- Training plans : operative training, supervisory training, Executive training
- General industrial education
- Training materials and audio-visual training aids
- Reading rooms and libraries
- Records and statistics.

(*c*) *Maintaining Satisfactory Personnel Contacts and Employee Relationships*

- Job analysis, job specifications, etc.
- Merit rating of employees
- Wages and rewards
- Labour audit
- Labour records and labour statistics
- Regularization of employment
- Handling grievances
- Labour turn-over
- Labour market surveys
- Suggestion systems
- Morale studies.

(d) Maintaining satisfactory group relationships, by

- Contacting employer's groups
- Contacting employee's representatives
- Contacting government agencies
- Integrating group interests.

(e) Maintaining employees health

- Health standards
- Sanitation control
- Physical examinations
- Treatment of minor injuries and diseases
- Hospitalization
- Personnel hygiene and health education
- Rest periods, Recreation, etc.

(f) Maintaining employees safety

- Safety standards
- Safety guards and inspection of safety equipments
- Safety programmes, safety publicity, safety rules and safety contests
- Fire protection and accident investigations
- Safety records and workmen compensation for injuries.

(g) Maintaining employees service activities (employee welfare)

- Credit unions
- Savings and investment plans
- Group insurance
- Profit sharing
- Pension
- Legal assistance
- Housing programme
- Company stores and restaurants
- Recreation plans.

20.3. PRINCIPLES (CHARACTERISTICS) OF A GOOD PERSONNEL POLICY

- A personnel policy is a directive, usually written, to help personnel department in accomplishing its objectives or functions.
- A personnel policy is dynamic to meet fundamental changes or the current situation.
- A personnel policy contains the information regarding

(i) Recruiting employees	*(ii)* Employment conditions
(iii) Promotions	*(iv)* Discharge
(v) Safety practices	*(vi)* Training
(vii) Financial aid	*(viii)* Health standards, etc.
(ix) Separation.	

- Various characteristics/principles of a good personnel policy are :

1. It should avoid opportunism and be stable.

2. It should have due regard for the human equation, the employees, the employers and the consumers (or public).
3. An employee should be able to approach personnel manager to express his grievances.
4. It should not contain ambiguities and uncertainties.
5. It should guarantee permanent employment to competant employees.
6. It should be flexible enough to meet varying needs of employees and the changing conditions.
7. It should have provision to train competent employees for promotion.
8. It should be easily understood by all concerned persons.
9. It should guard employees against unfair dismissal.
10. It should have a fair wage agreement system.
11. It should provide good working conditions, safety and medical benefits.
12. It should recognize individual differences in capacities, interests, emotional reactions, etc.
13. It should organise and encourage social facilities.
14. It should be above religious, social or political discrimination.
15. A worker or workers should have formal recognition in phases of management of their vital interest.
16. It should maintain effective consultation between employers and employees.

20.4. RECRUITMENT AND SELECTION OF EMPLOYEES

Introduction

- The first step in the development of a concern's personnel activity is to *employ* the right type of persons to operate the organization. if the organization does not possess right kind of people, it leads to lowered production and employee morale and increased absenteeism and labour turn over.
- Employing people is one of the most critical steps in the establishment and growth of a business.
- The basic purpose of the employment office of the company is to hire desirable employees for specific company openings.
- Recruitment is a major step in the total staffing process.
- *Recruitment* may be described as the process of getting potential employees willing to apply for a iob with the concern or firm.
- In other words, recruitment develops and maintains adequate manpower to run an organization efficiently.
- The term *recruitment* is used to describe the attraction of applicants from among whom to select.
- *Recruitment* is the process of searching for prospective employees and stimulating them to apply for jobs in the cencern.
- For this reason, recruitment is a positive process ; it increases the number of candidates aspiring to take up a job with the organisation.
- As compared to *Recruitment, Selection* is a negative process because it picks out a few suitable persons from amongst a number of applicants and thus eliminates many candidates aspiring for the same post.
- Selection divides the applicants approaching for employment into the classes – those who will be offered employment and those who will not.
- A *good and effective selection* of employees :

(*i*) Raises output,
(*ii*) Improves product quality,
(*iii*) Reduces total product cost,
(*iv*) Minimizes disputes and grievances, and
(*v*) Lowers the labour turn-over rates, etc.

– The applicant selected for the post should :

(*i*) Be willing to work,
(*ii*) Be able to handle the job,
(*iii*) Be stable, *i.e.*, stay with the organisation for a fair period,
(*iv*) Be able to fit in the work situation, and
(*v*) Have development and growth potentialities.

Functions of Employment Section of the Company

(*a*) To hire right type of employees for specific company openings.
(*b*) To maintain adequate supply of right kind of employees.
(*c*) To develop job specifications.
(*d*) To procure information about current wage rates.
(*e*) To introduce selected employees with personnel policy of the company.
(*f*) To follow up the new recruits for initial adjustment.
(*g*) To look after employee counselling and operating the seniority system.
(*h*) To keep records of employees, hired, resigned, discharged and transferred.

Sources of New Employees

(a) *From within the Company*

– By promotion
– By transfer
– Former employees who had good service records when they left.

(b) *From outside the Company*

– Friends and relatives of present employees duly recommended by them.
– Through press and other advertisements.
– Through employment agencies.
– Through schools, colleges and universities.
– Through labour unions.
– From waiting lists.
– As recommended by Professional bodies and societies.
– Foreign sources.
– From unsolicited applications received, both at the gate and through the mail.
– Through trade associations.
– From Government employment exchanges.
– From labour contractors.
– Through personnel consultants.
– With the help of Notices exhibited at the factory gate.

SELECTION PROCESS OR TECHNIQUE

- After attracting a number of applicants through various sources described earlier, the next stage is the selection process, *i.e.*, to select the persons most appropriate for the organization.
- The different procedural steps involved in the selection process are

(A) (Obtaining) job descriptions,
(B) Application forms,
(C) Employment tests,
(D) Interviewing,
(E) Physical examination,
(F) Induction or orientation.

(A) Job description

- The first important step of any selection process is to develop job descriptions for the positions to be advertised and filled.
- A *job description* is a combination of short statements that describe both the work to be performed and the essential requirements of the particular job.
- The *job description* includes

(*i*) Job title.
(*ii*) Department in which the job exists.
(*iii*) Work to be performed by the new employee.
(*iv*) Job responsibilities, *e.g.*, care and maintenance of machine tools.
(*v*) Job Knowledge, *i.e.*, ability to read from job instructions and blue print.
(*vi*) Mental concentration.
(*vii*) Dexterity and accuracy.
(*viii*) Machines, tools and processes to be handled.
(*ix*) Relation with other jobs.
(*x*) Qualification and experience required.
(*xi*) Amount of supervision.
(*xii*) Physical activities.
(*xiii*) Working (environment) conditions, *i.e.*, whether hazardous or safe.

- **The job description of Personnel Officer may look like**

Responsible for all personnel management functions involving industrial relations, personnel administration, manpower planning, selection, training and development, labour laws, welfare services, etc. will advise the management regarding labour disputes, grievance handling, disciplinary action, bipartite negotiations on a day-to-day basis and also coordinate with Government departments. Should be gradutate having post-graduate qualification in Personnel Management or Industrial Relations in the age group of 30-40 with a minimum of 5/8 years' similar experience.

(B) Application Forms

- An application blank or form is the most universal mechanism used to screen the applicants to be called for interview and other tests for selection purposes.
- The contents of an application form can discourage unsuitable applicants and its design can, reflect a firm's dignity, reduce to a minimum the time required to fill it out and simplify its review.
- The application form may be used to get from the applicant, the information such as his age,

marital stauts, previous education and training, previous work experience, including nature of duties, salary, length of time on the job, reasons for leaving, etc.

- A duly filled application form helps determine which applicants meet the job requirements, because an application form elicits sufficient accurate information that the least likely applicants can be eliminated by simply reviewing the contents of the filled application forms.
- An application form tests an applicant's ability to write, to organise his thoughts and to present facts clearly and succinctly.
- An application form tells whether the candidate has consistently progressed to better jobs and whether his education, training and experience have been logically patterned.
- For assessing and screening purposes, the various questions listed in the application form may be weighted and scored according to their predictive value. Such scores are then matched against the scores of company employees with good tenure and performance records.
- An application form should be made simple, easy to fill and easy to check.

(C) Employment Tests

- Very often considerable training money is expended upon an employee when it is discovered that he is unsuited to do the job for which he was employed. For this reason and in order to avoid the re-occurrence of such a situation, employment tests are, sometimes considered an essential part of the selection programme.
- Tests are conducted as a means of scaling applicants in terms of their innate abilities.
- Tests are conducted as a means of scaling applicants in terms of their innate abilities.
- Tests are helpful in determining a mimumum below which the candidate has little or no chance for reasonable success.
- A test is a rapid method of obtaining samples of behaviour to help the interviewer form a judgement to hire or not to hire a given applicant.
- An *employment test* measures selected psychological factors such as ability to reason, capacity for learning, temperament, specific aptitudes, physical or motor abilities (*e.g.*, manual dexterity or eye-hand coordination), etc.
- *Characteristics of good employment tests*

(*i*) A test should be designed on the basis of a sound job analysis programme.

(*ii*) The test should be reliable. *i.e.*, an applicant if tested even second or third time under same condition should achieve the same score.

(*iii*) The test should be valid, *i.e.* highly specific to the objective it intends to measure and to the particular business situation.

- *Advantages of a good test*

(*i*) A good test eliminates the possibility that the prejudice of interviewer will govern the selection decisions.

(*ii*) It uncovers the hidden talents of an applicant which might have been otherwise overlooked in the selection porcess.

(*iii*) A number of candidates can be tested at one time and a good amount of information about each applicant can be obtained in a relatively small duration of time.

(*iv*) Test score of an applicant is a positive point (reason) to accept him or to reject him.

(*v*) Tests tend to lower the cost of selection because a number of candidates can be tested simultaneously.

– **Types of employment tests**

A simple classification of tests used in selection would distinguish the following main types :

(*a*) Achievement tests,
(*b*) Aptitude tests,
(*c*) Intelligence tests,
(*d*) Interest tests.
(*e*) Dexterity (motor) tests, and
(*f*) Personality tests.

(a) Achievement tests or Performance tests

– When an applicant claims to know something, an achievent or permormance test is given in order to given him a chance to demonstrate his ability and thus to measure what the applicant knows about a particular job or what is his degree of proficiency in doing that job.
– Prospective stenographers are asked to take dictation and then type it out, a welder is asked to weld two metal pieces together, a machinist is asked to prepare a job involving many different machining operations, etc.
– Achievement tests prove to be very useful in selecting employees at the lower levels, *e.g.*, a welder, a typist, a driver, etc.
– Performance tests are highly acceptable to both management and applicants because of their evident close relationship to the job in question.
– **Trade Tests** measuring an applicant's (*e.g.*, a welder's or turner's) trade knowledge and skill are a type of achievement tests. Trade tests may be oral, written, picture or performance type.
– In general, performance tests achieve high validity when the tasks to be evaluated are representative and when the rating system is objective and uses appropriate standards.

(b) Aptitude Tests

– An aptitude test explores inborn tendencies of an applicant to perform well in a particular field.
– An aptitude test determines whether an applicant has the capacity or hidden ability to learn a given work if he is given proper training.
– Examples of aptitude tests are : mechancial, clerical, musical, and motor capacity tests such as finger dexterity, eye hand coordination, etc.
– An aptitude test is used to measure the job proficiency (from production records) and job training of an employee.

(c) Intelligence tests

– Intelligence tests give an idea of mental quickness or quickness of perception and general knowledge of an applicant.
– An intelligence test is probably the most widely administered standardized test in industry.
– An intelligence test explores
  Quick learning,
  Alertness,
  Comprehension, and
  Reasoning.
  Judgement making qualities of an applicant and his ability to deal with abstract symbols, ideas, words, number and so forth.

- Questions in intelligence tests are practical, job oriented and abstract type.
- Generally many industries make use of short, paper-and-pencil tests which give a rough approximation of the I.Q. (Intelligence Quotient) of the applicants.
- Intelligence tests can be employed by an organization for selecting all levels of employees taking from workers to managers.
- An example of an intelligence test is as follows :

Fill in the blank space :

16	28	41	58
37	49	62	

(Ans. Seventy nine)

(d) Interest tests

- A person interested in a job will do it much better than the one who is uninterested. Interest is a main factor which contributes to the success on the job.
- Interest tests discover the patterns of an applicant's interests and thus suggest what types of work may be satisfying to the prospective employee.
- Interest tests measure an applicant's preferences for certain activities of either a vocational or avocational nature.
- Most widely used interest tests are
  - (*i*) Strong Vocational Interests Blank for men and women. The applicant is asked if he likes, dislikes or is indifferent to many examples of school/college subjects, amusements, occupations, particular activities, etc. and then his interests are compared with the interests of successful personnel in specific professions and occupations.
  - (*ii*) Kuder Preference Record.

  The test deals with more basic interest groupings. These areas are mechanical, scientific, computational, musical, social service, etc.
- Interest tests are very useful in counselling situations where a person is in need of help and is willing to cooperate fully.

(e) Dexterity Tests

- They discover an applicant's cleverness to work with his hands and fingers when the job requires the skilful use of one's hands and body, *e.g.*, assembling operations.

(f) Personality Tests

- An applicant may possess intelligence, aptitude, interest and what not, but if he lacks in personality, he may not be able to get along with and motivate other persons in the organization.
- A personality test measures an applicant's :
  - (*i*) Self-action or knowledge of other people's behaviour.
  - (*ii*) Social or unsocial tendencies.
  - (*iii*) Emotional adjustment and instability.
  - (*iv*) Vocational interests.
  - (*v*) Originality.
  - (*vi*) Motives and basic needs.
  - (*vii*) Self-confidence, and decisiveness.

(*viii*) Capacity for interpersonal relations.

(*ix*) Optimism, Patience etc.

– A few examples of personality tests are

(*i*) Do you ever feel that people are staring at and laughing at you : Yes/No.

(*ii*) Do you frequently wake up in a *cold sweat* : Yes/No.

– Personality tests are very useful in counselling and in selecting salesmen, supervisors, etc.

(D) INTERVIEWING

– An interview is a conversation (directed to a definite purpose) between an applicant and the interviewer and much of the interaction between these two is carried on by gestures, postures, facial expressions and other communicative behaviour.

– It is in the interview that both the prospective employee and the employer get the chance to learn and know about each other.

– The interview is a commonly used method of human evaluation and it is also probably the oldest.

– If an organization is asked to pick up a single method for selecting employees, it would choose interviewing most frequently.

Purpose of Employment Interview

(1) It measures all relevant attributes and integrates and clarifies all other information about the applicant.

– An interview helps studing the impact of personality of the applicant upon others.

– An interview helps exploring the innate abilities, *e.g.*, quickness in the uptake, of the applicant.

– An interview helps studying the motivation and emotional adjustment of an applicant.

(2) It helps the employer to view the total individual (*i.e.*, applicant) and to appraise the person and his behaviour direclty.

(3) It measures the applicant against the specific requirements of the job and helps deciding whether there will be a good "fit".

(4) It helps finding the suitability of one or a few candidates from amongst the many.

(5) It gives the applicant a chance to learn the opportunities and job possibilities that exist in the organization.

Types of Interviews

(1) Guided, directed or patterned interview in which a list of questions (to be put up to the applicant) is prepared based on the analysis of the job specification.

– A patterned interview measures the personality traits such as self-reliance, emotional stability, ability to get along with others, willingness to take up responsibility etc.

– The typical employment interview is guided, nonetheless, as its average length is 30 minutes for plant employees and 45 minutes for office employees.

(2) Unguided, nondirected or unpatterned interview as its name implies is not directed by the interviewer; instead the applicant talks about what he chooses.

– Unguided interview is more often used in situations other than employment, *e.g.*, counselling, handling grievances, etc.

Conducting the Interview—Procedure

The typical sequence of functions that occur in the process of interviewing are as follows :

1. *Preparation for the interview*
   - Spell out the specific objectives of the interview.
   - Select the appropriate type of interview *i.e.*, guided or unguided.
   - Determine the number of interviewers.
   - Review all the information submitted by the applicant on the application form.
   - Decide the length of interview.
2. *Setting for the interview*
   - Decide the place for interview. The place should be private, comfortable and free from all disturbances.
   - Mental setting will help the interviewee to feel at ease. Allow a little time to interviewee to get accustomed to you and your situation.
3. *Conduct of interview*
   - Make interviewee feel that you have a basic liking and respect for people and you are interested in hearing the applicant.
   - Begin with simple questions and encourage the interviewee to talk.
   - Once you get into the main topic of interview, do everything to get interviewee talk freely with as-little prodding from you as possible.
   - Listen the interviewee attentively, patiently and, if possible, projectively (*i.e.* by projecting one's consciousness into that of another person).
   - Do not run the risk of letting the interview loose direction, keep control of interview.
4. *Close the interview*
   - The interviewer should make some overt sign (*e.g.* laying his pencil down, pusing back the chair), to indicate the end of interview.

     At the close of interview, watch for additional information in the casual remarks of interviewee.
   - Give to the interviewee some type of answer or indication of future action.
5. *Evaluate the interview*
   - The interview provides much opportunity for inferences, sound and unsound.
   - The applicant may be finally assessed on the basis of

   (a) *The Analytic Approach* in which a rating sheet is used and the applicant is rated on the basis of a number of factors predictive of success.

   (b) *The Integrative Approach* evaluates the applicant as a total integrated person, *i.e.* the applicant is assessed on the basis of overall fitness.
   - From the interview, the interviewer concludes whether the applicant is :

     (i) Dependable.
     (ii) Adaptable.
     (iii) Persevering.
     (iv) Cooperative.
     (v) A hard worker.
     (vi) Able to work under pressure.
     (vii) Positively motivated.
     (viii) Good in human relations.
     (ix) A turn-over problem.

(E) Physical Examination

- The physical examination as a step in the employment procedure is found in most businesses.
- Many jobs require unusual stamina, strength or tolerance in unpleasant conditions.

The physical examination reveals whether or not an applicant is fit for a particular job.

- *A physical examination may include*

(*i*) Family medical history.
(*ii*) Personal history of previous illness.
(*iii*) Height, chest and weight measurements.
(*iv*) General physical examination of the skin and joints.
(*v*) Examination of eyes, nose, throat, teeth and ears.
(*vi*) Chest X-ray.
(*vii*) Check-up of heart and blood pressure.
(*viii*) Urine and blood test, etc.

- *Purpose of physical examination*

(*i*) To ascertain the physical capabilities of the applicant. *i.e.*, can he work standing up? Can he lift heavy objects ? etc.

Physical examination prevents employees from being assigned to jobs which are beyond their strength.

(*ii*) To find if the applicant has the general physical characteristics required for the job.

(*iii*) To find if the applicant is suffering from communicable diseases.

(*iv*) To determine the exact state of health of the applicant in order to protect the company against unwarranted claims under workmen's compensation laws or against law suits for damages.

(*v*) The company's general health programme is facilitated by initial physical examination. Later physical check-ups will indicate whether the employee's general health is improving or deteriorating.

- The physical examination may be conducted by the doctor of the industrial hospital or of a civil hospital.

(F) Induction and Orientation

- It has been reported by many concerns that over half of the voluntary (employee) quits occur within the first six months on the job and a large portion of these is because workers are introduced to their jobs in a haphazard manner.
- Induction implies introducing or orienting a new employee to the organisation.

20.5. EDUCATION AND TRAINING

20.5.1 Introduction

- When the employment aspect of the personnel function has succeeded in providing suitable employees for various tasks, it is followed by an Education and Training aspect which brings employees to a standard where they can carry out industrial tasks efficiently.
- One of the characteristics of modern society is the increasing rapidity of change today compared with older social orders. This intensifies the need for study, adaptation and new education and training.
- In the field of education and training, personnel management deals with an extensive programme, ranging from the placement, induction and training of new recruits to the provision of courses for middle and higher management levels.
- Training is an ever-continuing process in all organisations and it is employed as a technique of control as well as of imparting information and developing new skills.

- The main object of all industrial training is to prepare people to do efficiently their own particular tasks or to do another job equally well.
- Industrial training is based upon a specific need. It imparts knowledge and develops employees aptitude and skill for a particular industrial task.
- *Education* improves an employee and he can take up and handle jobs of higher responsibility whereas

Training prepares an individual so that he can accomplish his industrial task efficiently and effectively.

- Every industrial organisation realises the *need* of training the recruits before putting them on a (new) job. If there is no planned training programme, the employees train themselves by trial and or by observing others; this not only results in higher training costs (because of more work spoilage and scrap rate), the learning period gets considerably lengthened and even then employee is not able to learn the best operating methods.

20.5.2 Objectives, Aims or Need for Training

Training of employees is essential in order :

1. To ensure an adequate supply of properly trained employees at all levels of industry.
2. To improve the performance of each employee to the highest attainable level and to develop his potential so that he can take up jobs of higher responsibility.
3. To attain precision and clarity in the transition of business.
4. To increase productivity by conceptual skill, imagination and judgement of employees.
5. To reduce scrap rate.
6. To reduce accident rate.
7. To minimize absences.
8. To reduce fatigue and tardiness.
9. To minimize over-time.
10. To reduce labour turn-over.
11. To boost employee morale.
12. To promote cooperation and good relations between workers and management.
13. To reduce cost of product through economic and more efficient use of company resources.
14. To provide knowledge and appreciation of techniques necessary to enable a trainee to do his job.
15. To inculcate a broad understanding of relevant science and technology so that the trainees adjust to the changes in the nature of work.
16. To teach employees the standardized work methods.
17. To inculcate good work habits on the part of employees.
18. To promote team work.
19. To find out whether an employee is suited to the job.
20. To adjust employee's outlook to new needs of new times.

20.5.3 Advantages of Employee Training

1. Increased productivity.
2. Fast production rate and improved product quality
3. Reduced supervision of employees.
4. Better cooperation and team work among employees.

5. Increased organizational stability and flexibility.

6. Reduced labour turn-over, quits and fires.

7. Reduced accidents.

8. Less fatigue to workers.

9. Heightened morale of the employees.

10. Increased labour efficiency.

11. Reduced scrap rate.

12. Less equipment maintenance problems because a properly trained worker handles machinery carefully.

13. Increased wage rates.

14. More job satisfaction.

20.5.4 Methods of Training

Instructional methods may be classified as follows :

1. *Individual Instruction.* This involves devoting personal attention to an employee in order to teach him a complicated skill, *e.g.*, to run a machine or to perform a complicated assembly operation.

2. *Group Instruction.* Under this method of instruction, a group of trainees are given certain basic facts about the job *e.g.*, explaining to the workers the importance of adopting a new method for doing the same old job.

3. *Lecture Method.* It is the most effective method for giving to trainees the basic or supplementary (usually technical) information on specific subject, *e.g.* mathematical treatment of the forces acting on a lathe tool when doing rough turning.

4. *Demonstration Method.* It is employed to help trainees to grasp manual skills *e.g.,* the right way to hold the job against the grinding wheel.

5. *Written Instructional Method.* This method is used to give to trainees the important information in permanent form for immediate or future use, *e.g.*, Standard Practice Instructions on how to perform various jobs.

6. *Oral Instructions.* Oral instructions method is used when it is required to give information needed at once—in short form, *e.g.*, when an employee starts on a new job. The oral instructions explain the principles behind the work and reason why it is required to do.

7. *Conferences.* The conference method of training is of particular value on account of its flexibility. It helps solving problems or changing attitudes, *e.g.*, how to reduce waste or scrap rate or how to control absenteeism.

In conference method, the text material plays only a minor role, practical experience forms the background for every discussion.

8. *Meeting.* Meetings are held to exchange information, solve immediate problems or to get ideas of group *e.g.*, department safety meeting will extract from the employees as how to make machine operation more safe, how to reduce accidents, etc.

20.5.5 The Training procedure

The procedural steps involved in the process of training are :

1. Make the instructor ready to teach

The instructor should,

Know the job himself thoroughly.

Break up the job into logical steps, for example for infeed grinding on a centerless grinder, first

step is to place the workpiece on the plate against the grinding wheel, the second step is to lower the lever, feed and grind, etc.

- Know at which stage of training which training method (*i.e.* lecture, demonstration, etc.) is to be used,
- Keep physical work place ready for training.

2. *Get the trainee ready to learn*
   - because a person who is interested in learning is easiest to teach,
   - make trainee feel at ease,
   - explain to the trainee what he is going to learn, what is the purpose behind, what is the importance of job, how it is related to work done before and afterwards and what is the benefit of rapid and effective learning.

3. *Demonstrate the method of doing the job*

Tell and show to the trainee the correct procedure of doing the job, step by step, using appropriate training aids and let the trainee watch the whole show. While doing so

- explain the sequence of the entire job,
- demonstrate each operation using the best motions and their correct sequence at a standard pace rate,
- repeat if necessary, and
- emphasize key points in each step. A key point is one which might damage the job or injure the trainee.

4. *Let the trainee try the operations himself*

Under the guidance of the instructor

- correct the trainee when he is wrong,
- encourage him when he is working right,
- learning curves* may help at this stage, and
- an attitude of patience and goodwill on the part of instructor might be very much beneficial.

5. *Gradually put the trainee on his own*
   - When the instructor feels that the trainee can do the work resonably well in his presence, he may let the trainee loose for a while; but not abondon him completely.
   - The time for which the trainee is working independently should be increased gradually and gradually.

6. *Follow up*
   - The trainee should be checked from time to time in order to find whether he is doing correctly and working satisfactorily or not.
   - Any deviation from the standard method (practice) noticed should be told to the trainee and corrected accordingly.

20.5.6 Systems, Forms or Kinds of Training for Different Levels of Staff in Industry

- Different staff levels and the type of training conducted for each level is listed in Table 20.1 below

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Refer 'Workstudy' by Dr. O.P. Khanna (Page 106).

Table 20.1

Staff	*Type of training*
(*a*) Workers or Operators Training	1. Induction and orientation. 2. By skilled and old workers. 3. On-the-job training. 4. Apprentice Training. 5. Vestibule schools.
(*b*) Foreman or Supervisor Training	1. Induction. 2. Lectures. 3. Written material (instructions). 4. Conferences. 5. Training within Industry (TWI).
(*c*) Executive Training and Development	1. Management induction. 2. On-the-job experience, coaching and under study. 3. Conferences. 4. Meetings. 5. Special projects. 6. Committee assignments. 7. Selective reading. 8. Special courses and classes.

(a) WORKER'S OR OPERATOR'S TRAINING

1. Induction and Orientation

- When a new worker joins a concern, everything is strange for him; physical layout is unfamiliar and he does not know to whom to approach for the most obvious day-to day requirements.
- The induction and orientation training aims to get over this settling in period as quickly as possible and with the minimum of emotional upsets being experienced by the new employee.
- Induction and orientation training involves familiarizing the new employee about the following :
  - (*i*) The concern or the enterprise which he has joined, its history, organisation structure, products being manufactured, etc.
  - (*ii*) Conditions of employment, disciplinary rules and other aspects of personnel policy.
  - (*iii*) Employee activities and service benefit plans.
  - (*iv*) Community facilities and plant facilities (*e.g.*, Canteen, etc.)
  - (*v*) Information about the work, he has to undertake and the department in which he has to work.
  - (*vi*) Wage rate and incentive schemes.
  - (*vii*) Safety and proper use of tools and equipments.
  - (*viii*) Introduction with fellow workers and supervisor.

2. Training by Skilled, Experienced and Old Workers

- The new worker is attached with an old, skilled and experienced worker. The new worker watches the experienced worker while he works and then tries to do the same himself in the same way. From time to time he gets instructions from the skilled worker also.

- This type of training can be seen in very small concerns, *e.g.* auto repair shops where there is no established training programme.
- This method of training has a disadvantage that the new worker will learn even the wrong work practices followed by the old worker.

3. On-the-Job Training

- On-the-job training is imparted to the new workers on-the job itself ; no additional training equipment is required.
- This type of training is conducted either by the shop supervisor or by an experienced worker already familiar with the job.
- The supervisor explains and demonstrates to the trainee the job, the use of tools and equipment and the correct procedure to do the job.

The trainee is then asked to try himself and make the job.

Mistakes, if any, made by the trainee are corrected and he is kept under constant watch until he develops correct work habits.

Advantages

1. It is a simple and inexpensive method of training.

2. It does not require any additional machinery for training purposes.

3. Its flexibility permits a programme to be started and stopped at will and to be adjusted to the individual concerned.

4. The worker has first-hand experience with the job and learns by doing. He gets introduced very soon to the realism of the actual work situation.

Limitations

1. All supervisors are not inherently successful teachers.

2. A trainee may not be able to learn efficiently on the production floor because of the noise and bustle of the work-place.

3. This type of training will not produce skilled workers in a short time.

4. On-the-job training does not produce workers uniformly skilled.

5. Working of trainee on the production floor may increase chances of spoilage of material, damage to equipments, accidents, etc.

6. On-the-job training tends to be administered and coordinated on a somewhat haphazard basis.

4. Apprentice Training

- Apprenticeship training has an academic side as well as practical one *i.e*, a trainee attends certain courses as well as receives practical training.
- Apprentice training is a variation of on-the-job training in which a trainee is taught the WHY as well as the HOW and he is given a broad training to enable him to take up a wide varity of tasks within his field of specialization.
- An apprentice is trained to do a job requiring highly skilled work applied to varying work patterns.
- Under this scheme young boys 16 to 18 years of age are trained for 2 to 4 years. The training involves doing a planned sequence of jobs and spending a prescribed number of hours in the class-room. The apprentice is paid wages (normally increasing with the passage of time) for hours of instruction as well hours of production.
- Apprentice training is being conducted in a number of fields such as electrician, turner, welder, moulder, motor mechanic, etc.

Apprentice training is a long, thorough and costly practice.

5. Vestibule Schools

- This type of training is performed outside the shop floor-as if it were carried out in the vestibule (*i.e.* a fore-court or an entrance hall) of the company before actual entry into the working part of the plant.
- It becomes necessary for a concern to start a vestibule training school when the amount of training to be imparted and the number of trainees exceed the capacity of a shop supervisor (to impart on-the-job training).
- A vestibule school is set up on the company property and equipment actually used on the shop floor is duplicated as closely as possible.
- A large number of trainees undergo a planned course of instructions and practice usually by instructors not attached with immediate production.
- After the trainees achieve proficiency, they are transferred to production floor to take up regular production work without delay.

Advantages

1. A large number of trainees can be trained in similar skills, quickly and uniformly.
2. Unlike on-the-job training, the vestibule school training does not damage actual production.
3. The school atmosphere is calm, peaceful and conducive to efficient learning.
4. Instructors are not worried about immediate production.
5. Specially trained and professional instructors can be employed for imparting instructions to trainees.
6. Wastage and spoilage of raw material and damage to production machinery is eliminated.

Limitations

1. It is a costly affair and every industry cannot afford it.
2. Production machinery need be duplicated.
3. A trainee does not achieve familiarity with actual shop floor conditions while he is being trained in the vestibule school. Therefore he requires a period to adjust himself with the shop floor conditions when he enters the working area of the plant after completing his training in the school.
4. If the demand of workers is uneven, usually either a part of vestibule school is idle or trainees are rushed through it without proper training.

(b) FOREMAN OR SUPERVISOR'S TRAINING

Introduction

- Foremen or supervisors are the next step above the workers or operators level employees in the organizational pyramid.
- A forman is the keyman who interprets management to the workers and at the same time is responsible for production. He stands between management and the *rank and file* level employees.
- *A supervisor generally has to take care of the following :*
  - (*i*) Selecting and training of workers.
  - (*ii*) Work production.
  - (*iii*) Control of quality, quantity and cost.
  - (*iv*) Discipline, motivation and morale of workers.
  - (*v*) Work method improvement.
  - (*vi*) Accident prevention.
  - (*vii*) Maintaining machinery and supplies.

(*viii*) Compliance with labour laws.

(*ix*) Cooperation and coordination with other departments.

(*x*) Handling labour grievances.

(*xi*) Record keeping.

– Therefore, the training of the foreman should be planned by keeping the above-mentioned points in view.

– **The foreman training should :**

(*i*) Bring his impact up to the standard where he can handle his interactions with others effectively.

(*ii*) Primarily aim to develop the qualities of leadership.

(*iii*) Equip him with an adequate knowledge of management methods to deal with other people.

(*iv*) Broaden him and at the same time develop qualities of analysis that will enable him to visualize his job.

(*v*) Encourage the development of his motivation and adjustment.

(*vi*) Develop the foreman to qualify for advancement to positions of greater responsibility.

(*vii*) Impart to him a deep knowledge about the work so that workers should feel that he is superior to them.

(*viii*) Develop in him the skill to impart instructions to the workers under him.

(*ix*) Develop in him the skill to improve upon the existing methods of work.

(*x*) Preferably be conducted within the company itself.

– **Foreman Training Techniques**

1. **Induction**
   - Any new employee whether he is a worker or foreman needs proper induction before he is asked to do the job or work predecided for him.
   - For details of induction programme refer to section 20.5.6.
2. **Lecture (class-room) Method**
   - Class-room training depends entirely upon lectures as the medium of training.
   - Lecture can be delivered to as many supervisors as can be accommodated in the room.
   - Lecture is delivered by experts from within or outside the company.
   - Lecture is a very good medium of training where no reliable books or other written meterial is available.
   - The value of the lecture can be enhanced by using audio-visual aids such as technical films, slides, overhead transparencies, etc.
3. **Written Meterial**
   - Refer section 20.5.4.
4. **Conference**
   - A conference brings together many people who tend to train themselves and learn together.
   - People attending a conference, compare, consider and discuss the subject matter of their interest, *e.g.*, how to control absenteeism, how to minimize scrap rate etc.
   - A conference helps pooling ideas and experiences of different persons and puts them open for discussions to arrive at a feasible solution of the problem in hand.
   - A conference can uproot fixed ideas, change attitudes and develop analytical and questioning ability.

- The conference discussions should be thoroughly planned and the points of conclusion (but not the conclusion itself) must be predetermined.
- The conference leader or trainer should guide, be active, lead, interpret, stimulate and draw out the ideas and opinions of the group engaged in discussion.

5. Training within Industry (TWI)

- An outcome of World War II was the TWI-Training Within Industry Programme of the War Manpower Commission.

This was basically a supervisory training programme to make up for the shortage of civilian supervisory skills during the war.

One of the parts of this programme was the job instruction training course, which was concerned with how to teach.

- During war time and even afterwards more supervisors have been trained by TWI than by any other method.
- TWI courses can be held on a concern's premises and cause little disruption of work.
- TWI courses are based upon group conference method, and supervisors attend on a part-time basis.
- TWI courses can be easily adapted to special needs and impart effective training in minimum time.
- A TWI course imparts training in

(*a*) *Job Instruction.* The supervisor develops the ability to impart clear instructions to the workers as regards what to do and how to do it.

(*b*) *Job Relation.* This programme develops in a supervisor

- Leadership qualities.
- The ability to analyse and handle labour problems.
- The ability to promote good working relations.

(*c*) *Job Method.* This programme increases supervisor's skill to

- improve methods of doing work, and
- make best use of men, materials and machines.

(*d*) *Job Safety.* Supervisor learns how to

- Prevent accidents.
- Spot dangers and eliminate them.

(C) EXECUTIVE TRAINING AND DEVELOPMENT

- Executive training and development is one of the most important and complex tasks of Personnel Management.
- Larger concerns give increased attention to the training and development of their Managers and Executives.

The primary emphasis in executive development should be in self-development. There is no substitute for personal drive, initiative and ability.

- Executive training and development can be classified as follows :

(*i*) *On-the-job training* and development which includes,

- Learning by experience.
- On-the-Job coaching.
- Understudies. The trainee is kept understudy and he learns the ways of his superior under whom

he is at study.

- Position Rotation. Rotating an executive from one position to another broadens his background in the business.
- Special Projects. A special assignment, *e.g.*, "to develop a system of dust collection in the foundry," is highly useful and flexible training device.
- Committee Assignments. Unlike special projects, committee assignments are regularly constituted. Committee assignments very well impart the necessary general background.
- Selective Reading, *e.g.*, going through Business Magazines, Trade Journals, etc.

(ii) Off-the-Job training and development which includes

- Attending special courses conducted at colleges and universities.
- Role Playing. It involves constructing artificially a conflict situation in which the trainee is given a strategic position to play.

Role playing increases the trainee's skill in dealing with other people (*e.g.*, Sales Training).

- Sensitivity Training. It develops executive's awareness and sensitivity to behavioural patterns of oneself and other people.
- Simulation. Trainees are asked to make decisions about production, cost, inventories, sales etc., for a simulated firm.
- Conference Training (discussed earlier).
- Attending Special Meetings of one or two days duration in various fields, *e.g.*, Personnel, Production or Marketing Management, etc.

20.6. SAFETY ENGINEERING

Safety in Industry

- The modern safety movement started around 1912 with the First Cooperative Safety Congress and the organization of the National Safety Council in U.S.A.

From 1912 to the present time, remarkable advances have been made in reducing the rate and severity of accidents.

- The importance of industrial safety was realized because every year millions of industrial accidents occur which result in either death or in temporary and permanent disablement of the employees and involve a good amount of cost such as resulting from wasted manhours, machine hours etc.
- In 1952 in U.S.A., fifteen thousand workers were killed in industrial accidents, 2,000,000 were injured and the total cost of these accidents was about $ 2,900,000,000.
- Loss of lives and accidents costs gradually led to the formation of Factories act, Office, Shops and Railway Premises Act etc.
- The requirement for consideration of safety by management as part of its responsibility arises primarily from these Acts.
- Safety begins on the drawing board when in the original design of tools or workplace layout, accident hazard may be built in or eliminated.
- *Safety results*

  (*i*) from safe plant, processes, and operations, and

  (*ii*) by educating and training workers and supervisors regarding safe practices on the shop floor.
- In an industry, safety may be considered from the mechanical side (equipment, tools etc.) or from legel angles of workmen's compensation or even as a matter of training in and motivation towards safe work practices for workers (especially newly recruited ones).

Need for Safety

Safety in industry helps,

(*i*) Increasing rate of production.

(*ii*) Reducing production cost.

(*iii*) Reducing damage to equipment and machinery.

(*iv*) Preventing premature death of talented workers who are an asset to the society.

(*v*) Preventing needless pain and suffering to its emplyees.

Organization for Safety

- In a small concern each shop supervisor may be made responsible for safety in his shop.
- Each shop supervisor may report to top executive as regards safety matters.
- Since the shop supervisor has its main job to turn out production, he may treat safety as a secondary aspect.
- For this reason sometimes the safety function is taken care of by personnel officer or general foreman.
- With the growth in the size of the industry and depending upon the hazardousness of processes/ operations, a full fledged safety department may be created with the safety Director/Manager as its chief executive and a number of persons under him at different levels.

The safety Director/Manager may be given a line position or staff position depending upon the conditions in the industry.

- Sometimes the responsibility for safety rests on a safety committee.

Safety Committee

- A safety committee may consist of executives, supervisors, and shop floor workers.
- Thus the lower level employees get a channel of communication on safety matters direct to executive level.
- It was observed that those organizations which made safety committees had lower record of accidents than those without safety committees.
- Safety committees aid in developing safety consciousness as well as it is a policy making body on such safety matters as come before it.
- The Safety Manager/executive requires a degree of firmness and ready discrimination to exclude personal and union matters in which safety is merely the pretext for their airing.
- The safety executive should guard jealously the responsibilities of management and supervision.
- Lastly, to get maximum out of a safety committee
  - (*i*) It should be assigned specific problems and duties such as planning safety rules, publicizing them etc.
  - (*ii*) Its members should be asked to go on the shop floor and watch what is being done about it (*i.e.*, the safety).
  - (*iii*) It should be asked to report periodically as what improvements have been made and what more can be done.

Safety Programmes

- A safety programme tends to discover when, where and why accidents occur.
- A safety programme aims at reducing accidents and the losses associated with them.
- A safety programme begins with the assumption that most work-connected accidents can be prevented.

- A safety programme does not have an end ; rather it is a continuous process to achieve adequate safety.
- A safety programme tries to reduce the influence of personal and environmental factors that cause accidents.
- A safety programme involves providing, safety equipments and special training to employees.
- A safety programme is composed of one or more of the following elements :
  - (*i*) Support by top management.
  - (*ii*) Appointing a Safety Director.
  - (*iii*) Engineering a safe plant, processes and operations.
  - (*iv*) Educating all employees to work safely.
  - (*v*) Studying and analysing the accidents to prevent their occurrence in future.
  - (*vi*) Holding safety contests, safety weeks etc., and giving incentives/prizes to departments having least number of accidents.
  - (*vii*) Enforcing safety rules.
- A safety programme includes mainly four E's (as explained above also) :
  - (*i*) *Engineering i.e.*, safety at the design and equipment installation stage.
  - (*ii*) *Education* of employees in safe practices.
  - (*iii*) *Enlistment.* It concerns the attitude of employees and management toward the programme and its purpose. It is necessary to arouse the interest of employees in accident prevention and safety-consciousness.
  - (*iv*) *Enforcement, i.e.*, to enforce adherence to safety rules and safe pratices.

Safety Instructions and Training

- This is essential for educating the employees to think, act and work safely so that the number of accidents can be minimized.
- Safety training/education gives knowledge about safe (and unsafe) mechanical conditions, personal practices and of the remedial measures.
- Safety training involves :
  - (*i*) Induction and orientation of new recruits to safety rules and practices.
  - (*ii*) Explaining safety function, during, on the job training.
  - (*iii*) Efforts made by the first level supervisors.
  - (*iv*) Formulating employees safety committees.
  - (*v*) Holding of special employee safety meetings.
  - (*vi*) Displaying charts, posters, films etc., to emphasize the need to act safely.

Educating Employees to Develop Safety Consciousness

- A worker will usually accept the use of a safety measure if he is convinced of its necessity.

Therefore, suitable measures should be adopted to increase the awareness of a need for safety in the environment of work.

- Some such measures to develop safety consciousness among workers/employees are as follows :
  - (*i*) Display of safety posters and films to remind workers of particular hazards/accidents.
  - (*ii*) Providing simple and convenient safety devices.
  - (*iii*) Providing allowance (in the standard time) to the worker for setting, removing and replacing any necessary safety devices.
  - (*iv*) Ask the employee from the first day he starts work to adopt safety measures because a

worker who has commenced work and has become familiar with it would never feel the need for safety measures at a later date.

(*v*) Hold safety competitions and award prizes to the winners.

(*vi*) Give due respect and recognition to safe workers and create in employees a feeling of pride in safe work.

(*vii*) Elaborate on the safety theme until all the employees are safety-conscious.

(*viii*) Hold regular safety meetings. They stimulate ideas and workers get more safety conscious as the time of meeting approaches near.

(*ix*) Lay out work areas to reflect safety considerations.

(*x*) Mail information and literature pertaining to safety at the homes of all employees.

(*xi*) Report safety activities to all employees.

(*xii*) Welcome all safety suggestions.

(*xiii*) Cross-mark all accident areas.

(*xiv*) Conduct safety training lectures periodically.

20.7. ACCIDENTS

– An industrial accident may be defined as an event, detrimental to the health of man, suddenly occurring and originating from external sources, and which is associated with the performance of a paid job, accompanied by an injury, followed by disability or even death. An accident may happen to any employee under certain circumstances.

Economic Aspects (Cost) of Accidents

– An accident can be very costly to the injured employee as well as to the employer of the concern.

– There are definite costs associated with the accident, *e.g.*, *direct and measurable costs* and *indirect, i.e.*, somewhat intangible but nevertheless real *costs*.

Direct Costs of an Accident. They associate :

(*i*) Compensation insurance, including Payment, and Overhead costs.

(*ii*) Uncompensated wage losses of the injured employee.

(*iii*) Cost of medical care and hospitalization.

Indirect Costs of an Accident. They associate :

(*i*) Costs of damage to equipment, materials and plant.

(*ii*) Costs of wages paid for time lost by workers not injured.

(*iii*) Costs of wages paid to the injured worker.

(*iv*) Costs of safety engineers, supervisors and staff in investigating, recording and reporting of accidents and its causes.

(*v*) Costs of replacing the injured employee.

(*vi*) Cost of lowered production by the substitute worker.

(*vii*) Cost of delays in production due to accident.

(*viii*) Cost of reduction in efficiency of the injured worker when he joins the concern after getting recovered.

And lastly the influence of accident on the morale of employees.

Example 20.1. Cost of an accident. A foundary worker got burns on his foot while pouring molten metal from the ladle into the mold.

Direct costs	
Compensation paid for burns	Rs. 350
Medical expenses	Rs. 150
Total compensation cost	Rs. 500
Uncompensated wage loss	Rs. 100
Total direct cost	Rs. 600
Indirect cost	
Material spoiled and labour for cleaning it up	Rs. 200
Injured worker's make up pay while at home	Rs. 80
Fellow workmen standing and watching at time of accident	Rs. 300
Supervisor's time in investigating and recording	Rs. 110
Down time on casting	Rs. 150
Slowed up production rate of other employees	Rs. 120
Total indirect cost	Rs. 960
Total cost of *accident* [Not including overhead charges which may raise the total cost of accident by as much as 50%]	Rs. 1560

Causes of Accidents

- An accident is an unplanned incident and for each such incident there is usually a specific cause or causes if one could but discover them.
- Accident may be caused due to

1. Technical causes — Unsafe conditions — Mechanical factors / Environmental factors
2. Human causes — Unsafe acts — Personal factors.

- **Technical causes or unsafe conditions** reflect deficiencies in plant, equipment, tools, materials handling system, general work environment, etc.
- **Human causes or unsafe acts** by the person concerned are due to his ignorance or forgetfulness, carelessness, day-dreaming, etc.

  It has been estimated that there are four accidents caused by human causes to every one that is caused by technical causes.
- **Mechanical causes or factors**
  1. Unsafe mechanical design or construction.
  2. Hazardous arrangement (piling, over-loading etc.)
  3. Improper machine guarding.
  4. Unsafe apparel.
  5. Defective agencies or devices.
  6. Improper material handling.
  7. Broken safety guards.
  8. Protruding nails.
  9. Leaking acid valve.
  10. Untested boilers or pressure vessels.

Environmental Factors

Environmental factors indicate improper physical and atmospheric surrounding conditions of work which indirectly promote the occurrence of accidents. Environmental factors include

1. Too low a temperature to cause shivering.
2. Too high a temperature to cause headache and sweating.
3. Too high a humidity (in textile industry) to cause uncomfort, fatigue and drowsiness (especially when the atmosphere is also hot).
4. Defective and inadequate illumination causing eyestrain, glares, shadows, etc.
5. Presence of dust, fumes and smokes (*e.g.*, in foundary or welding shop) and lack of proper ventilation.
6. High speed of work because of huge work load.
7. More number of working hours and over and above them the tendency of the employer to insist for over-time work.
8. Inadequate rest pauses or breaks between the working hours.
9. Noise, bad odour and flash coming from the nearby machinery, equipment or processes.
10. Poor housekeeping.

Personal Factors

1. Age.
2. Health
3. Number of dependents.
4. Financial position.
5. Home environment.
6. Lack of knowledge and skill.
7. Improper attitude towards work.
8. Incorrect machine habits.
9. Carelessness and recklessness.
10. Day-dreaming and unattentiveness.
11. Fatigue.
12. Emotional unstability, *e.g.*, jealousy, revengefulness, etc.
13. High anxiety level.
14. Mental worriness.
15. Unnecessary exposures to risk.
16. Non-use of safety devices.
17. Working at unsafe speeds.
18. Improper use of tools.

Types of Accidents

1. Near accident – *i.e.*, An accident with no damage or injury.
2. Trivial.
3. Minor.
4. Serious.
5. Fatal.

Accident Prevention

- Accident prevention is highly essential in an industry, in order to
  - (*i*) Prevent injury to and premature death of employees.
  - (*ii*) Reduce operating and production costs.
  - (*iii*) Have good employer-employee relations.
  - (*iv*) High up the morale of employees.
- Above all, prevention of accidents is a true humanitarian concern.
- Accident prevention does not occur by itself ; there should be consistent implementation of safety measures and safety programmes emphasizing the need for
  1. Safe workplace layout and working conditions.
  2. Safe material handling.
  3. Personal protective devices.
  4. Safety activities in the organization.

1. Safe Workplace Layout and Working Conditions

Layout

- Although most accidents take place because of unsafe act of the employees, the role of the environments and surroundings cannot be ignored in determining the cause of accident.
- A good layout and working conditions play a major role in preventing many accidents which would have otherwise occurred.
- For preventing accidents, the *layout* should be such that:
  - (*i*) Every employee has enough space to move and operate.
  - (*ii*) Passageways between working places, roads, tracks and alleys, etc. must never be ob structed.
  - (*iii*) It prevents the inrush of cold/hot air and draughts to the working place.
- For adequate lighting, ventilation etc., the heights of the working rooms should be of 3 metres.
- Floors must be of nonskid type, satisfactorily plane and must possess such properties that they can be easily cleaned and absorb sounds.
- Windows should be of adequate dimensions in order to make full use of natural day light.
- Doors and gates leading to open should be provided with guards, etc., to prevent draughts at the neighbouring workplaces.
- Fire hazards can be reduced by utilising fire walls to separate manufacturing area into several compartments.
- A worker operating on the machine should have easy access to the safety switches provided on the machine/near workplace.

Working Conditions

- In enclosed rooms, in order to have comfortable conditions, the following should be controlled.

  Air temperature, air purity, velocity of air, humidity of air, and heat radiations between bodies of different temperatures.
- Not only in enclosed rooms, even otherwise proper ventilation is a must if the manufacturing processes give rise to dust, smoke, fumes,etc.
- Whether natural or artificial, there should be sufficient illumination, of adequate colour of light, continuous and uniform and free from glare.

- A high noise level at the workplace impairs men at work and may even endanger them. Noise develops from riveting, grinding, forging, engines, compressors etc. To reduce noise level and to minimize detrimental effects (*e.g.*, deafness) arising out of it :
  - (*i*) Select, purchase and make use of machines and processes which produce little noise.
  - (*ii*) Isolate and keep noise producing machines in separate closed cabins.
  - (*iii*) Use silencers to minimize the hissing sound of compressed air escaping from blow-off valves in pneumatic tools and machines.
  - (*iv*) Use suitable machine mounts to damp down the vibrations.

2. **Safe Material Handling**
   - Careless handling of heavy materials and components is a major source of back and foot injuries.
   - To avoid premature fatigue of transport workers, full use should be made of mechanised materials handling equipment.
   - Use mechanical means of conveyance to ensure the safety of men engaged in material handling.
   - The transport workers should not be asked to lift more than the permissible load, *e.g.*, for a boy of 16 to 18 years of age, this load is 19 kgs.
   - During transport, sharp materials, sharp edged goods, poles etc., should be covered, placed in stable holders and retained by means of wire.
   - Goods should be piled up such that they do not collapse due to impact or vibrations.
   - Containers or vessels employed to transport liquids or small parts :
     - (*i*) should not be too large to limit the range of vision and impede lifting and carrying,
     - (*ii*) should be light, and
     - (*iii*) should not be defective/leaking.
   - Depending upon the condition of material, use a proper material handling equipment, (Refer chapter on Material Handling).
   - All material handling equipments should be promptly repaired and adequately maintained on priority basis.

3. **Personal Protective Devices for**

   (*a*) *Protection of head*
   - Safety hard hats.
   - Rubberized hats for protection against liquids (chemicals).
   - Ear protectors.

   (*b*) *Protection of face*
   - Face mask.
   - Face shields.
   - Welding helmets.

   (*c*) *Protection of eyes*
   - Goggles of case-hardened and clear glass for protection against impact.
   - Eye cup goggles for protection against flying objects and dust.
   - Eye cup goggles impervious to chemicals for protection against acids/alkalies splashes.

   (*d*) *Protection of lungs*
   - Air line respirators
   - Cartridge respirators

- Oxygen or air-breathing apparatus.
- Gas mask.

(*e*) *Protection of other body parts, e.g., hand, foot, leg, etc.*

- Protective asbestos clothing.
- Gloves.
- Safety shoes.
- Foot guards.
- Safety body belt.
- Aprons.
- Safety (moulder's) shoes.

4. Safety measures Essential in Industry

- Refer section 20.6.
- Other *safety measures* which may be adopted are :
- Provide wire mesh *safety guards* to all rotating parts, *e.g.*, pulleys etc.
- High voltage equipments and other machines which cannot be properly guarded should be *fenced*.
- Pressure vessels and their component parts (*e.g.*, valves, gauges, etc.) should be periodically tested as per their specifications, the defective parts should be replaced.
- Material handling equipments should have unobstructed paths to move on.
- Defective tools, *e.g.*, hammers, spanners, etc., should be immediately replaced.
- Power should be switched off before repairing the equipment.
- Inflammable material should be stored separately and away from the general store.
- Electrical connections and insulation should be checked at regular intervals.
- To avoid electrical accidents
  - (*i*) None except the electrician should be permitted to touch electrical connections.
  - (*ii*) All live wires should be isolated and insulated from each other.
  - (*iii*) Electrical connections and ground connections of all portable and unportable machinery should be checked periodically.
  - (*iv*) Damp environmental conditions (floor etc.) should preferably be avoided.
- Fire extinguishers should be kept in proper condition and at key places.

Accident Proneness

- Examination of safety records often show that out of all the workers doing the same job and being subjected to the same physical environments, only a few have substantially more accidents than the rest.
- Such few workers who are found consistently to experience more accidents than the average (other) workers, are classified as ACCIDENT-PRONE workers/employees.
- ACCIDENT PRONENESS may be defined as the continuing tendency of a person to have more accidents as a result of his persisting characteristics etc.
- Accident proneness is perhaps because of peculiar psychological and physiological make up of certain persons.

Causes of Accident Proneness

(*i*) Unattentiveness and day-dreaming.

(*ii*) Poor eyesight and hearing and lack of stamina.

(*iii*) Poor adjustment of work ; distaste for the job.

(*iv*) Too much sensitivity and tendency to get perturbed easily, (Emotional stresses).

(*v*) Dislike of the supervisor/foreman, etc.

(*vi*) Lack of training, proficiency and skill to do a work.

(*vii*) Insufficient intelligence.

(*viii*) Unsafe behaviour of the worker (*e.g.*, intentionally not using safety devices and safe practices).

Methods to Reduce Accident Proneness

(*i*) Depending upon the job conditions select only those applicants who possess appropriate standards of physical and mental ability.

(*ii*) Transfer accident prone workers to comparatively less hazardous job situations.

(*iii*) Impart adequate training to a recruit before putting him on the job.

(*iv*) Encourage employees working under you and see that they do not get unnecessarily perturbed, frustrated or emotionally disturbed.

First-Aid

- Even after taking all safety precautions and measures, accidents occur in factories.
- An injured worker needs immediate proper treatment : in the absence of which, his condition may become critical.
- To take care of such situations, factories employ full time, at least a person who has successfully completed his Red-cross first-aid course, and who can give preliminary treatment to the injured person, who may later on be taken to the hospital as the ambulance arrives.
- Besides the above service, a first-aid personnel can look after those workers who get minor cuts, burns or electric shock.
- A first-aid box which contains the following is always kept ready during working hours.

Contents of a First-aid Box

	Items	*Numbers*
(*i*)	Rolled bandages 10 cm wide	12
(*ii*)	Rolled bandages 5 cm wide	12
(*iii*)	Pair of scissors	1
(*iv*)	Bottle (4 oz) of salvolative having the doze and made of administration indicated on label	1
(*v*)	Large size sterilized dressings	12
(*vi*)	Medium size sterilized dressings	12
(*vii*)	Small sized sterilized dressings	24
(*viii*)	Safety pins	2 packets
(*ix*)	Large size burn dressings	12
(*x*)	Packets of sterilized cotton wool	2
(*xi*)	Eye drops	1 small bottle
(*xii*)	Adhesive plaster	2 roller
(*xiii*)	4 oz bottle containing a 2% alcoholic solution	1
(*xiv*)	4 oz bottle containing $KMnO_4$ crystals, etc.	2

20.8. GOOD-HOUSEKEEPING

Definition and Concept

– The term *housekeeping* has been borrowed from the maintenance of domestic properties in the home/house and is now liberally applied to the maintenance of both *cleanliness* and order in all kinds of business establishments, *e.g.*, industries etc.

Cleanliness is a condition wherein buildings, work and rest areas, machinery, equipments and tools are kept free from dirt, dust filth, stain etc.

Necessity of Good Housekeeping

Good plant housekeeping is essential in order to :

1. Make and maintain a clean, neat and orderly factory work area and its surroundings.
2. Make work areas look pleasant, more satisfying and motivative for a worker to work.
3. Minimize fatigue and discomfort to the workers.
4. Minimize injury and accidents.
5. Increase the life of plant, building and the facilities it contains.
6. Avoid fire and other hazards.
7. Permit effective natural illumination and ventilation.

Advantages of Good Housekeeping

1. Fewer accidents.
2. Increased life of building, machinery, tools, etc.
3. Improved employee morale.
4. Increased production.
5. Better product quality.
6. Continuous cleaning reduces housekeeping costs because intermittent clean up is more expensive.
7. Little or no time is lost in searching for tools etc.
8. Material handling and transportation pick up speed.
9. Inspection, maintenance and production control functions become easier.
10. Much floor space otherwise occupied by unused raw material and tools, etc. is released for production.

Good Housekeeping Procedure

1. Plan and project the housekeeping programme carefully and completely. Associate the employees in this venture.

2. Divide the plant and offices into cleaning zones and assign a person to each zone. This person is responsible for the good housekeeping and orderliness of his zone.

3. Keep an eye on the performed housekeeping schedule and conduct periodic housekeeping inspections. The following *check-list* may help in carrying out inspection properly.

(*a*) *Machinery and Equipment*

- General cleanliness.
- Containers for waste materials.
- Machine guards on and operating.
- Oil, air, water, steam leakage.
- Portable equipments–Do they hamper personnel and material movements ?

(*b*) *Materials and Storage*

- Piling and stacking—Can material slip easily ?
- Materials protruding out of racks, bins, benches, machines etc.

(*c*) *Building*

- Windows clean and unbroken.
- Painting and upkeep.
- Door jambs clean.
- Fire extinguishers and sprinklers clear.

(*d*) *Floors*

- Slippery, wet or oily.
- Badly worn or rutted.
- Garbage, dirt or debris.
- Loose materials.

(*e*) *Stairways and Aisles*

- Clear and unblocked
- Well lighted.

(*f*) *Employee facilities*

- Drinking taps clean.
- Toilets and locker rooms clean.
- Soap and towels available.

(*g*) *Other Aspects*

- Lamps and lamp reflectors clean.
- Bulletin boards and safety signs clean.
- Protective equipment and clothing clean and in good condition.
- Electrical motors clean.
- Ventilation unobstructed.

20.9. PERSONNEL (LABOUR) WELFARE

Definition and Concept

- Employee services are provided under a number of titles in industry. Sometimes, it is referred as
  Benefit Programmes,
  Personnel (employee, labour) welfare, or as
  Hidden payroll.

Perhaps employee services are generally described as a part of *Fringe Benefits.*

- Fringe benefits include those elements of compensation other than wages which are significant when initially considering employment and in the ongoing evaluation of one's welfare on the job.

Fringe benefits may be of

(*i*) Monetary nature, *e.g.*, Retirement benefits, Insurance benefits, and Investment plans, etc.

(*ii*) Non-monetary nature, *e.g.*, Position title, Good office, Automobile, and Good parking space etc.

Importance (and Objectives) of

Personnel welfare or employee service and benefit programmes are important because they :

(1) Make the plant personnel a healthier, sounder-thinking and more forward-looking group.

(2) Make the employee a group of citizens better able to carry on the productive processes.

(3) Contribute to the maintenance of employee morale and loyalty.

(4) Maintain an employee's favourable attitude towards his work and work environment.

(5) Serve to attract and keep a work force in competition with other organizations.

(6) Serve to maintain some degree of peace with the organized labour union.

(7) Fulfil social, recreational, and cultural needs of the employees and at the same time make their life easier.

(8) Reduce labour turn-over and absenteeism.

(9) Promote good public relations.

(10) Encourage employees and promote goodwill and cordial relations between employers and employees, which ultimately result in more production, better product quality and increased profits.

Welfare (and Services) Methods or Measures

They may be categorised into three classes, namely

(1) Economic.

(2) Recreational.

(3) Facilitative.

1. *Economic*

(*a*) Insurance (including group insurance)

(*b*) Retirement and pension plans.

(*c*) Health and accident services.

(*d*) Credit unions[1].

(*e*) Paid holidays.

(*f*) Profit sharing.

2. *Recreational*

(*a*) Sports.

(*b*) Social get-togethers.

(*c*) Special interest groups such as dramatics, athletic programmes, flying and particular hobbies.

3. *Facilitative*

(*a*) Housing.

(*b*) Transport.

(*c*) Educational facilities and library services.

(*d*) Medical services (including first-aid, hospitalization, sick leave, etc.).

(*e*) Canteens, cafeterias and lunch wagons (Eating facilities).

(*f*) Company (cheap) stores.

(*g*) Discounts on purchases of company products.

(*h*) Rest-rooms and locker-rooms.

(*i*) Legal and financial counselling.

The above listed facilities are self-explanatory.

1. A credit union is an organized group of people who pool their money and agree to make loans to one another at the time of need.

20.10. COMMUNICATION IN INDUSTRY

Introduction

- In recent years there has been an increasing recognition of the importance of communications in industrial organisations. Communication function is viewed as one of the most important processess of Management.
- The subject of communication is one of the broadest in the field of Personnel Management. It encompasses a consideration of the subjects to be communicated, media, channels, communicators and the symbols of communication.
- Nearly every aspect of human relations and of supervisor-subordinate relations involve communications.
- *Communication* is the process of conveying messages. For communication to take place, messages must be composed, transmitted and understood.
- Communication is the process of transmitting ideas or thoughts from one person to another, for the purpose of creating understanding in the thinking of the person receiving the ideas or information.

Formal and Informal Communication

(*a*) A *formal communication* is official that is a part of recognized system involved in the successful operation of a concern.

- Information passed on from the supervisor to a worker to do a particular work is an example of formal communication.
- Formal communication may be written, or oral.
- Formal communication may be a
  - (1) *Vertical communication, downward* from top management to workers to do a job, a praise or a reprimand; or *upward* from workers to higher management levels giving work accomplishment report or other feed-back information.
  - (2) *Horizontal communication, i.e.*, the transmission of information from and to, to positions of the same level, *e.g.*, Manager production informing Manager maintenance regarding a machine breakdown.

(*b*) An *informal communication* is one that is outside the formal, recognized communication system, such as conversations between and among workers and the *grapewine.*

- A person is motivated to communicate naturally. When he is unable to communicate his feelings to his supervisor/ Manager, he communicates the same informally to his colleagues. Such (*i.e.*, informal) communication arises from social interaction.
- Informal communications or grapewine
  - (*i*) is a natural and normal activity of a person and arises out of social relationships of people,
  - (*ii*) works like a cluster chain in which each link (*i.e.*, person) associates and communicates to a cluster of other links (*i.e.*, persons),
  - (*iii*) spreads fast,
  - (*iv*) is a good method of vertically upward or downward communication,
  - (*v*) involves feelings, facts, rumours, etc.

Communication Channels and Structure

- Communication channels tend to

  Discover clashes of interest,

  Reconcile conflicts, and

Coordinate efforts.

- It is better to set up formalized communication channels between the different levels of organization, but among personnel at the same level, the information flow should be circular and more free.
- Proper structure of communication leads to efficiency.
- Less structuring leads perhaps to greater individual job satisfaction.
- Communication left largely unstructured among personnel, gets a significant amount of structure of its own after a period of time.
- Upward channels of communication include :

1. Face-to-face contact.
2. Group meeting.
3. Grievance/complaint procedure.
4. Counselling.
5. Morale questionnaires.
6. Open-door policy.
7. Labour union.
8. Grapewine.

- Downward channels of communication include :

1. Chain of command.
2. Company periodicals.
3. Notice boards.
4. Information racks.
5. Pay inserts.
6. Annual reports.
7. Group meetings.
8. Employee handbook.
9. Labour union.
10. Grapewine.

Communication Process and Systems

- A communication process involves

1. The sender.
2. The media to transmit information.
3. The receiver.

- A meaning or concept is first of all converted into *symbols* by the sender and then transmitted at the receiving end.
- The symbols of communication are

(*i*) Words.
(*ii*) Actions.
(*iii*) Pictures.
(*iv*) Numbers.

The media to transmit information consists of channels of communication described earlier.

– The receiver or person at the receiving end receives the symbols and translates them into meanings for himself.

For other details refer to chapter 7.

Barriers to Successful Communication

– A barrier to successful communication does not permit the transmission of accurate and full information at the receiving end.

– A communication barrier breaks down, obstructs, delays, distorts and tends to give another colour to the information by the time it reaches the destination.

– Various barriers to successful communication are:

(1) More levels in the organization structure through which an information has to pass.

(2) Long and ill-structured channels of communications.

(3) Heavy work-loads at certain levels in the organisation structure.

(4) Attitude—either not to hear or to hear what one expects to hear.

(5) Prestige and superiority complex.

(6) Sender and Receiver having different perceptions.

(7) Sender unable to symbolise the information correctly.

(8) Prejudiced and biased attitude of the receiver.

(9) Receiver unable to get the information (subject to different meanings) clarified.

(10) Receiver ignoring conflicting information.

(11) Receiver tending to evaluate information from his own angle.

(12) Receiver emotionally upset.

Techniques to overcome Barriers and Improve Communication. They are :

1. Sending direct and simple messages.

2. Feedback system to know whether the message has been understood correctly or not.

3. Using many communication channels.

4. Adopting face-to-face communications.

5. Be sensitive to the private world of the receiver, try to predict the impact of what you say on his feelings and attitude and tailor your message to fit the receiver's vocabulary, interests and values.

6. Time the message carefully. Communicate when the receiver is motivated to listen and he is not worried about other things.

7. Reinforce the words with actions, *e.g.*, employees are more likely to accept the change when they themselves participate in the process of change.

8. Introduce a proper amount of redundancy in the message, *i.e.*, some amount of repetition of information, so that the information is not misunderstood.

9. Create cordial and peaceful atmosphere in the organisation.

20.11. SUGGESTION SYSTEM

Concept

– One of the most successful bridges between plant-improvement efforts and good industrial relations is the use of a *suggestion system.*

– A *suggestion system* taps the tremendous store of ideas that rest in the mind of employees.

Certain employees volunteer their ideas because they derive satisfaction by making a suggestion, while others feel reluctant and thus arises the necessity of setting up a proper suggestion system so that

employees can give way to their feelings, ideas and valuable suggestions.

- Majority of companies make a cash reward for a valuable and useful suggestion.
- All suggestions go to the suggestion committee by-passing the immediate supervisor and other intermediate levels of management.

Purpose (objectives). Suggestion systems have the following purposes :

1. To suggest to management as how to improve company efficiency. Employees may suggest how to cut waste, prevent safety hazards, improve work methods, etc.

2. To encourage the submission of complaints.

3. To raise employee morale through giving them a chance to express their ideas on how the job should be done, to take pride in seeing their suggestions accepted, etc.

A well run suggestion system may yield a never-ending stream of ideas which cut costs and increase the employee's feeling of accomplishment and participation.

Procedure

- A suggestion committee is usually formed in order to consider, analyse and evaluate all suggestions made by employees.
- Suggestions Blanks (Fig. 20.1) are designed as a means of writing suggestions.

Serial No. 58267

A. B. C. Co. FARIDABAD
SUGGESTION FORM
PUT YOUR IDEAS TO WORK

Date _____

I suggest .....
.....
.....

I believe the above suggestion will result in .....
.....

Name _____ Clock No. _____ Department _____

Fig. 20.1. A suggestion form or blank.

- Suggestion boxes are placed in conspicuous and convenient places throughout the plant.
- Employees write their suggestions on suggestion forms (or blanks) lying by the side of suggestion box and drop the same in the box.
- The suggestions are periodically collected and put before the suggestion committee for review, investigation and action.

  The practicability of each suggestion is explored and evaluated in consultation with the supervisors who may be affected.
- For all those suggestions which are accepted, the employees get a reward, often 10 to 25% of the savings produced by the suggestion during the first year.

Suggestion System Problems : A number of problems may be encountered in the establishment and administration of a suggestion system, *e.g.*,

1. Suggestion system bypasses the (immediate) supervisor so there is a considerable amount of apathy or outright opposition by the supervisors on a worker's suggestion being accepted and adopted. Thus, suggestion system instead of doing benefit may do harm by antagonising supervisors.

Supervisors fear that if a worker's suggestion is adopted they may be criticized by their superiors for not having thought of the suggestions presented by the workers.

This problem may be solved by giving recognition to both the supervisor as well as to the worker who submits a good suggestion.

2. A good suggestion helps doing the same job with less effort, *e.g.*, with less number of workers. Thus, worker's jobs are threatened. For this reason, workers generally hesitate to submit suggestions.

3. Suggestions being submitted and rewarded on an individual basis may generate serious resentment within the group.

4. Suggestion systems, sometimes, arouse union opposition because, as a form of upward communication, they usurp what the union regards as one of its rightful functions.

20.12. DISCIPLINE IN INDUSTRY

Definition

1. Discipline may be defined as instruction or training,
   - To behave in accordance with rules and regulations,
   - To train to obey implicitly an order,
   - To bring under control, etc.
2. Discipline relates to employee conduct.
3. Discipline is employee self-control to meet organisational standards and objectives.

Purpose. Discipline is necessary in all efficient organisations in order to

1. Encourage employees to behave sensibly at work.
2. Effectively realise or attain the objectives of the organisation.
3. Help employees learn the requirements of their job.

Forms (Types). There are two basic forms of discipline

1. *Negative discipline*
   - Negative discipline controls employees by force, *e.g.*, by threats, dismissal etc.
   - With the growth of trade union movement and from 1945 onwards, negative discipline to some extent has been replaced by a constructive approach.
2. *Constructive, co-operative or positive discipline*
   - Constructive discipline means the fostering of cooperation and a high level of morale so that written and unwritten rules and regulations are obeyed willingly. Employees should be told clearly whatever is expected of them.

Prerequisites of Discipline

1. Define the company rules and regulations clearly in unambiguous terms.
2. Communicate these rules to all those concerned.
3. Specify the rules enforcing authority.
4. Specify the punishment associated with breaking the rules.
5. Check out a procedure for appeal.

Effects of Indiscipline

Increased :

1. Absenteeism.
2. Accidents.
3. Sick leaves.
4. Labour turn-over.
5. Grievances and frustrations amongst employees.
6. Waste and scrap rate.

Reduced :

1. Production.
2. Product quality.
3. Employee morale.

Disciplinary Action and Penalties

- Disciplinary action generally means the application of penalties that lead to an inhibition of undesired behaviour.
- The objective of disciplinary action is to reform the offender, to deter others and to maintain the integrity of the organisation. It is therefore educational and corrective rather than punitive slapping back at an employee in the wrong.
- Disciplinary action penalties commonly employed are :

1. Oral warning (reprimand).
2. Written warning.
3. Loss of privileges.
4. Fines.
5. Lay-off.
6. Demotion.
7. Discharge.

Methods to Improve Discipline

1. Effectively communicate the rules and regulations to all employees and the penalties to be inflicted for breaking the rules.

2. Positively motivate the employees.

3. Create within the employees "a sense of belonging to industry" by introducing fair wages, their participation in management and other activities of the industry.

4. Give rewards and recognition to disciplined employees.

5. Study the factors promoting frustration, grievances, etc. and leading to indiscipline.

6. Continuously keep on informing the employees the losses which occur to them and to the organisation as a whole due to indiscipline among employees.

7. Counsel the employees from time to time so that they can be made better disciplined.

20.13. PROMOTION, TRANSFER, LAY-OFF AND DISCHARGE

Introduction

- Employees do not remain at one job level throughout their life. They are promoted, transferred and if conditions are unfavourable they may even be demoted or laid off and discharged.

– Promotions and transfers can do a lot in improving the morale of employees and in motivating them. Even if the new job does not involve monetary benefit, and it is just a change in (night) shift or from a hot, dusty and smoky location to a better one, employees often consider it as a promotion.

(A) Promotion. *Promotion* may be defined as a significant enlargement in job responsibility, but also variably :

1. any increase in pay, prestige, rank or status ;
2. an upgrading within a certain job classification ;
3. Any increase in responsibility that provides additional privileges, comforts, etc.

– There should be a well-developed system of making promotions. Lines of promotion should be clearly defined and a real promotion policy should be formulated.

– A sound personnel policy demands that promotions should be made from within the industry if suitable persons are available.

– Promotion from within

1. Develops employee loyalty and builds up employee morale.
2. Increases job satisfaction.
3. Motivates employees.
4. Is a good incentive to the employees.
5. Enables the formation of an efficient and stable workforce.
6. Increases efficiency and efficacy of the organisation.

– However the policy to promote always from within the organisation

1. May stop talented outside persons to join the organisation.
2. May prevent the knowledge and drive that comes from new ideas.
3. Stops mobility of labour and labour turn-over which should be present to some extent for the good health of the concern or enterprise.

– Bases for promotion from within

If promotion from within is to be an incentive for the employees, the best performing employees ought to be promoted. The following factors help deciding the best performing employee :

1. The results of Merit Rating or Employee Rating System.
2. Productivity and Quality records of the employees.
3. Attendance and punctuality records of employees.
4. Health and physique (stamina) of the employee to meet the challenge of the higher job.
5. Personal file and records of employees.
6. Skill and proficiency on the existing job.
7. Seniority of the employee.
8. Qualification and experience, if any, possessed by the employee as per demands of the higher job.
9. Ability, *i.e.* potential performance of the employee on other jobs taken up till date.

(B) Transfer

– Transfer implies a change in job where the new job is substantially equal to the old one in terms of pay, status and responsibilities.

– Just like promotions, transfers also require planning.

– A *good transfer policy* should ascertain and consider

1. The reasons for a transfer.
2. The department(s) in which the transfer can be made.
3. The effect of seniority on the transfers.
4. Whether the transfer is temporary or of permanent nature.
5. The posting of available job openings.
6. The effects, if any, of the transfer on the salary of the employee, etc.

– **Types of transfers.** The different types of transfers are those

1. Which shift individual who have just gone into wrong jobs.
2. Designed to enhance training and development (role playing).
3. Which are made to meet changing production requirements (temporary transfer), *i.e.* adjustments to varying volumes of work within the concern.
4. Remedial transfers which are made when an employee has some trouble in doing his work or develops friction with his boss or fellow employees.
5. That are made to provide an opportunity to an employee occupying a dead-end job to move sideways into another job.
6. That are made to give some relief to an employee from his monotonous job such as fitting a single part in an equipment over and over again, all day long. Periodic transfers under such conditions stimulate greater job interest.
7. Requested tranfers in which the employee requests for a transfer because he is allergic to oil or some type of smell, etc.

(C) Lay-off

– Whereas promotions mean more money and better status, transfers imply rarely any loss, *lay-off* means taking away something.
– Lay-off is the temporary removal or suspension of the employee from his job (during period of emergency).
– Lay-off is undergone in order to reduce financial burden on the concern when the employees cannot be utilized profitably.
– Lay-off indicates the temporary inability of an employer to avail the services of the employee due to following reasons :

1. Non-availability/shortage of material, fuel or power.
2. Accumulation of excess stocks.
3. Breakdown of machinery.

Besides, lay-offs afford an opportunity to weed out sub-standard employees, those who have not the inclination to do a fair day's task and those who create disciplinary problems.

– A laid off employee who has more than one year's of continuous service with the firm is entitled to compensation equal to 50% of his salary (*i.e.* basic pay+DA) during the laid off period.

(D) Discharge or Dismissal

– Discharge is most severe penalty that an organization can give to its employees.
– Many arbitrators, indeed, refer to discharge as *Industrial Capital Punishment.*
– Discharge means ending the services of an employee. In other words, separating or removing the employee from the pay roll for following reasons :

1. Serious or habitual infractions of company rules and policies.
2. Dishonesty.

3. Poor job performance.
4. Malicious damage.
5. Intoxication.
6. Fighting.
7. Insubordination.

– Discharging an employee throws an extra expense (on the organisation) to train a new employee to take the place of the discharged one.

Moreover, because of the hardships the discharged man faces, the unions pressurize the management to think twice before discharging an employee.

– Because of these and other serious implications of discharge many concerns reserve only to higher management the final decision wheather to discharge the employee or not.

– Adequate records should be made to justify discharge and they should be duly signed by the immediate supervisor, manager and the employment officer with any other witnesses who are available.

– To support a case for disharge, it is often essential to have

1. A permanent merit rating record of the employee.
2. Memoranda indicating attempts to correct the employee faults.
3. A copy of the final warning.
4. A letter of discharge stating the reasons for the action.

20.14. LABOUR TURNOVER

Introduction, Definition and Calculation

– Labour turnover refers to the movement of workers into and out of an organisation.

– Labour turnover has been a subject of manager concern and scholarly study for atleast half a century because labour turnover rate is an index of the stability of workforce in an organization.

– Labour turnover may be defined as the time-to-time changes in the number of the work force that result from the hiring, release and replacement of employees.

– The simplest measure of labour turn over is the *separation rate*, generally defined as the number of separations per month per hundred of the average working force. Separations include all quits, lay-offs and discharges

$$\text{Net labour turnover} = \frac{\text{Total separations}}{\text{Average working force}} \times 100 \qquad \ldots(a)$$

Assume an average working force of 1000 employees for a month. If during this period 100 employees had severed their relationship with the concern, then

$$\text{Labour turnover/separation rate} = \frac{100}{1000} \times 100 = 10\%$$

– The formula for calculating labour turn-over as given by equation (*a*) above has certain limitations :

(i) It does not take seasonality into account.

(ii) It does not differentiate among the causes for labour turnover.

– In order to overcome these limitations, current practice makes use of Refined net labour turnover rate which is the ratio of the avoidable separations to the average working forces (per hundred). The formula is

$$T_R = \frac{(S-U)}{W} \times 100 \qquad \ldots(b)$$

Where T_R is the refined net labour turn-over rate.

S is the total separations.

U is the unavoidable separations.

W is the average workforce for the period.

Causes of Labur Turnover

(a) Voluntary withdrawals (by the worker) Due to,

- dislike for the present job ;
- better job available elsewhere ;
- conditions at home ;
- ill-health ;
- poor working conditions ;
- bad treatment from the boss ;
- lower wages and excessive hours of work ;
- job being hard and hazardous ;
- poor training and induction ;
- dirty politics prevalent in the industry ;
- partiality in making promotions and transfers and due to,
- ineffective and inefficient management.

(b) Lay-offs due to seasonal nature of industry, shortage of power, fuel, raw material, etc.

(c) Discharges due to undesirable activities of the employees, insubordination or they being found unsuitable for the job.

(d) Retirement.

(e) Death.

Cost of Labour Turnover

- Excessive labour turnovers are undesirable and expensive, because the expense of training new recruits is usually a significant aspect of production costs and voluntary withdrawal by employees (is undesirable as it) produces an unfavourable and disheartening impression on the existing employees.
- When an employee leaves a concern, such costs as the following are usually involved :

(i) Hiring costs, involving time and facilities for recruitment, interviewing etc.

(ii) Training cost, involving time of foreman, personnel department, etc.

(iii) Exploring other sources of labour supply.

(iv) Payment to a recruit in excess of what he produces.

(v) Accidents and damage to machinery by new recruits.

(vi) Cost of work spoiled by new recruits.

(vii) Loss of production during the period between the separation of old worker and the replacement by the new one.

(viii) Production machines not being used to their maximum capacity during the hiring interval.

(ix) Extra over-time paid to remaining workers.

(x) Cost of not meeting delivery dates.

Methods to Reduce Labour Turnover

The best method to reduce labour turnover is to study the causes of labour turn-over and then attempt to remove the reasonable factors that promote labour turnover. A few methods to reduce labour turnover are

(*i*) Improve factory working conditions.

(*ii*) Handle worker's grievances faithfully.

(*iii*) Do not abuse and fire workers for petty matters.

(*iv*) Try to minimize fluctuations in the work load.

(*v*) Give appropriate wages and incentives to the workers.

(*vi*) In matters of hours of work compensation, disputes, etc., go by the appropriate Labour Laws.

(*vii*) Take care of employee's health and welfare.

(*viii*) Adopt safety and good housekeeping practices.

(*ix*) Motivate the employees and try to high up their morale.

(*x*) Be impartial in the matters of promotion and transfers.

21

Union and Industrial (Labour) Relations

21.1. INTRODUCTION

Trade Unions

- The social historians Sydney and Beatrice Webb defined a trade union as

  "A continuous association of wage-earners organised for the purpose of maintaining and improving the condition of their working lives".

  This definition was given in 1920; today it has been widened and includes salary earners as well.
- There are more than 17,000 registered trade unions in India with the average membership per union of the order of around 575 to 600.

Industrial Relations, Definition and Concept

- Industrial Relations is that aspect of management which deals with the manpower of the enterprise—whether machine operator, skilled worker or manager.
- Cordial and peaceful Industrial Relations between the employees and the employer are highly essential for increasing productivity and the economic growth of the country.

  Through good industrial relations only, the enterprise can move towards the welfare of the employees and the management of the concern.
- Industrial Relationship is the composite result of the attitudes and approaches of the employees towards each other with regard to the planning, supervision, direction and co-ordination of the activities of an organisation with a minimum of human effort and friction, with an animating spirit of cooperation and with proper regard for the genuine well-being of all the members of the organization.
- The term *Industrial Relations* has been looked upon and worded differently by different pioneers of the field.

Integrated programmes of industrial relations are of relatively recent origin. Fragmented attention to employee concerns started around World War I and became inclusive during the 1940s. The human-relations approach is a long term trend toward recognizing the individual interests of workers.

Certain people define Industrial Relations as—the relations between employers and employees in industry.

Others describe Industrial Relations as—the relationships between employees and management that grow out of employment.

Still others call Industrial Relations as—Social relations in production.

However, with the industrial developments after World War II, the term *Industrial Relations* has been widened in its meaning and now it implies—Employers-Employees-Unions and Government relationship in industry.

- The **basic requirements** of an Industrial-relation programme are

(*i*) To have the support of top management.

(*ii*) To be based on sound personnel policies

(*iii*) To follow proper practices.

(*iv*) To follow up and evaluate the pattern of employee action.

– The important *functions* of Industrial Relations are :

(*i*) Employee Relations.

(*ii*) Labour Relations.

(*iii*) Public Relations.

– The important aspects of Industrial Relations are :

(*i*) Cooperation.

(*ii*) Conflict.

The remaining portion of this Chapter will describe functions and aspects of Industrial Relations.

Labour Relations

– Whereas **Employee Relations** is a broader term which represents the relations and contacts between the Management and its (all) employees ; Labour Relations has its field of contact between Management and employees, limited. In other words unlike Employee Relations, Labour Relations represents relations and contacts between Management and employee representatives (or the union) only.

– The increased size of today's employers and union organisations have caused the government to become more active in employer-employee relationship and for this reason, Legislation and Government regulations affect considerably the field of Labour Relations.

– *The Labour Relations department of an industry*

(*i*) Deals with management and the labour union in arriving at a satisfactory resolution of problems such as low wages, poor fringe benefits, etc.

(*ii*) Carries out all correspondence with the labour unions.

(*iii*) Participates in Grievance handling.

(*iv*) Represents the company in arbitration cases.

(*v*) Participates in negotiations.

(*vi*) Conducts the necessary correspondence with government labour agencies.

In brief, Labour Relations Department looks after,

(*i*) Union Relations.

(*ii*) Collective Bargaining.

(*iii*) Discipline in the Industry.

(*iv*) Handling Grievances.

21.2. TRADE UNIONS OR LABOUR UNIONS

Definition

– A trade union or labour union is a continuing long term association of employees formed to promote, protect and improve, through collective action, the social, economic and political interests of its members.

– A trade union may also be defined as any combination, whether temporary or permanent, formed primarily for the purpose of regulating the relations between workmen and employers or between workmen and workmen or between employers and employers or for imposing restrictive conditions on the conduct of any trade or business and includes any federation of two or more unions.

Origin

- Trade unions are the creation of industrialisation and modern industrial conditions.
- Industrial Revolution destroyed the earlier way of life and left the individual worker, who was protected by the customary values, to drift by himself in the anonymity of the town, and (also) gathered these workers together around the employer.
- The employer did pay as little as possible to the workers ; the workers as individual could not protest against it and therefore those (workers) similarly situated, economically and socially and closely associated with the work of the same employer developed mutual understanding and a common solution of their problems of living and this crystallised them into a self-conscious group what we may call as Trade Union.
- Trade unions got originated out of the necessity of workers to protect and defend themselves from encroachment, injustice and wrong imposed upon them by the employer or the management of the concern.
- The aspects of the process of industrialisation those necessitated the origin of trade union are :

(*i*) Separation between the ownership of capital and labour, both of which are essential for producing goods and rendering services to the consumers.

A difference got created between the owners of capital and the labour. The former wanted to pay lowest possible to the latter and the latter were interested to secure the maximum possible price for the work done for the former. These two classes with divergent and conflicting interests gave rise to conflicting situations and the workers thought of uniting.

(ii) Since, individually the workers did not have any other source of the livelihood except that of service under the owners of capital, there was no match between the two as regards economic resources or bargaining power or skill. It was the owner of capital who dictated the terms and conditions of employment, *i.e.* wage rate, hours of work, etc and either a worker had to serve under those conditions or starve. This again infused a spirit of union among the workers.

(iii) When the workers were suffering in this way, the State or Law remained silent because in its eyes workers and employers were equal. This further increased the exploitation of workers by the owners of capital.

(iv) Though an individual worker was dispensable to an employer, but he could not afford to dispense with the services of a group of workers. The day it was realised by the workforce, they thought to unite and get their reasonable rights from the owners of capital.

Functions. Functions of trade unions are

1. The *provision of friendly services* such as a place for leisure pursuits, information about jobs existing in other factories, games and outings, etc.

2. The *provision of social services* such as insurance against old age, unemployment, strike, pay, payment for hospital fee, legal services, etc.

3. *Wage bargaining, i.e.* collective wage bargaining with the employers.

4. *Safeguarding* the job of the workers.

5. *Political activities, i.e.* the political pressure for reform, *e.g.* trade union legislation works to protect the union and the workers from such industrial abuses as delay in payment of wages, excessive hours of work, poor working conditions, etc.

6. To *develop cooperation with employers.*

7. To *arouse public opinion* in favour of labour.

8. To *secure some shares* in profit and in the control of the enterprise.

Objectives. Objectives of trade unions are :

1. To take labour out of the competitive process ; because if a number of workers freely compete for a job, the employer will definitely offer them less wages.
2. To negotiate at all levels with employers over wages and conditions of work.
3. To protect the workers in their inalienable right to higher and better life.
4. To make workers to take part in union activities and to obey union rules and decisions.
5. To protect and promote the interests of the workers.
6. To provide legal assistance to workers (*i.e.*, union members) in connection with work affairs.
7. To improve economic status of workers.
8. To protect the jobs of the workers against lay off, retrenchment, etc.
9. To ensure that workers get as per rule, the pension, provident fund, compensation for injuries, etc.
10. To ensure for the workers, better health, safety and welfare standards.
11. To have a voice or participation in the factory management.
12. To ensure that workers get respect and human treatment from the foremen, managers, etc.
13. To improve their political status.
14. To offer educational services to the workers.

21.3. INDUSTRIAL DISPUTES

Definition and Introduction

- An *Industrial Dispute* means any dispute or difference between employers and employers or employers and workmen or between workmen and workmen which is connected with employment or non-employment or terms of employment or conditions of labour, of any person.
- Every human being (say a worker) has certain needs. *e.g.*, economic needs, social needs and needs for security. When these needs do not get satisfied, there arises a conflict between labour and capital. A conflict means a struggle or clash between the interests of the employer and the workers. For example, in order to compete in the market, the employer would like to reduce the price of his product and for doing so he will tend to reduce the wages of the workers ; the workers would not agree to it and the result will be an *industrial conflict* between the employer and the workers.
- When an industrial conflict (which otherwise is general in nature) acquires a concrete and specific display or revelation, it becomes an *Industrial Dispute*.
- A conflict takes the shape of Industrial Dispute as soon as the issues of controversy are submitted to the employer for negotiations.
- An industrial dispute may be looked upon as a controversy or disagreement between employer (or management) and the workmen on issues such as

  Wages and other benefits,

  Work hours and working conditions, etc.
- Industrial disputes cause losses to , workers, management and nation as a whole.

  (*i*) Workers lose their wages.

  (*ii*) Management loses its profit.

  (*iii*) Public suffers due to shortage of goods in the market.

  (*iv*) Nation suffers due to loss of production.

Causes of Industrial Disputes

Some of the common causes of Industrial Disputes have been listed below :

(i) Psychological causes

- Difficulty in adjusting with each other (*i.e.*, employer and worker).
- Clash of personalities.
- Authoritarian Leadership (administration).
- Demand for self-respect and recognition by workers.
- Strict discipline.

(ii) Institutional causes

- Non recognition of the labour union by the management.
- Matters of collective bargaining.
- Unfair conditions and practices.
- Pressing workers, not to become members of union, etc.

(iii) Economic causes

(a) Terms and conditions of Employment

- More hours of work.
- Working in night shifts.
- Promotion, lay off, retrenchment, dismissal, etc.

(b) Working conditions

- Environmental conditions such as too hot, too cold, noisy, dirty, messy, etc.
- Improper plant and workstation layout.
- Old and trouble giving machines.
- Frequent changes in products, etc.

(c) Wages and other benefits

- Inadequate wages.
- Undesired deductions from wages.
- Poor fringe benefits.
- No bonus or other incentives, etc.

(iv) Denial of legal and other rights of workers

- Not proceeding as per labour laws and regulations, standing orders etc.
- Violation of already made mutual agreements (*i.e.* between employer and workers).

21.4. STRIKES

Introduction

- Whenever workers feel any grievance and if the same is not removed by the management, the workers unite together to fight it out and this causes industrial unrest, conflict and dispute. The industrial disputes generally result in **Strikes, Lockouts, Picketing or Gherao.**
- The word *strike* is an innovation of the early 19th century but the phrase *to strike work* was used in the eighteenth century.
- Strike is the ultimate weapon of the trade union by which it can threat the employer.
- Strike implies that,

(*i*) there shall be cessation of work or refusal to work by a body of workmen ; and

(*ii*) workmen should be acting in concert in order to enforce a demand against the employer during an industrial dispute.

– Success of strike depends upon the ability of the workmen to stop the employer from continuing to operate.

Causes of Strikes

– Finding the causes of strikes means searching the causes that lead workers to strike in preference to other methods available to achieve their objectives.

– The various causes of strikes are,

(*i*) Wage disputes (including bonus, etc.)

(*ii*) Working arrangement and conditions.

(*iii*) Discipline and other factory rules.

(*iv*) Demarcation, dismissals, suspension, retrenchment, etc.

(*v*) Dispute over hours of work.

(*vi*) Trade union recognition.

(*vii*) Internal union disputes.

(*viii*) Victimisation of membership.

(*ix*) The closed shop.

(*x*) Undeserved punishments.

(*xi*) Assaults, abuses and misbehaviours (from supervisors or management).

(*xii*) Sympathetic strikes.

Effects of Strikes

(i) Strikes are costly to workers. They may not have money to feed themselves and their families.

(ii) Strikes cause emotional tensions and mental strains.

(iii) Strikes deplete trade union funds.

(iv) Strikes result in mass unemployment.

(v) Strikes may result in violence and thus injuries to many workmen.

(vi) Strikes result in loss of output and profits.

(vii) Strikes involve loss of valuable man hours.

(viii) Strikes sometimes lead to damage to property and costly equipments.

(ix) Public suffers from shortage of products of the striking industry.

(x) If the strike fails, it :

– brings misery, dismissal and even withdrawal of already given privileges ;

– terrorises workmen and degrades their morale.

Forms of Strikes

(i) Official and unofficial strikes

– An official strike is one which is called by the union.

– An unofficial strike is one which has not been approved by the union.

(ii) General and Particular strikes

– A general strike is one where there is concert or combination of workers in stopping or refusing to resume work.

A general strike covers a wide range of industries and is over quite a large part of the country, *e.g.* General strike of 1926 in Great Britain.

- Particular strikes have smaller coverage, *e.g.* they may remain confined to one or a few factories in a city.

(iii) Go-slow strikes

- Workers come to the factory, but they work at pace slower than the normal; this lowers down the production and results in loss to employer.

(iv) Quickie strike

- Workers come to factory but they stop work for few minutes or few hours.

(v) Sit-down strikes

- Workers come to factory, report to their duties but do not work.

(vi) Sympathetic strikes

- A sympathetic strike for a day or so is conducted in sympathy with another group of workers who are already on strike, in order to boost their morale.

21.5. LOCK-OUT

Introduction and Definition

- Just as strike is a weapon in the hands of workers to force employers to accept their demands; similarly *lock-out* is the weapon of employer to pressurize workers to come down in their demands.
- A lock-out means,

  "Closing the place of employment or suspension of work or the refusal by an employer to employ any number or persons employed by him".
- As the employer declares a lock-out, he tells workers to keep away from the work.
- Lock-out is the outcome of an industrial dispute.

21.6. PICKETING

Introduction and Definition

- Picketing is almost a standard practice when a union strikes against an employer.
- some workers are placed at the factory gate to discourage others from entering the work premises.
- Pressure on the employer increases when employees of other companies refuse to cross picket line to deliver or pick up goods from the struck employer.
- In picketing, workers may parade with banners to inform public about the dispute with the employer and to enlist popular support for the workers or unions.
- Picketing may be designed to interfere with business and thus to pressurize the employer to comply with union demands.
- Picketing by one group of employees often stops other employees from working in the same factory.
- In doing so, the pickets sometimes insult and even block physically the path of those (employees intending to) enter the factory.

21.7. GHERAO

- Like strike and picketing, Gherao is also a method to pressurize employer to fulfil union demands.

- In gherao workers force the employer or managers to remain confined in their offices for hours or even days. The employer sometimes is forced to remain without water and food ; he is not allowed to go out even for natural calls.
- Workers encircle the office of the employer, close all the exits and sit around in batches.
- In contrast to strikes which put economic pressure on the employer, a gherao involves physical coercion, *i.e.* it tends to inflict physical duress on the employer or manager.
- Thus a gherao besides endangering industrial harmony, creates problems of law and order also.
- Actually gherao is a primitive method which used to be employed in England by early trade unions.

21.8. SETTLEMENT OF INDUSTRIAL DISPUTES

- Industrial disputes, their causes and ill effects have been discussed under section 21.3.
- The ill effects of industrial disputes pressurize employees, employers and the state to settle such disputes for the betterment and welfare of all the parties involved.
- The different **methods** employed for **settling the disputes are :**

(a) Without state intervention

1. Collective bargaining.
2. Voluntary arbitration.

(b) With state intervention

3. Compulsory collective bargaining.
4. Bipartite committees.
5. Compulsory arbitration.
6. Compulsory conciliation and Mediation.
7. Compulsory investigation.

21.9. COLLECTIVE BARGAINING

Introduction

- Collective Bargaining constitutes the negotiations between the management and the union with the ultimate objective of agreeing on a written contract covering the terms and conditions of settlement of the disputed issues.
- Collective bargaining is basically a give-and-take process involving proposals and counter proposals.
- Meetings between management representatives and union leaders are conducted in an attempt to arrive at an agreement or at the settlement of the dispute.
- In such meetings, the two parties bargain with each other on disputed issues (which may be such as salary and fringe benefits, terms and conditions of employment, etc.) to arrive at an agreement.
- The agreement is signed by both the parties and the length of time the treaty will operate may be specified.
- Collective bargaining introduces an element of democracy in the field of Industrial Relations and Management.
- Collective bargaining imposes certain restrictions upon the employer. Unilateral action is prevented. The employer is no longer free to make and enforce employment decisions. Management must bargin with the union on appropriate subjects.
- The collective bargaining is not an easy process and it is often exasperating.

Procedural steps

The steps involved in collective bargaining process are :

(*i*) Putting up before the management, by the employees, their demands and grievances collectively.

(*ii*) Discussing and negotiating with the management representatives, with a view to settle the disputed issues.

(*iii*) Signing a formal or informal agreement mutually arrived at.

– The mutual agreement may be as regards the following :

(*a*) Union security.

(*b*) Wages, bonus and other benefits.

(*c*) Terms and conditions of employment:

Hours of work.

Holidays.

Safety and health.

Promotion, transfer and discharge, etc.

(*d*) Grievance procedure.

(*e*) Incentives.

(*f*) Management responsibilities, etc.

– If either of the party, later on, feels reluctant in abiding by its commitments under the mutual agreement, the other party can employ economic pressures to force that party to meet its obligations.

(*iv*) In the event of no agreement, various pressures are brought to bear upon the management by the union (such as strikes, picketing, gheraos, etc.) or on union by the management (such as lock-out) to reconcile.

But both the parties, *i.e.*, management representatives and union officials have a basic obligation to establish a constructive relationship of working harmony in the settlement of disputes and in the advancement of labour-management peace.

Voluntary Arbitration

– In this method of settling disputes, a third neutral party as a judge (to decide the disputed issue) hears and collects the facts from the two primary parties and proceeds to make a decision which is usually binding upon the union *i.e.* one primary party and the management (*i.e.* the second primary party).

– Many industrial disputes have been (*e.g.* those between union and management of Rohtas Industries Ltd., Dalmia Nagar etc.) and are being settled today through voluntary arbitration.

– The Industrial Dispute Act 1947 recognises voluntary arbitration as a method for settling industrial disputes.

Establishment of Compulsory Collective Bargaining

– If, either union or management resists the establishment of voluntary collective bargaining, but the state feels that collective bargaining will be useful, it may advise, encourage or even impose collective bargaining compulsorily on the two parties to settle their disputes through negotiations and discussions.

Compulsory Establishment of Bipartite Committee

– A bipartite committee consists of representatives of workers as well as of the employer (at the factory level).

- Such committees work on the principle of 'nip the evil in the bud' and settle labour-management disputes as soon as they appear and do not permit them to grow large and take an unmanageable shape.
- The main purpose of such *Bipartite committees or works committees is to*
  - (i) promote measures for securing and preserving amity and good relations between workers and employers ;
  - (ii) comment upon matters of their common interest ;
  - (iii) compose any material differnce of opinion in respect of such matters and to
  - (iv) encourage workers and management to settle their differences without the *Arbitrator.*

Compulsory Arbitration or Adjudication

- Unlike voluntary arbitration, in Adjudication, the Arbitrator or Adjudicator is appointed by the government.
- In adjudication, the industrial dispute is referred for arbitration by the government and both the parties have to accept the decision of the arbitrator.
- The objective of adjudication is to maintain industrial peace by stopping the parties from causing work-stoppages and providing a method for settling the industrial dispute.

Compulsory Conciliation (machinery) and Mediation

- Conciliation is a process by which the discussion between workers and employer is kept going on through the activities of a conciliator *i.e.*, third party.

  A conciliator aids resolving the differences between two parties and keeps them to understand and appreciate the situation better.
- Mediation is a process by which the third party attempts to stimulate labour and management to reach some type of agreement. The mediator cannot decide the issue. He is strictly neutral who can only listen, suggest, communicate and persuade.
- What has been described above, it is voluntary conciliation and mediation.
- In compulsory conciliation and mediation, the government imposes an obligation on the workers and management to refer their disputes to the conciliation and mediation service. The government also prevents both the parties from work-stoppages till the conciliation or mediation is going on.
- Conciliators and Mediators are asked to furnish their report within a time period. If the efforts to reconcile fail, workers are free to go on strike and the employer is free to declare a lock-out.

Compulsory Investigation

- Government may set up a machinery to investigate into any dispute. Machinery may be a *Court of Inquiry* to explore facts and issues involved. A wide publicity may be given to it because, quite possible, the public opinion may compel the two parties to leave their rigid and obstinate attitudes and try to arrive at a settlement.
- Moreover, the period during which Court of Inquiry is being conducted, may serve as a cooling off period for the two primary parties to reconsider their stands coolly.
- Court of Inquiry is given almost same powers as remain with a civil court.

21.10. HANDLING OF WORKERS' GRIEVANCES AND GRIEVANCE PROCEDURE

Introduction and Definition of Grievances

- Individual employees generally have some complaints called *grievances* against the working rules of the business enterprise, *e.g.* wages, bonus, working conditions, behaviour of supervisors etc.

- The one thing which is very harmful to good relations between workers and management is the feeling among workers that the management does not look into their problems and difficulties.
- This results in dissatisfaction in the minds of workers and distrust towards management which in turn introduces inefficiency and lack of co-operation from the worker's side.
- Hence, if no systematic way exists for bringing workers' complaints or grievances to the surface, they may pile up and explode into an industrial Dispute.
- A **Grievance** may be defined as any feeling of discontent or dissatisfaction, whether expressed or not and whether valid or not, arising out of anything connected with the company that an employee thinks, believes or even feels is unfair, unjust or inequitable. A grievance may be :

(*i*) unvoiced or stated by the worker,

(*ii*) written or unwritten, and

(*iii*) valid or ridiculous, and may arise out of something connected with the company, *e.g.*, company policy or actions.

Examples of Workers Grievances

1. Regarding wage structure, wage calculation, deduction, incentive, etc.

2. Regarding factory working conditions such as light, noise, smoke, fumes, too hot or too cold, environments, dampness, inadequate toilet facilities, lunch rooms, impure drinking water etc.

3. Regarding supervision such as rigid rules, regulations not clearly posted, foreman being partial, inadequate job instruction, etc.

4. Regarding partial attitude of management towards deciding seniority, promotions, transfers, discharges, lay-offs, penalties, night shifts, etc.

5. Regarding collective bargaining, *e.g.*, management violating agreements, not attending to union grievances, penalising workers who belong to union, etc.

Grievance Procedure

- If an enterprise wants to get maximum out of its workers/employees, it must attempt to satisfy them by providing good working conditions, fair wages, settling grievances and taking them into confidence.
- Thus, an adequate and effective procedure must be developed by the management to handle and settle grievances of its employees. A good grievance procedure is essential to develop sound labour relations.
- **A good grievance handling procedure should**

(*i*) be simple, easy to understand and to operate;

(*ii*) settle grievances at lower level ;

(*iii*) systematically handle the grievances and promptly remedify the conditions complained of ;

(*iv*) depending upon the nature of grievance, refer it to appropriate authority ;

(*v*) ask the employee to give his complaint in writing ;

(*vi*) permit the worker to appeal against the decision taken at lower level, and lastly

(*vii*) the grievance procedure should be made, realising the importance of industrial harmony and good labour relations.

- **Steps involved in grievance handling prodedure**

Fig. 21.1 shows steps involved in a grievance procedure.

Step 1. The aggrieved employee presents his grievances in writing to his foreman or supervisor ; he puts his grievance to union representative who also is a full time employee of the company. If the foreman,

aggrieved employee and the union representative fail to work out a settlement of grievance, the dispute in the written form is sent to a higher step in the procedure.

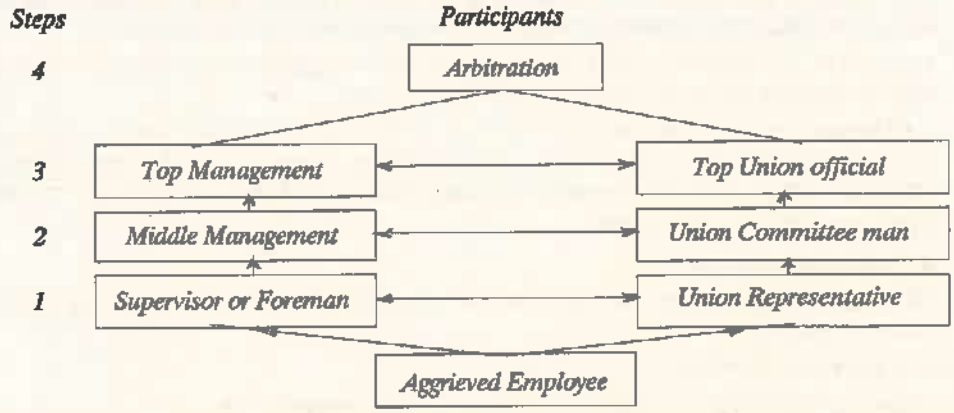


Fig. 21.1. A Grievance Procedure.

Step-2. The grievance is looked into by the middle management and the union committee man ; a union committee man supervises several union representatives and is specialist in union management negotiations. If the situation still remains unsettled, as the third step, the case is forwarded to top management and top-union officials.

Step-3. Top management representatives and top union official discuss the grievance which by this time has now become issue that has political implications. Thus it is very difficult to secure an integration of interests at this high level.

Step-4. If top management and union leaders fail to settle the issue, the fourth step, then, is to submit the same to an impartial Arbitrator for a final decision as to the action required.

A failure to settle the issue at step-4 may result in strike, picketing, Gherao or lockout.

It is the best if the grievance gets settled at the level of supervisor and union representative.

21.11. WORKER'S (EMPLOYEE'S) PARTICIPATION IN MANAGEMENT

Concept

- Worker's participation in management can be in any shape, from establishing work-committee to auto-management by the employees.
- The aim of management is to get work through others. Workers, if they are permitted to participate and involve themselves in some of the decisions relating to work situation, etc., perhaps more effectively the company objectives can be achieved.

Objectives or Necessity. The objectives or the necessity of permitting workers to participate in management can be :

(*i*) To achieve industrial peace and harmony.

(*ii*) To develop internal motivation in the workers.

(*iii*) To boost the morale of employees.

(*iv*) To raise the levels of the employee production, productivity and product quality.

(*v*) To satisfy workers by making them feel that they have their voice in the management.

(*vi*) To give workers a better understanding of their role in the working of industry.

(*vii*) To develop better mutual understanding so that the workers do not resist a change for the

betterment of the concern (*e.g.*, introduction of work study, etc.).

(*viii*) To reduce labour turn-over, absenteeism and tardiness.

(*ix*) To minimize the number of grievances and therefore industrial disputes.

(*x*) To make managing the subordinates easy.

Types of Worker's Participation

Worker's participation in management may take many forms, *e.g.*

(*a*) Formal participation.

1. Ascending participation
2. Descending participation.

(*b*) Informal participation.

(*a*) **Formal Participation.** It consists of some plan for labour-management cooperation, *i.e.*, to some degree, recognised as a *modus operandi* between management and workers, frequently through a union.

- Workers and management may work together on such plans as
  - Accident prevention
  - Elimination of waste and defective work
  - Attendance & Absenteeism
  - Employee insurance plans, etc.
- In **Ascending** type of participation, the elected representatives of workers participate in managerial decisions at higher levels such as in the board of directors of the enterprise.
- In **Descending** type of participation, workers participate in the planning and deciding their own work on the shop floor.
- **Collectively**, workers can participate in
  - (*i*) *Works Committees* which are meant for promoting measures for securing and preserving amity and good relations between workers and management. A works committee comments upon matters of common interest and attempts to settle any material difference of opinion between the two parties.
  - (*ii*) *Joint-councils* of workers and management may decide the issues on which interests of management and workers are identical, *e.g.*, accident prevention and safety measures, determination of production standards, worker's training, welfare measures etc.
  - (*iii*) *Information sharing* in which workers are told about certain aspects of the company, *e.g.*, plans for expansion, financial position of the company, etc.
  - (*iv*) *Employee's director*, *i.e.*, an elected representative of the (employee's or) worker's is one of the Board Directors.
- **Individually** workers can participate in management through

(*i*) *Suggestion System* (Refer Chapter-20).

(*ii*) *Delegation and job enlargement* in which workers plan and decide their own work.

(*b*) **Informal Participation**

- It is more typically at the work-group level, where the foreman develops the opportunity for the group of workers to take part in a problem-solving or decision making process. Typically, the matters on which decisions are taken are those within the prerogatives of the foreman or supervisor.

Conditions for the Success of Worker's Participation in Management

(*i*) There should be an atmosphere of cooperation and trust between the management and the workers.

(*ii*) Workers those who are participating must be capable of understanding the problems, their complicacies and interactions.

(*iii*) The participating workers should be able to express themselves to their own satisfaction.

(*iv*) Workers should be permitted to participate in the decision on maximum of company matter, *e.g.*, introducing new machinery, newer methods of operation, etc.

(*v*) The participation of a worker must not adversely affect his status or role.

(*vi*) Discussions should be frank and free and without any reservation.

(*vii*) Besides caring for the immediate interests of itself, both the parties should respect each other's interests also. For example, workers need not remain solely interested in their wages and welfare and employers in raising efficiency and reducing cost of production.

(*viii*) It is generally commented that "most of the relatively rare successes of such consultations seem to occur where an unusually progressive manager is blessed with unusually competent union officials".

21.12. UNION-MANAGEMENT RELATIONS

- Union organisations, when studied in regard to group concepts of human relations, offer a key to improved union-management contacts.
- In large business organisations where the channels of communication are often blocked in vertically upward direction, union provides the channels of communication for the workers.
- Unions are more concerned than management with the feelings and attitudes of workers.
- Union-management relations can be good as well as bad, this depends upon the attitude of one towards the other.
- Many successful firms have enjoyed peaceful union-management relations on the basis of acceptance of collective bargaining, union's widespread creative participation, negotiations conducted in a problem solving atmosphere and an effective grievances procedure.

Management gave unions the chance to participate in discussions of problems affecting workers, *e.g.*, safety studies, workstudy, promotion, etc.

Grievance procedure provided excellent communication channels which further improved union–management relations and gave union the opportunity to carry out its function of representing the workers.

- On the other hand, if union thinks management as unintelligent, stubborn, arrogant and hypocritical; and Management calls union leaders as dishonest, greedy, emotional and unscrupulous, and thus they mutually develop sharp divergence in attitude, resistance to participation, lack of understanding, failure to communicate, etc., naturally the union-management relations cannot become cordial and peaceful.
- It is agreed that the conflicts or disputes between workers/union and management is inevitable, because both management and union want something. it is actually the selfishness of the management as well as of union that gives rise to disputes and prevents cooperation and good relations being established between the two.
- Development of semi-automatic and automatic equipments and machines is also responsible for spoiling (worker) union-management relations. Earlier, workers used to respect their supervisors because the supervisors possessed some definite skill to teach to workers, but later on when the machines became all important, the supervisor's job was simply to enforce a set of rules. Moreover, it became a practice to import personnels for higher levels from outside the factory. The existing staff, thus, could not work its way up in the factory organisation and this created discontentment in their minds.

22

Industrial (Labour) Legislation

22.1. INTRODUCTION

- There has always been struggle, conflict and clashes between the employees (labour) and the employer on the matters of (more) wages, allowances, other facilities etc.
- During the last fifty years with the increase in cost of living, the employee-employer conflicts also increased thereby resulting in strikes, lockouts, picketings and gheraos.
- Ultimately, the government which initially was a silent observer of such conflicts, had to intervene to minimize employee-employer disputes, for the welfare and economy of the country; and thus the government contributed to the personnel field by legislation. Since 1920's there has been a growing stream of protective labour laws regulating wages, compensation, disputes, safety etc.

22.2. IMPORTANCE AND NECESSITY OF LABOUR LEGISLATION (i.e., LABOUR ACTS)

Labour legislation,

1. Improves industrial relations, *i.e.*, employee-employer relations.
2. Helps pay fair wages to workers.
3. Minimize unrest among the workers.
4. Gives compensation to workers, victims of accidents.
5. Reduces conflicts, strikes etc.
6. Procures job security for the workers.
7. Promotes wholesome environmental conditions in the industry.
8. Fixes hours of work, rest pauses, etc.

22.3. PRINCIPLES OF LABOUR LEGISLATION

Labour legislation is based upon the following principles:

1. *Social justice.* Social justice implies proper distribution of business profits and benefits between employer and employees. Labour acts which base themselves on social justice are,

(*a*) Factories Act

(*b*) Minimum Wage Act

(*c*) Workmen's Compensation Act, etc.

2. *Social equality*

3. *National economy*

4. *International uniformity and solidarity.* To keep international uniformity in all labour matters, different countries seek guidance from International Labour Organisation (ILO) conventions and recommendations for making Labour Laws.

22.4. TYPES OF LABOUR LAWS

1. ***Laws connected with working conditions in factories:***

(*a*) Factories Act, 1948.

(*b*) Industrial Employment Act, 1946.

(*c*) The Mines Act, 1952.

(*d*) Indian Merchant Shipping Act, 1923.

2. ***Laws related to specific matters, e.g., wages, welfare, etc.***

(*a*) The Payment of Wages Act, 1936.

(*b*) The Minimum Wages Act, 1948.

(*c*) The Workmen Compensation Act, 1923.

(*d*) The Employee State Insurance Act, 1948.

(*e*) The Employee Provident Fund Act, 1952.

3. ***Laws related to worker's associations***

(*a*) Trade Union Act, 1926.

(*b*) Industrial Dispute Act.

4. ***Laws related to social insurance***

(*a*) The Maternity Benefit Act, 1961.

(*b*) The Workmen Compensation Act, 1923.

(*c*) Employee's State Insurance Act, 1948.

Some of these laws will be discussed briefly in this chapter.

22.5. THE FACTORIES ACT, 1948

22.5.1. Object and Scope

- The factories act regulates conditions of work (health, safety etc.) in factories, it safeguards the interest of workers and it is for the welfare of factory workers.
- This act received the assent of Governor-General of India on September 23, 1948 and came into force on April 1, 1949. This act was further amended in 1950, 1951, 1954,etc.,and lately in 1987.
- This act is applicable to any factory in which ten or more than ten workers are working.
- The factories act has a provision in respect of
  1. Employee health and safety,
  2. Hours of work,
  3. Sanitary conditions and wholesome work environments,
  4. Employee welfare,
  5. Leave with wages, etc.

22.5.2. Important definitions

(*a*) *Factory.* A place wherein ten or more persons are working and in which a manufacturing process is going on using electricity, steam, oil, etc.

(*b*) *Manufacturing process.* A process for

- making, altering, repairing, finishing, packing, washing, cleaning, or otherwise treating a substance for its use, sale, transport, disposal, etc. ;
- pumping oil, water or sewage, or
- generating, transforming, or transmitting power, or
- composing types for printing, printing for letterpress, lithography, photogravure or other similar process or book binding ;

– constructing, reconstructing, repairing, refitting, finishing or breaking up ships or vessels.

(*c*) *Worker.* Worker means a person employed directly or through any agency, whether for wages or not, in any manufacturing process or in cleaning any part of the machinery or premises used for a manufacturing process or in any other kind of work incidental to or connected with, the manufacturing process or the subject of manufacturing process.

(*d*) *Adult.* A person who has completed his eighteenth year of age.

(*e*) *Child.* A person who has not completed his fifteenth year of age.

(*f*) *Power.* Electrical energy or any other form of energy which is mechanically transmitted and is not generated by human or animal agency.

(*g*) *Machinery.* It includes

– Prime movers : engine, motor, etc.

– Transmission machinery : shaft, wheel, drum, pulley, belt etc.

– And all other appliances whereby power is generated, transformed or transmitted.

(*h*) *Occupier of factory.* A person who has ultimate control over the affairs of factory and where the said affairs are entrusted to a managing agent, such agent will be considered as the occupier of the factory.

22.5.3. Approval, Licensing and Registration of Factories

– Before starting a factory,

1. Take permission of the state government or chief inspector for the site on which factory is to be made.

2. Get the factory plans and specifications approved by the inspector of industries.

3. Pay the necessary fees and get the registration and licensing of the factory.

– If on an application to chief Inspector to use a particular site for a factory, nothing is heard within three months, the permission is deemed to have been granted.

– In case of refusal from chief inspector or state government, the applicant within 30 days of the date of such refusal may appeal to central government in this connection.

– An occupier should, atleast 15 days before he occupies a place as a factory, send to Chief Inspector a written notice containing--name and address of occupier and factory, nature of manufacturing process, nature of power to be used, name of factory manager, number of workers required, etc.

22.5.4. Inspectors. State government appoints Chief Inspector and other Inspectors who

(*i*) may enter any factory ; and

(*ii*) may make examination of premises, plants, machinery and any documents related to factory.

– Certifying Surgeons

State government may appoint qualified medical practitioners as certifying surgeons for

(*i*) the examination and certification of young workers, and

(*ii*) the examination of workers engaged in dangerous occupation or processes.

22.5.5. Main Provisions of the Act. They are as follows :

22.5.6. Health

1. Cleanliness

– Removal and disposal of dirt and refuse from floors, benches etc., everyday.

– Washing of floors of work room at least every week, using disinfectant.

– Effective means to drainage to avoid collection of water, etc., on the work floor.

– All inside walls and partitions, all ceiling tops of rooms, passage and staircase

(*i*) to be repainted once in 5 years if they are already painted ; and

(*ii*) to be white-washed and the white-washing to be carried out at least once in fourteen months.

2. Disposal of Wastes and Effluents

Effective and suitable arrangements should be made for the disposal of wastes and effluents due to the manufacturing process.

3. Ventilation and Temperature

In every factory, effective and suitable provision shall be made for securing and maintaining in every workroom,

(*i*) Adequate ventilation by fresh air circulation,

(*ii*) Suitable temperature to provide conditions of comfort and prevent injury to the health of workers.

4. Dust and Fumes

Employer shall take necessary steps to keep workrooms free from dust or fumes offensive or injurious to the health of the workers.

5. Artificial Humidification

In factories (*e.g.*, textile) where humidity of air is artificially increased, state government may make rules

(*i*) Prescribing standard of humidification ;

(*ii*) regulating the method of artificially increasing humidity ;

(*iii*) directing prescribed test for determining humidity ; and

(*iv*) Prescribing method for achieving adequate ventilation and cooling the air in workroom.

The water employed for humidification shall be from a source of drinking water.

6. Overcrowding

- No workroom should be overcrowded to an extent, which is injurious to the health of workers.
- The minimum space provided for a worker should be 4.2 cu. m.

7. Lighting

- Light whether artificial or natural or both, should be sufficient and suitable in all workrooms.
- Sky lights and glazed windows for lighting the workrooms should be kept clean and unobstructed.
- Glares and shadows which cause eye strain or risk accidents should be prevented.

8. Drinking Water

- Drinking water should be available at suitable points conveniently situated in the factory. All such points shall be legibly marked *drinking water*. No such points shall be located within 6 metres of any latrine, urinal, etc.

9. Latrines and Urinals

- Sufficient latrine and urinal accommodation of the prescribed type should be provided. It should be conveniently situated and accessible to workers.
- Separate enclosed accommodation shall be provided for male and female workers.
- Latrines and urinals should be adequately lighted, ventilated and maintained clean at all times.
- State government may prescribe the number of latrines and urinals to be provided in proportion to the number of workers.

10. Spittoons

- There should be a sufficient number of spittoons at convenient places and maintained in clean hygienic condition.

– No worker shall spit except in a spittoon and if a person contravenes this, he shall be punishable with a fine not exceeding rupees five.

22.5.7. Safety

1. Encasing and fencing of machinery

– In every factory the following shall be securely fenced unless they are in such position as to be safe for each worker

(*i*) Moving parts of prime-mover and flywheel connected to it.

(*ii*) The head race and tail race of water wheel and water turbine.

(*iii*) Any part of a stock bar projecting beyond the lathe head-stock.

– The following parts should be securely fenced by safeguards which shall be kept in position while the parts are rotating,

(*i*) Parts of electric generator, motor, etc.

(*ii*) Parts of transmission machinery.

(*iii*) Dangerous parts of any other machinery.

2. Work on or near machinery in motion

– Any part of machinery if it is required to be examined while it is in motion shall be examined only by a specially trained adult male worker wearing tight fitting clothing.

– No woman or young worker shall be permitted to clean, lubricate or adjust any part of a moving machinery which involves a risk of injury.

3. Employment of young persons on dangerous machines

No young person shall work on a dangerous machine unless

– he has got sufficient training to work at that machine ; and

– he is under adequate supervision of an adult experienced worker/supervisor.

4. Hoists and lifts

– Every hoist and lift shall be

(*i*) of good mechanical construction, adequate strength and sufficiently protected and fitted with gates ; and

(*ii*) adequately maintained and periodically (at least once in six months) examined.

– Hoists and cranes meant for carrying persons shall have at least two ropes or chains separately connected with the cage. Each rope or chain with its attachments shall be able to carry weight of the cage together with its maximum load (*e.g.*, weight of persons).

– Devices should be provided to support cage in the event of breakage of the ropes or chains.

5. Lifting machine, chains, ropes and lifting tackles

Factory cranes and other lifting machines such as crab, winch toggle, pulley block, etc., shall be of good construction, sound material, adequate strength, properly maintained and thoroughly examined atleast once a year.

6. Pressure plants

It should be ensured that the working pressure of such parts does not exceed the safe value.

7. Floors, stairs and means of access to different places

They should be of sound construction, properly maintained and provided with handrails.

8. Pits, sumps, openings in floors, etc., shall be either securely covered or suitably fenced.

9. Excessive weights

No person shall be asked to lift, carry or move any load so heavy as to cause him an injury.

10. Protection of eyes

To protect the eyes of workers from the flying particles (such as in fettling, rivet cutting, scale removal, etc.) or from exposure to welding rays, each worker shall be provided with effective screens or suitable goggles.

11. Precautions against dangerous fumes

No person shall be allowed to enter any confined space, chamber, tank, pit, etc. in which dangerous fumes are likely to be present so as to involve risk to the entering person.

12. Explosive or inflammable dust, gas, etc.

If a manufacturing process is producing dust, gas, fumes or vapour which can explode on ignition,

(*i*) the plant should be effectively enclosed ; and

(*ii*) such dust, gas fume, etc., should not be allowed to accumulate.

13. Precautions in case of fire

Every factory shall be provided with means as follows and others to help escape in case of fire :

(*i*) Fire warning signal.

(*ii*) Unlocked doors and openings towards outside the workroom.

(*iii*) Free passageways and easily openable windows.

22.5.8. Welfare

1. Washing facilities

- Washing facilities adequately screened for male and female workers should be provided in the factory.
- Washing facilities shall be easily accessible and kept clean.

2. Facilities for sitting

Suitable sitting facilities shall be provided for all workers obliged to work in standing position so that they may take rest if an opportunity occurs in the course of their work, without affecting the work.

3. First aid appliances

- For every 150 workers, minimum one fully equipped first-aid box shall be kept available during all working hours.
- A factory employing more than 500 workers shall have a properly equipped ambulance room.

4. Canteens

A canteen shall be provided in each factory in which more than 250 workers are ordinarily employed.

5. Shelters, rest-rooms and Lunch-rooms

Every factory in which more than 150 workers are ordinarily employed, adequate, suitable, clean, sufficiently lighted and ventilated rest and lunch rooms shall be provided.

6. Creches

Every factory shall provide clean, adequately lighted and ventilated rooms for the use of children (under the age of six years) of women workers, if the number of such women workers exceeds 30.

7. Welfare officers

- Every factory employing 500 workers or more shall employ welfare officers.
- The state government may prescribe the duties, qualifications and conditions of service of welfare officers so employed.

22. 5.9. Working Hours

1. Weekly hours

An adult worker shall be required to work in the factory for not more than 48 hours a week.

2. Weekly holidays

No adult worker shall be required to work on Sunday unless the factory manager substitutes Sunday by a holiday one or three days immediately before or after Sunday.

3. Daily hours

No adult worker shall be required to work for more than nine hours on any day.

4. Intervals for rest

No adult worker shall be required to work for more than 5 hours continuously, *i.e.*, after five hours, the worker shall have a rest for atleast half an hour.

5. Extra wages for over-time

If a worker works for more than nine hours on any day or for more than 48 hours in any week, he will get his overtime wages at the rate of twice his ordinary rate of wage (*i.e.* basic wages+allowances).

6. Restriction on double employment

No adult worker shall be allowed to work in a second factory on any day on which he has already been working in one factory.

7. Register of adult workers

Factory manager shall maintain a register of adult workers (stating their names, nature of work, group work, etc.) and make it available to the Inspector at all times during work hours.

8. Restrictions on employment of women

No women shall be employed in any factory except between the hours of 6 A.M. and 7 P.M.

22.5.10. Employment of Young Persons

1. Prohibition of employment of young children

No child under 14 years of age shall be allowed to work in any factory.

2. Non-adult workers

A child who has even completed his 14 years of age shall not be allowed to work in a factory unless he carries while at work a token giving reference to certificate of fitness.

3. Certificate of fitness

It is a certificate of fitness for working in a factory which is given to a young person by a certifying surgeon after examining him (*i.e.* the young person).

4. Working hours for children

No child shall be permitted to work

(*i*) for more than four and a half hours on any day ; and

(*ii*) during the night, (*i.e.* 10 P.M. to 6 A.M.)

5. Register of child workers indicating their particulars and nature of work shall be maintained by the factory manager and be made available to Inspector at all times during hours of work.

ANNUAL LEAVE WITH WAGES

– A worker who has worked for 240 days or more during a calender year shall be permitted during the subsequent calender year, leave with wages for a number of days at the rate of

1. One day for every 15 days of work performed by a *child* worker.

2. One day for every 20 days of work performed by an *adult* worker.

– A worker interested to take leave shall apply 15 days in advance.

SPECIAL PROVISIONS

1. Dangerous operations

Where the state government feels that any operation is of serious risk or bodily injury, poisoning or disease, it may make rules :

(*i*) declaring the operation dangerous;

(*ii*) stopping employment of women and children in this operation ;

(*iii*) providing protection of all concerned with that operation ; and

(*iv*) periodical medical check-up of all concerned with that operation, etc.

Notice of accidents

An accident causing death or bodily injury due to which the worker cannot work for a period of 48 hours or more immediately after the accident, shall be brought to the notice of such authorities, within such time as may be prescribed.

Notice of disease

If a worker is suffering from any disease specified in the schedule, a report immediately shall be sent to Chief Inspector giving particulars of the worker and the disease from which he is suffering.

Power to take samples

An inspector, during working hours, after informing the manager may take samples of any substance being used in the factory.

22.5.11. Penalties and procedure

General Penalty for Offences

– In case of any contravention of any of the provisions of this Act, the occupier and factory manager shall each be guilty of an offence and punishable with up to 2 years of imprisonment or fine up to Rs. 100,000 or both.

– If contravention continues after conviction, there will be a fine of Rs. 1000 per day.

After being convicted for an offence,if the person does contravention of the same provision again, he shall be punishable with imprisonment up to 3 year, a fine up to Rs 10000 to 3 lakhs or both.

Penalty for Obstructing Inspector

– An Occupier/Manager shall be punishable with imprisonment up to 6 months or fine up to Rs. 10,000 or both if he

(*i*) fails to produce registers or other documents on demand by Inspector ; and

(*ii*) prevents any factory worker from being examined by the Inspector.

Offence by Workers

– If any worker contravenes any provisions of the act, he shall be punishable with fine up to Rs. 500.

Appeals

An occupier/manager on whom a written order by an Inspector has been served under the provisions of the Act may within 30 days of the service of order, appeal against it to the prescribed authority.

Obligations of Workers

– No factory worker will misuse any appliance provided for the purpose of securing health, safety and employee welfare.

– A worker who contravenes this provision shall be punished with up to 3 months imprisonment or a fine of Rs. 100, or both.

Restriction on Disclosure of Information

No inspector will ever disclose any information relating to manufacturing processes, etc., which comes to his knowledge in course of his official duties. An inspector who does so shall have up to 6 months of imprisonment, or a fine of Rs. 1000, or both

22.6. THE PAYMENT OF WAGES ACT, 1936 (Amended up to 1982)

22.6.1. Aim

To regulate the payment of wages to persons employed in industry and drawing less than Rs. 1,000 per month.

This act is about :
(*i*) the date of payment of wages ; and
(*ii*) deductions (fines or otherwise) from wages.

22.6.2. Definitions

1. Factory, refer the Factories Act, 1948.

2. Industrial establishment

It means any :
- Motor transport service carrying passengers or goods or both on hire,
- Air and water transport service,
- Mine or oil field,
- Workshop, etc.

3. Wages

Wages include all remunerations (salary+allowances, etc.) payable to an employee in respect of his employment. Wages also include over-time remuneration, bonus, gratuity, pension, provident fund contribution by the employer, etc.

Responsibility for Payment of Wages

- An employer shall be responsible for the payment of wages to all his employees.
- An employer shall fix wage period (not exceeding one month) by which he shall pay wages to his employees.
- If the number of employees is less than one thousand, wages have to be paid before the expiry of the seventh day after the last day of wage period. In the other case, payment shall be made before the expiry of tenth day after the last wage period.
- Wages shall be paid on a working day.
- Wages shall be paid in current coins or currency notes or in both.

Deductions from Wages

- Only those deductions as authorized by the Payment of Wages act will be made from the wages of an employee. Deductions may be such as
  - (*i*) fines ;
  - (*ii*) those for absence from duty ;
  - (*iii*) due to damage to or loss of goods ;
  - (*iv*) for house-accommodation supplied by employer ;
  - (*v*) for amenities and services supplied by the employer ;
  - (*vi*) for recovery of advance and loan given to the employee ;
  - (*vii*) for income tax ;

(*viii*) provident fund; and

(*ix*) those by the order of a court.

Imposition of Fines

- Fine shall be imposed only after an employee has been given an opportunity of showing cause against the fine.
- Total fine shall not be more than an amount equal to 3% of the wages payable to an employee in respect of that wage period.
- No fine will be imposed on an employee below 15 years of age.
- Every fine shall be imposed on the day of the act and shall be recovered within sixty days from the day on which it was imposed and that too in one instalment only.
- All fines and their realization shall be recorded in a register and kept by the employer.

22.6.3. Enforcement of the Act

- Inspectors of Factories or otherwise appointed shall be responsible for the enforcement of the Act.

Powers of Inspectors

- Such an inspector may examine or make enquiry to ascertain whether the provisions of this act are being observed.
- Inspector may enter, inspect or search any factory premises and supervise the payment of wages for the purpose of carrying out the objects of the Act.
- The inspector can seize such registers or other documents relevant in respect of an offence under this Act.

Authority to Hear Claims

- To hear claims made by the workers in respect of unauthorized deductions from wages or delay in payment of wages, State Government may appoint an authority (who may be a presiding officer of a Labour Court, a judge of civil court, etc.) to dispose of such claims.
- After hearing, the authority may direct the employer to refund the deduction to the employee alongwith such compensation as the authority may feel proper but not more than ten times the amount deducted.
- If after hearing, it is found that the employee's application was malicious, he may be punished to pay up to Rs. 50, to the employer.
- An appeal can be made against the decisions of authority within 30 days of the date on which decision was told to the employer.

Penalty for Offences under this Act

- Whoever being required under this act to maintain any records of registers

(*i*) fails to do so;

(*ii*) wilfully refuses to furnish such information;

(*iii*) wilfully furnishes an information which he knows is false;

(*iv*) refuses to answer, or gives false answer, shall be punishable with fine of Rs. 200 to 1000.

- Whoever,

(*i*) wilfully obstructs an Inspector from doing his duty;

(*ii*) refuses or wilfully neglects to afford an Inspector any reasonable facility, for making any entry, inspection, examination, etc.;

(*iii*) wilfully refuses to produce on the demand of Inspector any register or other document;

(*iv*) prevents any employee from appearing before the inspector, shall be punishable with a fine from 200 - 1000 rupees.

- A person found guilty of the same offence second time shall be punishable with imprisonment up to 6 months and a fine of, from 500 to 3000 rupees.
- An employer who wilfully does not pay wages of an employee by the date fixed by the authority in this behalf, he shall without prejudize to any other action that may be taken against him, be punishable with an additional fine of up to Rs. 100 for each day for which such neglect continues.

22.7. THE MINIMUM WAGES ACT, 1948

This act has been amended in its local application by many states. For example, Bihar State amended it recently in 1988.

22.7.1. Objects

To prevent exploitation of the employees (workers), this act aims at fixing minimum wages which they must get.

22.7.2. Important Aspects of the Act

(*i*) The act lays down for fixation of

- A minimum time rate of wages,
- A minimum piece rate,
- A guaranteed time rate,
- An overtime rate, for different occupations, classes of work, for adults, children, etc.

(*ii*) The minimum wage may consist of a basic rate of wages and a cost of living allowance.

(*iii*) Cost of living allowance shall be computed by competent authority such as the Director, Labour Bureau.

(*iv*) Wages shall ordinarily be paid in cash.

(*v*) The act empowers the appropriate government to fix number of working hours in a day, a weekly holiday, and payment of overtime wages.

(*vi*) The employer is required to maintain registers and office records in proper manner.

(*vii*) Inspectors may be appointed to hear and decide claims arising due to payment of less than minimum wages.

(*viii*) Penalties shall be imposed for violating the provisions of the act.

22.7.3. Fixation and Revision of Minimum Wages

(*i*) Appropriate government shall fix the minimum rates of wages for persons employed.

(*ii*) Appropriate government shall review at interval not exceeding five years, the minimum rates of wages so fixed and revise the minimum rates.

(*iii*) In fixing or revising rates of wages:

- different minimum rates of wages be fixed for different scheduled employments, different classes of work and for adults, children and apprentices,
- minimum rates of wages may be fixed either by hour, by day, by month or by other longer wage period as may be prescribed.

(*iv*) For fixing or revising minimum rates of wages, the appropriate government shall,

(*a*) either appoint committees and sub-committees; and

(*b*) or publish its proposals for the information of persons likely to be affected and consider all representations received from those persons.

(*v*) The appropriate government shall appoint an Advisory Board for,

(*a*) coordinating the work of committees and sub-committees; and

(*b*) advising it as regards fixing and revising minimum wage rates.

22.7.4. Payment of Minimum Wages

(*i*) Minimum wages shall be Payable in cash.

(*ii*) An employer shall not pay less than the minimum wage rate fixed.

(*iii*) The government may

- fix number of working hours in a day ;
- provide a day for rest in every period of seven days ;
- provide payment for work on a day of rest at a rate not less than the over--time rate.

These provisions shall apply to

- employees engaged on urgent work, preparatory or complementary work ;
- employees whose employment is essentially intermittent, etc.

(*iv*) If an employee does two or more classes of work, each having a different minimum wage rate, he shall get payment in respect of time spent in each class or work.

22.7.5. Maintenance of Records

- Every employer shall maintain registers and other records giving details of employees, nature of work performed by them, wages paid to them, receipts given by them, etc., in such a form as may be prescribed.

22.7.6. Inspectors and their Powers

- Appropriate government may appoint Inspectors for the purpose of this act.
- The Inspectors shall have the following powers:

(*i*) To enter at all reasonable hours, any premises for examining registers, records of wages, etc.

(*ii*) To examine any person.

(*iii*) To seize relevant records in respect of an offence.

22.7.7. Claims

- An employee, an official of registered trade union on behalf of the employee or an Inspector can apply to the Authority (*e.g.*, commissioner for Workmen's Compensation, Labour commissioner, etc.) appointed by appropriate government to hear and decide claims:

(*i*) arising out of payment of less than minimum wage rate,

(*ii*) in respect of wages at the over-time rate,

(*iii*) in respect of payment of remuneration for days of rest, etc.

- Application for claim should be presented within six months from the date on which the claimed amount becomes payable.
- After receiving the application, the Authority shall hear both the employee (*i.e.* applicant) and the employer.

(*i*) If employee's stand is found correct, for claims arising out of payment of less than minimum wages, the employee shall get the extra amount plus a compensation not exceeding 10 times the amount of such excess.

(*ii*) In cases other than that of minimum wages, employee shall get the amount due towards him plus a compensation not more than Rs. 10.

(*iii*) If employee's application is found to be malicious or vexatious, he may be penalised to pay to the employer an amount up to Rs. 50.

22.7.8. Offences and Penalties

- An employer who contravenes any provision of the act, be punishable with fine extending up to Rs. 500 and an imprisonment for a term up to six month or both.
- An employer charged with an offence under this act, can file a complaint against the actual offender and if he succeeds in proving the offence by the other person, the actual offender (*i.e*, the other person) shall be liable to punishment.

22.8. THE WORKMEN'S COMPENSATION ACT,1923 (Amended upto 1986)

22.8.1. History

- The Workmen's Compensation Act came into force in 1924. Before this act, it was a lengthy and costly process for a worker who had got injured in the course of employment to get proper compensation from the employer.
- Originally the act covered workers of certain specified industries, not drawing more than Rs. 300 p.m.
- The Act was amended subsequently in 1933, 1938, 1939, 1946, 1958, 1962, 1976 and 1986).

The details of this act are as follows :

22.8.2. Main Features of the Act

- The worker (or his dependents) can claim compensation if the injury has been caused by an accident in the course of the employment ; provided he was not under the influence of drink or drug and the accident was not due to his wilful disobedience of the rules.
- The amount of compensation depends upon the result of the injury and the nature of disablement.
- All fatal accidents are to be brought to the notice of the commissioner and the employer shall deposit the amount of compensation with him (*i.e.* the commissioner) within 30 days.

22.8.3. Important Definitions

1. Dependents mean

- A widow, a minor son, unmarried daughter or a widowed mother, and
- If wholly or in part dependent on the earnings of the worker at the time of his or her death,

(*i*) a widower, a minor brother and unmarried sister ;

(*ii*) a widowed daughter-in-law ; and

(*iii*) A minor child of predeceased daughter, etc.

2. Minor. A person below 18 years of age.

3. partial disablement means disablement of temporary nature and which reduces the earning capacity of a workman.

4. Total disablement implies such disablement which (temporarily or permanently) incapacitates a workman for all work and he cannot earn at all (for a period or for ever).

5. Workman means a person (other than one whose employment is of casual nature and who is employed ortherwise than for the purpose of the employer's trade or business) who is

(*i*) a railway servant and not permanently employed in any administrative capacity ;

(*ii*) getting wages not exceeding

Rs. 500-As per Act of 1923

Rs 1000-As per Act modified in 1976.

22.8.4. Employer's Liability for Compensation

- The employer is liable to compensate if

(*i*) injury has been caused by accident :

(*ii*) during the course of employment ;

(*iii*) and has resulted in workman's death ; permanent or temporary, total or partial disablement.

– The employer is not liable to pay compensation if

(*i*) the injury disables a workman for less than 3 days ;

(*ii*) the injury is caused by an accident which occurred while the workman was under the influence of drink or drugs ;

(*iii*) the injury is caused due to wilful disobedience of the rules by the workman ; or

(*iv*) the injury is caused owing to the wilful removal of any safety guard by the workman.

22.8.5. Employer's Liability in Case of Occupational Diseases

If the disease contracted is an occupational disease peculiar to the employment (such as silicosis to foundry workers), the employer shall give compensation to the workman.

22.8.6. Amount of Compensation

(*a*)	Where death results from the injury	An amount equal to 40% of the monthly wages of the deceased workman multiplied by the relevant factor (Schedule iv) or An amount of 20,000 rupees, whichever is more.
(*b*)	Where permanent total disablement results from the injury	An amount equal to 50% of the monthly wages of the injured workman multiplied by the relevant factor or An amount of 24000 rupees, whichever is more.

Where the monthly wages of a workman exceed one thousand rupees, the monthly wages for the purpose of classes (*a*) and (*b*) above shall be deemed to be 1000 rupees only.

SCHEDULE IV

Completed years of age on the last birth day of the workman immediately preceding the date on which the compensation fell due	Factors
Not more than 16	228.54
20	224.00
24	218.47
28	211.79
32	203.85
36	194.64
40	184.17
..	..
..	..
50	153.09
..	..
60	117.41
..	..
..	..
65 or more	99.37

(c) Where temporary disablement whether total or partial results from the injury, a half monthly payment of the sum equivalent to 25% of monthly wages of the workman, to be paid.

22.8.7. Distribution of Compensation

- Payment of compensation in respect of death of a workman or under legal disability shall be deposited by the employer with the commissioner. Employer should not make payment of compensation directly.
- An employer of course can give advance to any dependent on account of compensation not exceeding Rs. 100.
- The commissioner, after deducting this advance, may allot the entire amount of the compensation to any one dependent.

22.8.8. Notice and Claims of Accident

- A workman injured in an accident should first of all give in writing a notice of the accident to the employer.

The purpose of giving a notice is to enable the employer to check the facts of the accident and also to enable the workman to take steps to mitigate the consequences of the accident.

- The notice should contain particulars of the workman, date of accident and cause of accident.
- A claim for compensation must be made within two years of the occurrence of the accident or within two years of the date of death.
- In case of occupational diseases the period of two years is counted from the day the workman gives notice of the disablement to his employer.
- Where the commissioner receives an information about fatal accident, he may send a notice to workman's employer asking the circumstances which led to workman's death, about deposition of compensation, etc.

22.8.9. Medical Examination

- An injured workman who has submitted a notice, shall present himself for the medical examination, if the employer wants.
- Such an offer by the employer must be free of charge and within 3 days from the time at which service of notice has been affected.
- If a workman does not present himself for the medical examination, his right for compensation shall be suspended for the period of refusal and he will get full compensation only after he provides sufficient cause for not presenting himself for the medical examination.
- If a workman whose right to compensation has been suspended, dies without presenting himself for the medical examination, the commissioner, if he thinks fit, may direct the amount of compensation to the dependents of the deceased workman.

22.8.10. Appointment of Commissioner

The State government may, by notification in his Official Gazette appoint any person to be commissioner for workmen's compensation for such areas as may be specified in this notification. Every commissioner is deemed to be a public servant within the meaning of the Indian Penal Code.

22.9. THE INDUSTRIAL DISPUTE ACT, 1947 (Amended Up to 1987)

20.9.1. Introduction and scope of Act

- The whole history of labour struggle indicates the continuous demand for fair return to labour.
- Industrial disputes are mainly the result of dissatisfaction amongst the labour as regards their existing labour conditions.
- With the above in mind, the Industrial Dispute Act came into force in 1947 and it aims at settling

the industrial disputes on a new pattern known under the Act as adjudication machinery.

- This act aims at making industrial peace through voluntary negotiations and compulsory adjudication.

The act makes provision for settlement of industrial disputes between employees (workers) and employer.

22.9.2. Important Aspects of the Act

(*i*) An industrial dispute may be referred to an Industrial tribunal.

(*ii*) An award shall be binding on both the disputing parties for a period not exceeding one year.

(*iii*) Strikes and lockouts are prohibited during the pendency of,

- conciliation and adjudication proceedings ;
- settlement reached in the course of conciliation proceedings,
- awards of industrial tribunals declared binding by the appropriate government.

(*iv*) In public interest or emergency, appropriate government can declare the following industries to be a public utility service for a maximum period of 6 months,

Transport by land, air, and water,
Foodstuff,
Coal,
Cotton textile, and
Iron and Steel.

22.9.3. Important Definitions

1. Award means an interim or a final determination of an industrial dispute. Decisions of Labour Court and Industrial Tribunals are awards.

2. Average pay means the average of wages payable to workman:

- in case of monthly paid workman, in the 3 calendar months ;
- in the case of weekly paid workman, in the 4 completed weeks ; and
- in the case of daily paid workman, in the 12 full working days.

3. Industry means any business undertaking, manufacture, etc. It includes any calling, service, employment, handicraft or industrial occupation or a vocation of workman.

4. Industrial dispute means

- any dispute or difference,
- between employers and employers,
  employers and workmen,
  Workmen and workmen ; and
- connected with employment, or
  non-employment, or
  terms of employment or
  conditions of labour, or any person

5. Lay-off means

- Failure, refusal or inability of an employer,

  on account of shortage of coal, power, raw material, accumulation of stock, breakdown of machinery or for any other reason,

  to continue to employ workers (in his industry) whose names are borne on the muster-rolls and who have been retrenched.

Lay-off is a temporary phase ; the employee-employer relations do not come to an end, but are simply suspended for some period (of emergency).

6. Lock-out means the closing of a place of employment or suspension of work or the refusal by an employer to continue to employ any number of workers employed by him.

7. Public utility services mean

Railway or transport service,
Postal, telegraph or telephone service,
Any industry supplying power, light or water,
Sanitation,
Foodstuffs, and
Coal, textile, etc.

8. Retrenchment means the termination of the services of a worker by the employer for any reason whatsoever other than due to disciplinary action. Retrenchment does not include,

- Voluntary retirement of the worker,
- Termination of services on reaching the age of superannuation, and
- Termination of services on the ground of continued illhealth.

9. Strike means refusal to work or cessation of work by a body of workmen for enforcement of a demand against the employer during an industrial dispute.

10. Settlement. It implies a settlement arrived at in the course of conciliation proceeding. It includes a written agreement between the workers and employer.

11. Workmen means any person (including an apprentice) employed in any industry for hire or award to do manual, technical, supervisory or clerical work.

22.9.4. Authorities Under This Act

Works Committee

- Any industry, in which 100 or more workers are and have been employed on any day in the preceding 12 months, shall constitute a works committee.
- Works committee shall have representatives of workers and employer both. Workmen representatives will not be less than those of employer in number.
- Works committee shall promote measures for securing and preserving amity and good relations between the workers and employer. It will comment upon matters of their common interest and try to compose any material difference of opinion in respect of such matters.
- Works committee shall smooth away frictions that might arise between the workers and the employer in day-to-day work.

Conciliation Officers

Conciliation officers will be appointed by any Appropriate Government and they shall mediate and promote the settlement of industrial disputes.

Board of Conciliation

Appropriate Government may constitute a Board of Conciliation to promote settlement of an industrial dispute.

- Board of conciliation will be headed by a chairman (an independent person) and shall have two or four other members which will be representatives of the parties to dispute. Both parties, *i.e.*, workers and employer shall have equal number of representatives.

Courts of Enquiry

- Appropriate Government may constitute a court of enquiry to look into any matter connected with industrial dispute.

- Court (of enquiry) may consist of one or more independent persons.
- The court shall inquire and submit a report ordinarily with in six months from the commencement of inquiry.

Labour Court

- The appropriate government may constitute Labour Court consisting of one person only for adjudication of industrial disputes relating to any matter specified in the 2nd Schedule.
- The matters within the jurisdiction of Labour Court as per *2nd schedule* are :
  - (*i*) The propriety or legality of any order passed by employer under the standing orders.
  - (*ii*) The application and interpretation of standing orders.
  - (*iii*) Illegality or otherwise of a Strike or Lock-out.
  - (*iv*) Dismissal of workers including reinstatement or relief to workers wrongly dismissed.
  - (*v*) Withdrawal of any concession or privilege.
- Presiding officer of one man Labour Court shall be,
  - (*i*) a judge of a high court ; or
  - (*ii*) a district judge who has worked for more than 3 years, etc.

Industrial Tribunals

Appropriate Government may constitute one person Industrial Tribunals for the adjudication of Industrial Disputes relating to matters specified in,

- (*i*) Schedule II (refer to Labour Court for details of Schedule II),
- (*ii*) Schedule III-Matters such as
  Wages,
  Compensatory and other allowances,
  Hours of work and rest pauses,
  Holidays and leave with wages,
  Bonus, provident fund, gratuity,
  Rules of discipline, and
  Retrenchment of workers, etc.
- (*iii*) Presiding officer of the tribunal shall have the same qualification as that of a Labour Court.

National Tribunals

- Central Government may constitute National Industrial Tribunals for the adjudication of the industrial disputes which involve questions of national importance.
- The presiding officer of the National Tribunal shall be
  - (*i*) an independent person ;
  - (*ii*) less than 65 years of age ; and
  - (*iii*) an existing or retired judge of a high court, etc.

Prohibition of adjudication by other tribunals

If any reference has been made to a National Tribunal, no Labour Court or Tribunal, shall have jurisdiction to adjudicate upon any matter which is under adjudication before the National Tribunal.

22.9.5. Strikes and Lock-out

1. No employee of a public utility service shall go on strike,
   (*i*) Without giving notice of strike, within six weeks before striking ; or
   (*ii*) within fourteen days of giving such notice ; or

(*iii*) before the expiry of date of strike mentioned in the notice ; or

(*iv*) during the pendency of conciliation proceeding.

2. No employer of any public utility service shall lock-out,

(*i*) without giving notice of lock-out within six weeks before locking out, or

(*ii*) before the expiry of date of lockout mentioned in the notice, or

(*iii*) during the pendency of conciliation proceeding.

The employer shall send information of strike or lock--out to the specified authority on the day on which it is declared.

3. prohibition of financial aid to illegal strikes and lock-out

- A strike or lock-out is illegal if it is declared in contravention of points 1 & 2 above (*i.e.*, section 22 and 23 of the act, respectively).
- No body shall knowingly expend any money in direct support of an illegal strike or lock-out.

22.9.6. Lay-off and Retrenchment

- For definition of Lay-off and retrenchment refer *Important Definitions* given earlier in this Act.

Right of Workmen laid off for compensation

- A worker having more than one year of continuous service under an employer, if is laid off, shall get compensation equal to 50% of the total of his basis wages and dearness allowance, subject to the following limitations :

  Provided that if during any period of 12 months, a workman is so laid-off for more than 45 days, no such compensation shall be payable in respect of any period of the lay-off after the expiry of the first 45 days, if there is an agreement to that effect between the workman and the employer, etc.

Workmen not entitled to compensation in certain cases

No compensation shall be paid to a worker laid-off under following conditions :

(*i*) If he refuses to accept alternative employment involving same wages, offered to him in the same concern or in any other concern of the same employer.

(*ii*) If the lay-off is due to a strike, etc.

Conditions precedent to retrenchment

No worker who has a continuous service of more than one year shall be retrenched by the employer until :

(*i*) The worker has been given one month's written notice stating the reason for retrenchment and the period of notice has expired or the worker has been paid in lieu of such notice, wage for the period of notice.

(*ii*) At the time of retrenchment, the worker has been paid compensation equivalent to 15 days average pay for every completed year of service.

Closing down the undertaking

- An employer who intends to close down an undertaking shall serve, atleast 60 days before the date on which he intends closure to become effective, a notice to Appropriate Government stating clearly the reasons for closing the undertaking.
- Compensation by reference to section 25-FFF of the Act is provided to workers who are in continuous service for not less than a year with the undertaking.

22.9.7. Penalties

- Workers who commence illegal strike shall be punishable with imprisonment extending up to one month and a fine of up to Rs. 50, or both.

- An employer who commences an illegal lock-out shall be punishable with imprisonment up to one month or with a fine up to Rs. 1000, or both.
- The act also specifies *penalties* of up to 6 months imprisonment or a fine of up to Rs. 1000 or both, for :
  - (*i*) Instigating for illegal strike or lay-out,
  - (*ii*) Giving financial aid to illegal strike or lock-out,
  - (*iii*) Breach of settlement or award, and
  - (*iv*) Disclosing confidential information, etc.

22.10. THE EMPLOYEES' STATE INSURANCE ACT, 1948 (Amended up to 1989)

22.10.1. Introduction

The Employee's State Insurance Act was passed (in 1948), because the Workmen's Compensation Act of 1924 could not do as much as was thought it (*i.e.*, the Act) would benefit the industrial workers. The Workmen's Compensation Act

- did not cover many diseases ;
- involved much delay in payment of compensation; moreover it was not easy to prove that the worker got injury because of lackness on the part of the employer, etc.

22.10.2. Object of Employee's State Insurance Act

To provide certain benefits to employees in case of sickness, employment injury, maternity and for certain other matters in relation thereto.

22.10.3. Important Definitions

1. *Contribution* means the sum of money payable to the corporation by the principal employer in respect of an employee. It includes any amount payable by or on behalf of the employee.

2. *Corporation* means the Employee's State Insurance Corporation set up under this Act.

- The corporation shall consist of

  A chairman

  A vice-chairman, and

  Not more than 5 persons nominated by Central Government.
- The corporation can
  - (*i*) sell, hold or otherwise transfer any movable or immovable property ;
  - (*ii*) invest any money which is not immediately required ;
  - (*iii*) raise loans ; and
  - (*iv*) employ necessary staff for the administration of its business.
- The corporation shall maintain correct accounts of income and expenditure.

3. *Employment injury* means a personal injury to an employee caused by an accident or an occupational disease arising in course of employment.

4. *Principal employer* means

- the owner or occupier of the factory and includes the Factory Manager ;
- any person responsible for supervision and control of the undertaking.

5. *Sickness* means a condition which needs medical treatment and requires absention from work on medical grounds.

22.10.4. Medical Benefit Council

- A medical-benefit council is set up to advise on matters relating to administration of medical

benefits.

- Such council can investigate complaints against medical practitioner (attending the workmen) in connection with medical treatment and attendance.

22.10.5. Finance and Audit

- The Act makes provisions for creation of a fund called Employee's State Insurance Fund.
- The fund is created mainly by the contribution made by the employer and the employees.
- The fund is held and administered by the corporation.
- The fund is utilized for
  - (*i*) payment of benefits and provisions of medical treatment to workmen and their families;
  - (*ii*) establishment and maintenance of ESI hospitals and dispensaries, etc.;
  - (*iii*) payment of fees, allowances, salaries, etc., to officers and servants of the corporation; and for
  - (*iv*) many other purposes related to proper functioning of ESI corporation.

Contribution

- Contributions towards making the fund is mainly from the Employer and Employees of the undertaking; though Central and State Governments also give grants and donations in the fund.
- The employer, deducts employee's contribution from their salaries and the same along with his own share, shall submit in a bank nominated for the purpose.
- The ESI corporation may appoint Inspectors to check the particulars about the amount (of fund) submitted by the employer.

22.10.6. Benefits

The Act provides the following benefits

1. Sickness benefit

It is in the form of periodical payment to any insured person when his sickness is certified by a duly appointed medical practitioner or by another person having qualifications as prescribed in regulations.

2. Maternity benefit

An insured woman employee is entitled to periodical payment in case of confinement or miscarriage or sickness arising out of pregnancy, confinement or premature birth of a child or miscarriage.

3. Disablement benefit

An insured person suffering from disablement as a result of injury in course of employment (*i.e.*, employment injury) is entitled for disablement benefit.

4. Dependents benefit

Where insured person dies of employment injury, dependents' benefit shall be payable.

5. Medical benefit

An insured person whose condition demands medical treatment is entitled to receive medical treatment and medical benefit.

22.10.7. Adjudication of Dispute and Claims

1. Employee's Insurance (EI) Court

State government shall constitute Employee's Insurance court to decide all matters, questions and disputes arising from the insurance of workmen.

2. Matters to be decided by E.I. court

- Whether any person is an employee within the meaning of this Act and if he has to pay the

contribution.

- Rate of contribution to be paid by principal employer.
- Rate of wages of an employee.
- Right of any workman to any benefit and as to the amount and duration thereof.
- Any dispute between the employer and ESI corporation.

22.10.8. Penalties

Punishment for false statements

- Imprisonment up to six months or fine not exceeding Rs. 2000 or both.

Punishment for failure to pay contributions

- Imprisonment extending up to 3 years or fine up to Rs. 10,000.

Prosecutions

- Prosecution shall be instituted only with the previous sanction of the Insurance Commissioner.
- No court inferior to that of a Presidency Magistrate or a First Class Magistrate shall try any offence under this Act.

22.10.9. Miscellaneous

- The appropriate government may exempt certain factories or employees from the operation of this Act, under certain conditions.
- Central Government, State Government and the Corporation has powers to make rules and regulations consistent with this Act.

23

Materials, Purchase and Stores Management

23.1. MATERIALS MANAGEMENT

23.1.1. Introduction

- Most manufacturing concerns spend more than 60% of the money they take in, for materials, *i.e.*, materials soak up a substantial portion of the capital invested in an industrial concern.
- This emphasizes the need for adequate *materials management and control* because even a small saving in materials can reduce the production cost to a fair extent and thus add to the profits.
- *Materials Management* may be thought of as an integrated functioning of the different sections of a company dealing with the supply of materials and other related activities so as to obtain maximum co-ordination and optimum minimum expenditure on materials.
- *Materials Management* involves controlling the type, amount, location, movement, timings of purchase of various materials etc., used in an industrial concern.

23.1.2. Functions of Materials Management

(*i*) Materials planning

(*ii*) Procurement or purchasing of materials.

(*iii*) Receiving and warehousing

(*iv*) Storage and store-administration.

(*v*) Inventory control.

(*vi*) Standardization, Simplification and Value-analysis.

(*vii*) External transportation (*i.e.*, traffic, shipping, etc.) and materials handling (*i.e.*, internal transportation).

(*viii*) Disposal of scrap, surplus and obsolete materials.

23.1.3. Objectives of Materials Management

(*i*) To minimize materials cost.

(*ii*) To procure and provide materials of desired quality when required, at the lowest possible overall cost of the concern.

(*iii*) To reduce investment tied in inventories for use in other productive purposes and to develop high inventory turnover ratios.

(*iv*) To purchase, receive, transport (*i.e.*, handle) and store materials efficiently and to reduce the related costs.

(*v*) To trace new sources of supply and to develop cordial relations with them in order to ensure continuous material supply at reasonable rates.

(*vi*) To cut down costs through simplification, standardization, value analysis, import substitution, etc.

(*vii*) To report changes in market conditions and other factors affecting the concern, to the concern.

(*viii*) To modify paper work procedure in order to minimize delays in procuring materials.

(*ix*) To conduct studies in areas such as quality, consumption and cost of materials so as to minimize

cost of production.

(*x*) To train personnel in the field of materials management in order to increase operational efficiency.

23.2. PURCHASING OR PROCUREMENT

23.2.1. Introduction

- The purchasing department occupies a vital and unique position in the organisation of an industrial concern because purchasing is one of the main functions in the success of a modern manufacturing concern.
- Mass production industries, since they rely upon a continuous flow of right materials, demand for an efficient purchasing division.
- The purchasing function is a liaison agency which operates between the factory organisation and the outside vendors on all matters of procurement.
- Purchasing implies—procuring materials, supplies, machinery and services needed for production and maintenance of the concern.

23.2.2. Objectives of Purchasing Department

(*i*) To procure right material.

(*ii*) To procure material in right quantities.

(*iii*) To procure materials of right quality.

(*iv*) To procure from right and reliable source or vendor.

(*v*) To procure material economically, *i.e.*, at right or reasonable price.

(*vi*) To receive and deliver materials at

- right place, and at
- right time.

Purchasing department has to perform certain activities, duties and functions in order to achieve the above mentioned objectives.

23.2.3. Activities, Duties and Functions of Purchasing Department

(*i*) Keep records—indicating possible materials and their substitutes.

(*ii*) Maintain records of reliable sources of supply and prices of materials.

(*iii*) Review material specifications with an idea of simplifying and standardizing them.

(*iv*) Making contacts with right sources of supply.

(*v*) Procure and analyze quotations.

(*vi*) Place and follow up purchase orders.

(*vii*) Maintain records of all purchases.

(*viii*) To make sure through inspection that right kind (*i.e.*, quantity, quality, etc.) of material has been purchased.

(*ix*) To act as liaison between the vendors and different departments of the concern such as production, quality control, finance, maintenance, etc.

(*x*) To check if the material has been purchased at right time and at economical rates.

(*xi*) To keep an uninterrupted supply of materials so that production continues with least capital tied in inventories.

(*xii*) To prepare purchasing budget.

(*xiii*) To prepare and update list of materials required by different departments of the organisation

within a specified span of time.

(*xiv*) To handle subcontracts at the time of high business activity.

(*xv*) To ensure that prompt payments are made to the vendors in the interest of good public relations.

23.3. PURCHASE ORGANISATION

- Purchasing department is a staff function in the overall company structure (Refer Fig.23.1).
- The internal organisation of the purchasing department is on a *line* basis, with purchasing agent, director of purchases or purchasing manager being the incharge of purchase department. He is responsible for the overall efficient operation of the department.
- The purchasing manager is, however, assisted in purchasing by a number of assistants and a few clerical staff (refer Fig. 23.1).
- The purchasing manager has the powers to execute purchasing contracts for the concern. He divides the duties among the assistants according to the nature of purchases to be made. For example, one assistant may purchase only electrical goods, another (major) raw material, third plant equipment and so on.

This functional division of efforts makes for increased specialisation and gives a chance to the assistant to better feel and know the market, he is assigned.

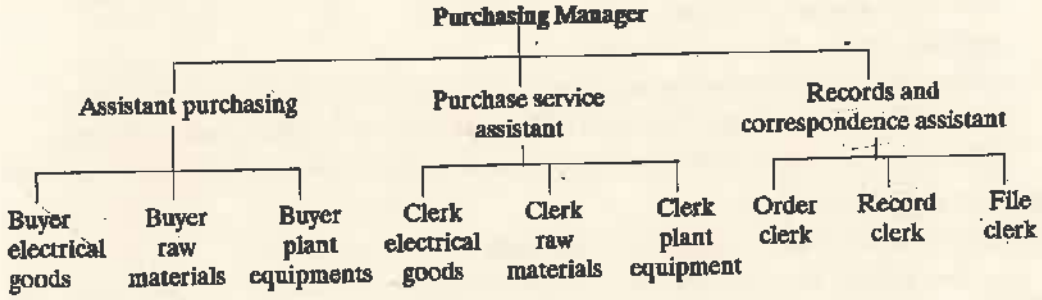


Fig. 23.1. Organisation of a Purchasing Department.

- Fig. 23.1 shows an organisation of a typical purchasing department. There are three main sections namely *purchasing, purchase service* and *records.*

1. *Purchasing section* places orders with the vendors.

2. *Purchase service section* follows the progress of the order at vendor's end, its shipment by the vendor and its final receipt in the company.

3. *Records section* maintains all records of quotations, costs, purchases, etc.

23.3.1. Centralized and Decentralized Purchase Organisations

- The problem of centralising or decentralising the purchase activities arises in large organisations—particularly in multiplant industries.

Advantages of Centralized Purchasing

- The centralization of purchasing,

(*i*) almost invariably makes for more efficient ordering of materials ;

(*ii*) forms a basis to gain bargaining advantage ;

(*iii*) eliminates duplication of efforts ;

(*iv*) helps procuring uniform and consistent materials ;

(*v*) simplifies purchasing procedure ;

(*vi*) simplifies the payment of invoices ; and

(*vii*) permits a degree of specialization among buyers.

Disadvantages of Centralized Purchasing

1. Centralized purchasing is little slower and more cumbersome than decentralized purchasing.

Applications of Centralized purchasing

1. For concerns using few materials whose quality and availability are vital to the success of the concern.

2. For purchasing small items of fairly high value such as tool bits, grinding wheels, dial gauges, etc., as well as those for which bigger quantity discounts can be obtained.

Advantages of Decentralized Purchasing

1. Improved efficiency.

2. Faster procurement of materials.

3. Control over purchases is no longer remote.

4. Decentralized operations are more flexible.

Disadvantages of Decentralized Purchasing

1. Less quantity discounts.

2. Involves duplication of efforts.

Applications of Decentralized Purchasing

1. Where different plants of a large organisation require quite different types of materials.

2. Where branch plants require heavy and bulky items such as oil products, fuels, paints, etc.

3. Where purchases are to be made within the local community to promote better public relations.

23.4. BUYING TECHNIQUES

Materials can be bought or purchased by one of the following techniques :

(*a*) **Spot Quotations.** The buyer can go to the market, collect minimum three quotations (for purchasing one material) from different suppliers, take a spot decision, pay cash and buy the commodity.

Generally the item is purchased from the vendor who furnishes a quotation of least price.

(*b*) **Floating the Limited Enquiry.** A few reliable (and otherwise registered with the company) vendors are written letters to send the price and other details for a particular commodity. A *quotation form* as shown in Fig. 23.2 is generally used for calling the quotations :

QUOTATION FORM

From .....

.....

To .....

No. M.E.D./..... Date.....

Dear Sir,

Please submit your quotations for the materials listed below so as to reach the office of the undersigned at the latest on .....at..... Please send full details, specifications, pamphlets, and other literature if any along with the quotations. Please note the terms and conditions mentioned below:

1. Please mention on the top of envelope :

Enquiry No..... Date on which due.....

2. Submit quotations in duplicate.

3. Preferably quote in the same order as in the enquiry letter.

4. Price each item separately and the prices quoted should be for destination.....

5. If you are unable to furnish materials as per our descriptions and wish to offer a substitute, please give details.

6. Quotations should be valid for at least one month from the date of opening.

7. Taxes should be mentioned for each case.

8. Quotations should be sent in sealed covers.

9. The right is reserved to accept or reject quotations on each item separately or as a whole.

The quotations will be opened on.....at.....in the office of the undersigned.

No.	*Description*	*Quantity*	*Unit*	*Price*	*Discount*	*Total Net Price*
1.	.....	.....	.....	.....	.....	.....
2.	.....	.....	.....	.....	.....	.....
3.	.....	.....	.....	.....	.....	.....
4.	.....	.....	.....	.....	.....	.....

Yours faithfully
Store Purchase Officer

Fig. 23.2

COMPARATIVE STATEMENT

Section.....
Enquiry letter No..... Dated.....
Last Date of Receiving Quotations.....
Date of Opening Quotations.....
Account on which the expenditure is debitable.....
Comparative statement Prepared by..... Checked by.....

Sl. No.	*Description of materials required*	*Quantity to be purchased*	*Supplier 1*	*Supplier 2*	*Supplier 3*
			RATES		
1.	.....	.....	.....	.....	.....
2.	.....	.....	.....	.....	.....
			TERMS AND CONDITION		
			1.*	1.*	1.*
			2.	2.	2.
			3.	3.	3.
			4.	4.	4.
			5.	5.	5.

* 1. Delivery date.
2. Place of delivery.
3. Terms of payment.
4. Taxes.
5. Packing & forwarding charges.

Fig. 23.3

- After getting replies from vendors, the quotations are opened and a *comparative statement* like one shown in Fig. 23.3 is prepared. The comparative statement helps studying and comparing different quotations at a glance and a quick decision can be taken as with whom to place the order.
- Comparative statement is analysed in the light of undermentioned points and the best quotation is selected for ordering the material.
  - (*i*) Price of the (article or) material.
  - (*ii*) Material specifications and quality.
  - (*iii*) Place of delivery.
  - (*iv*) Delivery period.
  - (*v*) Taxes, etc.
  - (*vi*) Terms of payment.
  - (*vii*) Validity of tender.
  - (*viii*) Guarantee period, etc.

(C) Tenders

- A tender or a quotation is in the form of a written letter or a published document (in newspapers). The aim is to find the price for procuring certain materials or to get a particular work done within the desired period and under specified conditions.
- *Types of* : The tenders may be of the following three types,

1. Single tender.
2. Open tender.
3. Closed tender or limited tender [Please refer to section 23.4(*b*)].

1. Single Tender. Tender is invited from one reliable supplier only. Single tender is called under following conditions :

- Proprietory items.
- High quality items.
- 'C' class items such as clips, pins, pencils, etc.
- When items are required comparatively urgently.

2. Open tender. Open tender which is also called *press tender* is published in Newspaper, Trade Journals etc., for procuring materials of desired specifications.

- It is open to everybody ; any vendor (reliable or unreliable) can furnish the quotations.
- Open tender gets very wide publicity.
- A vendor has to deposit an earnest money with the tender information. This is just to ensure that the vendor does not back out from the rates etc., which he submits.
- Given below (Fig. 23.4) is a typical example of tender notice published in Newspaper :

A.P. STATE ELECTRICITY BOARD
(*PROCUREMENT CIRCLE – A*)
TENDER NOTICE

SEALED Tenders in triplicate are invited for the supply of following items. The copy of the specifications (non-transferable) can be had from the office of the undersigned by remitting rupees as indicated against each item either by cash or by M.O. or by crossed Indian Postal Order in favour of the Accounts Officer, A. P. State Electricity Board, Hyderabad. The tenders will be received up to 2.30 p.m. and will be opened at 3.00 p.m. on the dates as indicated hereunder.

Sl. No.	*Specification No.*	*Particulars*	*Date of opening*	*Earnest money*	*Cost of specifications (or tender)*
1.	AP-661	110 KVA and 25 KVA 11/.433 KV distribution transformers	5-8-75	Rs. 100	Rs. 5
2.	AP-662	500 KVA and 250 KVA 11/.443 KV distribution transformers	12-8-75	Rs. 75	Rs. 5

Purchase of specifications is essential for the tenderers. The tender received without earnest money will not be considered. Earnest money shall be retained pertaining to the supplier furnishing lowest rates and it (*i.e.*, earnest money) shall automatically stand converted into Security Deposit. For other suppliers, the earnest money shall be refunded.

Chief Engineer

Fig. 23.4 Open Tender.

Earnest Money

Earnest money is demanded from the supplier who quotes the tender so that later on he does not back out from the rates he quotes for supplying the material or goods.

Security Deposit

After selecting the supplier to whom to give the tender, either on the basis of lowest rates quoted by him or otherwise, he is asked to make a security deposit so that in case the supplier fails to furnish the goods properly and in time, the security deposit can be forfeited.

23.5. QUANTITY AND QUALITY STANDARDS

23.5.1. Quantity Standards

- There are four important QUANTITY STANDARDS, namely
  - (*i*) Maximum inventory,
  - (*ii*) Minimum inventory,
  - (*iii*) Standard order, and
  - (*iv*) Reorder point.
- These quantity standards have been shown in Fig. 24.1 and explained in section 24.7.

23.5.2. Quality Standards

Quality. In the purchasing context, QUALITY refers to the suitability of a commodity for its intended use.

Therefore, in purchasing, the best is not necessarily the highest quality; the best quality can be even a lower quality.

Quality Standard. A quality standard is the description of an acceptable level of quality of a particular item.

Quality standards establish the quality objectives (of a commodity) to be measured or evaluated.

- In the past three decades, industry has seen a tremendous advance in the preciseness of its quality standards; quality has changed from a generic art to a specific science with definite quality standards and instruments to measure and compare the characteristics of a product against the quality standards set.

- The necessary *quality standards* for a particular product are stated on the drawing in terms of dimensional tolerances or written into the test *Specifications*.

The manufacturing department then makes products as per these standards and the inspection division inspects the products to the same standards.

- *Drawings* show the shape and the exact dimensions and the tolerances permitted on the product whereas *Specifications* describe such characteristics as colour, chemical composition, mechanical properties (*i.e.*, tensile strength, hardness), kind of raw material etc.
- Specifications can be in the form of,
  - (*a*) *Dimensional and material specifications.* They must consist of a list of physical or chemical properties desired in the product. Raw materials, oils and paints are specified this way.
  - (*b*) *Performance specifications.* They indicate the performance or use of the purchased item, for example, a component may be specified as capable of bearing a reverse bend at 100°C temperature.
  - (*c*) *Blue prints.* Blue print is the most precise and probably the most accurate of all types of descriptions and it finds applications where close tolerances or a high degree to mechanical perfection is desired.
- Both drawings and specifications describe what the product should be like after it has been made.

Quality standards are dictated by the following requirements

(*i*) The efficiency with which the product can perform its function.

(*ii*) The cost and the estimated life of the product.

(*iii*) The quality of interchangeability and the ease of making assembly.

(*iv*) Appearance and FEEL of the production in use.

23.6. ORDERING OF MATERIAL OR THE PURCHASING PROCEDURE

23.6.1. Steps Involved in One Complete Purchasing Cycle

(*i*) Recognition of need, receipt and analysis of purchase requisition.

(*ii*)Selection of possible potential sources of supply.

(*iii*) Making request for quotation.

(*iv*) Receipt and analysis of quotations.

(*v*) Selection of right source of supply.

(*vi*) Issuing the purchase order.

(*vii*) Follow-up and expediting the order.

(*viii*) Analysing receiving reports and processing discrepancies and rejections.

(*ix*) Checking and approving vendor's invoices for payment.

(*x*) Closing completed orders.

(*xi*) Maintenance of records and files.

These different subdivisions of the purchasing procedure will be briefly discussed below :

1. Recognition of need, receipt and analysis of purchase requisition

- Whenever a department needs an item, it is officially brought to the notice of the purchasing department. For this purpose two procedures are followed :
  - (*i*) One involves the issuance of requisition by the using department or the stores department,
  - (*ii*) The other involves the issuance of a bill of materials.

- A purchase requisition (Fig. 23.5) forms the basis for action by the purchasing department. A purchase requisition contains the following data
  - (*i*) What material is required and of what quality ?
  - (*ii*) Quantity of material to be purchased.
  - (*iii*) Date by which the material is required.
  - (*iv*) Place at which the material should be delivered.
- Purchase requisition is prepared in duplicate and is signed by authorized individuals only.
- Purchase requisition is usually routed through the stores department in order to check whether the item is available in stores.

Requisition No.....

Date.....

Please order the under-mentioned for delivery on or before .....to...

Quantity	*Description*	*Code No.*	*Requisition for*	*Unit price*
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....

Quantity in stock.....

Maximum stock.....

Minimum stock.....

.....

Storekeeper

Order No.....

For use by Purchasing Department — Checked by.....

approved by....

Fig. 23.5. Purchase Requisition.

- A bill of material is used when standard parts and small expendable tools are to be purchased. The buyer works out total material requirements from the bill of material, goes through the list of existing inventories and finally decides the net materials to be purchased.

(*ii*) Selection of possible potential sources of supply

- This process consists of selecting a fair number of vendors in accordance with established guidelines, from whom quotations will be requested.
- For items which are purchased frequently, the buyer usually has a few preferred suppliers from whom he purchases regularly.
- For purchasing new items, reference may be made to one or more of the following from which information may be obtained.
  - (*a*) Catalogues,
  - (*b*) Trade journals,
  - (*c*) Advertisements,

(*d*) Trade exhibitions and fairs, and

(*e*) Trade directories (classified).

– When considering a potential source of supply, the buyer should consider,

(1) whether to purchase from local market or farther afield ;

(2) whether to buy from a single vendor or from several vendors at a time ; and

(3) whether to purchase directly from manufacturers or through wholesalers.

(*iii*) Making request for quotations

– Request for quotations is made on prescribed quotation form (refer Fig.23.2) to all the selected (possible) sources of supply.

– The request is not a purchase order, rather it is merely an enquiry to know whether the vendor can supply the desired material by the specified date and if so, then at what rate.

– Quotation form has printed on it the terms and conditions under which the buyer would like to purchase the material.

(*iv*) Receipt and analysis of quotations

– After receiving a number of quotations from different suppliers, they are studied and a *comparative statement* (refer to Fig. 23.3) of rates and other terms and conditions mentioned in the quotations is prepared.

(*v*) Selection of right source of supply

– The comparative statement as prepared in step (*iv*) above serves a good guide in selecting the right source of supply.

– Other questions which might also be given a thought are,

1. Will vendor maintain quality ?
2. Will vendor supply material in time ?
3. Does the vendor have adequate facilities to handle the contract ?
4. How far the vendor's plant is situated ? etc.

(*vi*) Issuing the purchase order

– After selecting the right supplier, a purchase order (Fig. 23.6) is dispatched to him. The purchase order constitutes a legal document and it serves as the vendor's authority to ship the materials and bill the company.

– A purchase order once accepted by the vendor constitutes a contract for the delivery of the articles in accordance with the terms of purchase agreement.

– The purchase order is executed in six copies.

1. Two copies go to the supplier, one he preserves, other he signs and returns.
2. One copy goes to accounts section.
3. One copy goes to purchase service to follow-up the order.
4. One copy is sent to receiving department.
5. The last copy is kept in the files of the purchasing department.

(*vii*) Follow-up and expediting the order

– After placing the order, the purchase service section maintains contact with the vendor in order to,

1. Obtain information as to the progress of the order ;
2. ensure that delivery dates will be met ; and to
3. take corrective actions (such as transferring some of the orders to some other supplier, change the mode of shipment, *i.e.*, from rail road to air service etc.,) so that the materials can reach the plant as originally planned.

PURCHASE ORDER

ABC HARDWARE COMPANY

6, Harrison Road

CALCUTTA

Order No.....

To

.....

.....

.....

Please enter our order for the following materials or services and note instructions given below.

Manager
Purchasing Department

Item No.	*Quantity*	*Description*	*Price*	
			Each	*Total*

1. Number of this order must appear on your invoice.
2. Please return attached acknowledgement of this order and state the delivery date.
3. Mail invoices, etc., on date of shipment.
4. Only, invoices covered by a signed purchase order will be processed.
5. Packing slip must accompany each shipment.
6. All materials shall be received subject to buyer's inspection and rejection.
7. An order may be cancelled if not fulfilled within a reasonable time.

Fig. 23.6. Purchase Order.

- Specially designed postcards containing the following information are frequently employed for routine follow-up.
  1. Purchase order Number.
  2. Pre-decided delivery date.
  3. Promising shipment date , etc.

(*viii*) Analysing receiving reports and processing discrepancies and rejections

- Receiving reports are the records of what has been actually received.
- Receiving reports are compared with the purchase order in order to find discrepancies, *i.e.*, variations in quantity, etc., if any.
- Discrepancies found if any during inspection as regards the quantity or quality of the received material should be promptly brought to the notice of the supplier.
- Before returning the material rejected during inspection at his end, it is necessary for the buyer to get the vendor's authorization for return and replacement.

(*ix*) **Checking and approving vendor's invoices for payment**

– Invoices should be checked to ensure that :

1. the correct material (in quality and quantity) has been supplied ;
2. the material has been supplied at agreed prices ; and
3. agreed discounts have been given.

After confirming the above, the payment is made to the vendor for the (value of) goods received.

(*x*) **Closing completed orders**

– Before closing the completed orders, the file copy of the purchase order must be checked against both the receiving reports and the vendor's invoice and a notation of this fact should be made on it. It should then be removed and stored in the file of closed orders.

(*xi*) **Maintenance of records and files**

The final step in the purchasing procedure consists of filing the records of the transaction.

23.7. ACCOUNTING

– All purchase transactions initiate a chain of accounting transactions taking from charging the transaction to the proper account to the final payment of the bill.

– Basically, the checking of invoices is an accounting procedure which can be handled efficiently by the accounting department but unluckily when accounting department does so, it becomes a mere clerical routine procedure. Checking of invoices involves technical features also such as its (*i.e.*, invoice's) compliance with the description and specifications contained on the purchase order.

– For this reason and since large company funds and significant discounts are involved in accounting tasks, there should be close coordination between purchasing and accounting departments.

23.8. STORES AND MATERIAL CONTROL

23.8.1. Introduction

– Materials and supplies constitute the most important assets in the majority of business enterprises. The success of the business, besides other factors, depends to a large extent on the efficient storage and material control.

– Material pilferage, deterioration of material and careless handling of stores lead to reduced profits.

– Even losses can be incurred by concerns in which the store-room is available to all employees without check as to the quantities and purpose for which materials are to be used.

23.8.2. Requirements of a Material Control System

1. Proper coordination of departments such purchase, receiving, testing, storage, accounting, etc.
2. Making economy in purchase and use of materials.
3. Operating an internal check to verify all transactions involving materials, supplies, equipments, etc.
4. Storing materials and supplies properly in a safe place.
5. Operating a system of perpetual inventory to find at any time the amount and value of each kind of material in stock.
6. Setting of quantity standards.
7. Operating a system to see that right material is available to a department at the time of its need.
8. Keeping proper records of all material transactions.

23.8.3. Stores Management

– Stores management takes care,

1. that the required material is never out of stock ;
2. that no material is available in (much) excess than required ;
3. to purchase materials on the principle of economic order quantity (refer chapter 24) so that the associated costs can be minimized ; and
4. to protect stores against damage, theft, etc.

– This can be achieved through

1. A proper purchasing practice (*i.e.* when to order materials).
2. An adequate procedure of receipt and issue of materials.
3. Proper methods of storing materials.
4. An effective system of physical control of materials.
5. A proper method of keeping store records.

23.8.4. Functions of Stores Department and the Duties of the Storekeeper

1. To receive materials, goods and equipments, and to check them for identification.

2. To receive parts and components which have been processed in the factory.

3. To record the receipt of goods.

4. To correct positioning of all materials and supplies in the store.

5. To maintain stocks safely and in good and condition by taking all precautions to ensure that they do not suffer from damage, pilfering or deterioration.

6. To issue items to the users only on the receipt of authorised stores requisitions.

7. To record and update receipts and issues of materials.

8. To check the bin card balances with the physical quantities in the bins.

9. To make sure that stores are kept clean and in good order.

10. To prevent unauthorized persons from entering the stores.

11. To make sure that materials are issued promptly to the users.

12. To plan store for optimum utilisation of the cubic space (*i.e* length, breadth and height).

13. To ensure that the required materials are located easily.

14. To initiate purchasing cycle at the appropriate time so that the materials required are never out of stock.

15. To coordinate and cooperate to the full extent with the purchasing, manufacturing, inspection and production planning and control departments.

23.8.5. LOCATION AND LAYOUT OF STORES

23.8.5.1. Location

1. Location of the stores should be carefully decided and planned so as to ensure maximum efficiency.

2. The best location of stores is one that minimizes total handling costs and other costs related to stores operation and at the same time provides the needed protection for stored items and materials.

3. Store location depends upon the nature and value of the items to be stored and the frequency with which the items are received and issued.

4. In general, stores are located close to the points of use.

Raw materials are stored near the first operation, in-process materials close to the next operation, finished goods near the shipping area and tools and supplies in a location central to the personnel and equipment served.

5. All departments should have easy access to the stores and especially those which require heavy and bulky materials should have stores located nearby.

6. In big industries having many departments, stores department possibly cannot be situated where it is convenient to deliver materials to all departments and at the same time be near the receiving department ; thus it becomes often necessary to set up substores conveniently situated to serve different departments.

This leads to the concept of decentralized stores.

7. In *decentralized* stores system, each section of the industry (*e.g.*, foundry, machine shop, forging, etc.) has separate store attached with it ; whereas in centralised stores system, the main store located centrally fulfills the needs for each and every department.

– **Advantages of centralisation of stores**

(*i*) Better supervision and control.

(*ii*) It requires less personnel to manage and thus involves reduced related costs.

(*iii*) Better lay out of stores.

(*iv*) Inventory checks facilitated.

(*v*) Optimum (minimum) stores can be maintained.

(*vi*) Fewer obsolete items.

(*vii*) Better security arrangements can be made.

– **Advantages of decentralisation of stores**

(*i*) Reduced material handling and the associated cost.

(*ii*) Convenient for every department to draw materials, etc.

(*iii*) Less risk of loss by fire or theft.

(*iv*) Less chances of production stoppages owing to easy and prompt availability of material, etc.

An idea about the disadvantages of centralised and decentralised stores can be had from the advantages of decentralised and centralised stores (as explained above) respectively.

23.8.5.2. Layout

1. A good stores layout practice is one which usually brings the point or origin, store-room and point of use in adjacent and proper sequence for best flow of material.

2. Stores layout should be planned with the following objectives,

(*i*) To achieve minimum wastage of space.
(*ii*) To achieve maximum ease of operating.

3. Before planning the stores layout

(*a*) Classify all store items as follows,
(*i*) By measurement (*i.e.*, size)
(*ii*) By quantities (*i.e.* No. and weight) to be stored.
(*iii*) By frequency of handling.
(*iv*) By (material) handling arrangements.
(*v*) By possibility of perishing the items and the susceptibility to damage.

(b) List the available storage space

(*i*) Platforms
(*ii*) Floor space
(*v*) Bins
(*vi*) Trays

(*iii*) Racks (*vii*) Drums

(*iv*) Shelves (*viii*) Barrels

(*c*) *Determine the sequence of laying out storage space for locating the materials*

(*i*) *A Unit.* It is the smallest space for storage which is given a particular identity.

(*ii*) *A Tier.* A Tier consists of a number of units placed vertically.

(*iii*) *A Row.* A row consists of a number of units joined together and spread horizontally.

(*iv*) *A section.* A section is made up of a group of rows.

(*d*) Study the size and shape of the space available for laying out the stores.

4. *The following factors should be considered while planning the stores layout* ;

(*a*) A section adjacent to the store-room should be kept reserved for the receipt of materials and for its inspection before storage.

(*b*) Store layout should be such that it provides for easy receipt, storage and disbursement of materials, preferably, nearest to the point of use.

(*c*) Store-room layout should minimise handling and transportation of materials.

(*d*) An ideal store-room layout makes optimum utilisation of the floor space and height.

(*e*) Shelves, racks, bins, etc., should be situated in clearly defined lanes, so that items are quickly stored and located for physical counting or issuing.

(*f*) Main lanes or aisles should usually be between 1.5 and 3 metres wide, depending upon the type of material and the amount of traffic involved.

Sub-aisles between racks and bins may be a minimum of 80 cm wide.

(*g*) Storage spaces should be clearly marked to ensure easy and quick identification.

(*h*) Storage space should be adequately protected against waste, damage, deterioration and pilferage.

(*i*) A place for storing a material should be decided depending upon the material characteristics, *e.g.* fuels and flammable gases will require separate locations, cement, welding electrodes and ferrous parts need a dry place for storing, etc.

– Portable and salable items should be stored in areas enclosed with wire-mesh partitioning so that all unauthorized persons can be kept outside that area.

(*j*) Store layout should be such that for its efficient operation it can make use of modern material handling equipments such as fork-lift coveyors, etc.

(*k*) Store layout should be such that the storekeeper is not compelled to put newly arrived material on the top of the old. As a rule, all the old stock should be consumed first before using the new one.

(*l*) Due space (20 to 25%) should be left in each portion of the store to allow for expansion.

(*m*) Figs 23.7 (a) and 23.7 (b) show a poor and a good layout of storage space.

23.9. RECEIPT AND ISSUE OF MATERIALS

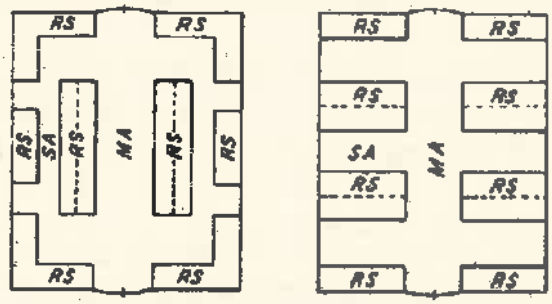
23.9.1. Receipt of Materials

– All materials from outside sources are received by the Receiving Department.

– The receiving department unpacks the goods received and checks quantities and conditions (of the goods).

– There is a packing slip inside each package that tells what it is supposed to be and usually it gives the purchase order number.

– A copy of the purchase order (Fig. 23.6) if it exists with the receiving department, can be made use of to check the items received.



MA-Main aisle
SA-Side aisle
RS-Racks, shelves, platforms, etc.

Fig. 23.7. Storage space layout.

[N.B. For more information, refer to section 4.12]

– Otherwise, a *Materials Received Report* (Fig. 23.8) is prepared by the receiving department and is sent either to the purchase or to the accounting department to get the same checked against the purchase order.

MATERIALS RECEIVED REPORT

Received : Purchase Order No.....
At.....
Delivery point
From..... .....
Vendor Address
Date.....

Quantity received	*Description*	*Grade*	*Condition of goods*

Counted by .....
Inspected by .....
Approved by .....
Title .....

Fig. 23.8. Materials Received Report.

– All the items after they have been received and before they are removed from the receiving department are *inspected and* sample tested to ensure that the purchase order specifications have been met.

– Results of the inspection and tests are indicated in special testing report, upon the basis of which *Clearance Report or Rejection Note* (Fig. 23.9) is prepared and sent by the inspection department to

(*a*) Purchase department,
(*b*) Production department, and
(*c*) Accounting department.

– In case of rejection, a part or whole of the consignment may be returned to the vendor, with a request either for a complete cancellation of the order or for replacement.

CLEARANCE REPORT
REJECTION NOTE

No.....
Date.....

Order No.....
Material .....
Supplier .....

THE ABOVE-MENTIONED MATERIALS
HAVE BEEN PASSED / REJECTED THROUGH INSPECTION

Details of examination :
.....
.....
.....

Reasons for rejections
.....
.....
.....

(Signed).....
Inspection Department

Goods received by
.....
(Storekeeper)

Fig. 23.9. A clearance report-cum-rejection note.

23.9.2. Issue of Materials

– Materials should be issued by the storekeeper to different departments, only upon receipt of a properly authorized withdrawal form-usually called a Material Issue Requisition form (Fig. 23.10).

MATERIAL REQUISITION

No.....

Material required for.....
(Job or Process)

Department.....

Date.....

Sr. No.	*Description*	*Code No.*	*Quantity*		*Rate*	*Amount*	*Entered on store register page No.*
			Demanded	*Supplied*			

Requisitioned by ..... Approved by ..... Material issued by ..... Received by .....

Fig. 23.10. Material issue Requisition form.

– Material requisition is prepared in duplicate by the foreman or the manager depending upon the nature and amount of materials or goods to be withdrawn from the stores.

– Both the copies are sent to the storekeeper who issues the materials and records the quantities disbursed.

- Both the copies are then forwarded to material accounting division for pricing and entry in the stock ledger.
- One copy of the material requisition is retained by the stock ledger clerk to be used as the basis for an entry in the Issued section of the stock ledger accounts. The balance section of the stock ledger accounts is then completed to show the new balance figures for quantity, cost, etc.
- The second copy goes to the foreman of the department who uses it as the basis for a charge to the appropriate production order for which he prepared the material requisition.

23.10. STORE RECORDS

- Two records are usually kept of materials and other goods received, issued or transferred– namely on *BIN (or STOCK) CARDS* and in the *STORE LEDGER.*
- Bin cards are written and kept in the stores, whereas store ledger is sometimes maintained by stores office or cost department.

This minimises the clerical work of the storekeeper and store ledger, *i.e.* stores accounting records are kept cleaner and accurate by an experienced personnel in the stores office or cost department.

23.10.1. Bin Cards

- In a store room, materials and other items are kept in appropriate bins, drawers or other receptacles ; some items are stacked, while others are racked.
- For each kind of material, a separate record is kept on a *BIN CARD* or *STOCK CARD* which shows details of quantities of each type of material received, issued and on hand each day. The storekeeper maintains bin cards up-to-date.
- Bin card is attached to each bin or shelf.
- A bin card is not considered as an accounting record ; it simply informs store-keeper of the quantities of each item on hand.

  Bin cards may be made in duplicate ; one card is attached to the bin (containing the material) and the second remains with the storekeeper on his table for ready reference to the quantity of any materials on hand.
- A bin card is used as a check on the stock ledger accounts in the material accounting division.
- Besides the details of the issue and receipt of materials, a bin card may contain the following information as well to increase it utility :
  - (*i*) The maximum and minimum quantity of each material to be carried out.
  - (*ii*) Normal quantity of each material to be ordered.
  - (*iii*) When certain materials or items require placing orders in advance, (*e.g.* when purchasing from some foreign country) an ordering level (between the maximum and minimum quantity) may be specified on the bin card so that the materials can be ordered and procured in time.
- Bin cards are checked periodically by the stores inspectors to see that they are accurately maintained. Discrepancies, if any, are noted.
- Fig. 23.11 shows a BIN (or STOCK) CARD.

23.10.2. Stores Ledger

- Store ledger is identical with bin card except that money values are shown.
- The ledger is usually of the loose-leaf or card type, each account representing an item of material in store.
- The store ledger accounts may be maintained by a separate material accounting department or in small concerns by the store-keeper himself.

BIN CARD

Bin No.....
Material.....
Code No.....
Stores Ledger Folio.....

Maximum Quantity.....
Ordering level.....
Minimum Quantity.....

Date	*Quantity Received*	*Quantity Issued*	*Balance*	*Remarks*

Fig. 23.11. BIN or STOCK CARD.

- Fig. 23. 12 shows a *Stores Ledger Account.*
- Entries in *ordered section* are made as a copy of purchase order is received from purchasing department.

STORES LEDGER ACCOUNT

Material..... Code..... Maximum Quantity.....
Bin No..... Folio..... Minimum Quantity.....

	ORDERED				*RECEIVED*					*ISSUED*						*BALANCE*		
Sl. No.	*Date*	*P.O. No.*	*Q*	*D.E.*	*Date*	*P.O. No.*	*Q*	*Unit cost*	*Total cost*	*Date*	*R No.*	*Dept*	*Q*	*Unit cost*	*Total cost*	*Q*	*Unit cost*	*Total cost*

P.O. No. - Purchase order No.
Q - Quantity
D.E. - Date expected
R. No. - Requisition No.

Fig. 23.12. Stores Ledger Account.

- After the material has been received and checked, the entries are made in the *Received section* from the invoice or the receiving department report.
- Entries are made in the Issued section from material requisitions received from store keepers for materials issued to different departments.

23.11. CODIFICATION OF MATERIALS

(Note : Refer to section 5.10.2 also)

- The use of material specification code numbers is an advantage, not only to the purchase department and drawing office, but also to the pricing clerk in the cost department, in that ambiguity is eliminated.
- Each material or item in the stores should be clearly identified so that the same can be easily located at the time of need. This is achieved by allocating CODE numbers.
- The code should be meaningful and impart a unique identity to each material.

If a material is described by its trade name, as well as by a serial number and also by its function, it is quite likely that different quantities of the same material might be located at three different places in the same store. This increases size of the inventory and creates an unnecessary confusion. Codification of materials removes this difficulty and avoids duplication of materials.

- A code consists of a combination of letters and numbers. The objective is to progress from general to particular.

Examples of material codes

(*a*) – B.S. 609 means Brass Screw 6 mm x 9 mm

– S.S. 815 means Steel Screw 8 mm x 15 mm

(*b*) Another code may be made up as follows :

Class	1* * *	– * * Primary material
Sub-class	* 1 * *	– * * Iron and carbon steel
Group	* * 6 *	– * *Bar
Series	* * * 4	– * * Mild Steel
	* * * *	– 8*8 mm diameter
	* * * *	– * B Bright (bar)

Thus 1164-8B implies a bright mild steel bar 8 mm diameter.

(*c*) ACC/TA/6–implies air-conditioner compressor, top assembly part number 6.

23.12. PHYSICAL VERIFICATION OF STORES (OR STOCK TAKING)

(A) Necessity of :

Physical verification of stores is essential in order to :

(*i*) ensure the correctness of stocks held by comparing them with the balance shown in the store ledger or bin cards ;

(*ii*) avoid shortages of materials in the stock ;

(*iii*) check losses in inventory due to

- pilferage ;
- improper storage or misplacement ;
- deterioration, etc.

(*iv*) correct and update store-records ;

(*v*) calculate the values of stock carried for the balance sheet and profit and loss account ;

(*vi*) calculate the rate of turn-over of an item ;

(*vii*) ensure maximum economy in stock carrying ;

(*viii*) effect insurance covers.

(B) Disadvantages of Physical stock taking

(*i*) Loss in production ; unless and until during period of physical stock taking, plant overhaul etc. is planned.

(*ii*) Labour and over-time expenses in carrying out stock taking (in order to complete it in a shorter duration of time).

Disadvantages of physical stock taking are minor as compared to the advantages achieved through it.

(C) Methods of physical stock taking

1. Annual Physical verification.

2. Perpetual Inventory and Continuous Stock Taking system.

1. Annual Physical Verification

(*i*) Near the year end, stores are closed for a few days ; no material, etc. is issued to any shop in the plant. In case this leads to plant shut down, activities such as repair and overhaul of equipment and machinery are resorted to.

(*ii*) A team of stores inspectors or stores verifying officers physically check and count each and every item laying in the complete store. They tally it with the quantities marked on bin cards and store ledgers.

(*iii*) Step (*ii*) above leads to the formation of a list of surplus and short items.

Damaged and obsolete items can also be traced and recorded.

(*iv*) Inspectors check a number of item everyday as per a preplanned schedule and finish the complete work within a few days.

(*v*) This method of stock taking is advantageous in the sense that all the items are checked at one time, so there is no confusion about any item being left unchecked.

Moreover, this method helps recording discrepant items at one time and at one place.

2. Perpetual Inventory and continuous Stock Taking system

(*i*) Annual Physical verification method may work well for a small plant involving a limited number of store items, because it is not economical to shut down a large plant involving huge inventory quantities for a number of days.

(*ii*) A more appropriate method for large plants is—the Perpetual Inventory and Continuous Stock Taking System which records store balances after every receipt and issue and facilitates regular checking and obviates closing down of the plant for stock taking.

(*iii*) Under this system, store items are checked continuously throughout the year ; a number of items are counted daily or at frequent intervals and checked (compared) with the bin cards and stores ledger.

(*iv*) Discrepancies found if any, owing to incorrect entries, breakage, pilferage, over-issue, placing of items in wrong bin, etc., are investigated and corrected accordingly.

(*v*) Every item of the store is checked atleast once or twice a year.

(*vi*) To reduce the work load, an item is checked generally when it reaches its minimum level.

Advantages. The perpetual inventory and continuous stock taking system claims the following advantages :

1. It is not necessary to close down the plant or stop production for stock taking.

2. Since, only a few items are to be checked every day, as compared to annual physical verification,

this method is less costly, less tiring, less cumbersome and hence is more accurate.

3. Discrepancies and incipient defects in the stores system are readily discovered and can be rectified before much damage through loss or irregular practices has occurred.

4. Slow moving stocks can be noted and, where necessary, action may be taken to prevent their accumulation.

5. The audit extends to comparing the actual stock with the maximum and minimum level and thus ensures that stocks are kept within the limits specified.

6. Since, stock is kept within the specified limits, the capital invested in the store-items cannot exceed the amount arranged and prescribed for the same.

24

Inventory Control and Management

24.1. INVENTORY

Inventory is a detailed list of those movable items which are necessary to manufacture a product and to maintain the equipment and machinery in good working order. The quantity and the value of every item is also mentioned in the list.

Inventory is actually 'money' kept in the store room in the shape of a high speed steel bit, a mild steel rod, milling cutters or welding electrodes.

24.2. INVENTORY CONTROL

- Inventory control is concerned with achieving an optimum balance between two competing objectives. The objectives are :
  - (*i*) to minimize investment in inventory,
  - (*ii*) to maximize the service levels to the firm's customers and its own operating departments.
- Inventory control may be defined as the scientific method of finding out how much stock should be maintained in order to meet the production demands and be able to provide right type of material at right time in the right quantities and at competitive prices.

24.3. INVENTORY CLASSIFICATION

Inventory may be classifed as follows :

(i) Raw inventories. They include, raw material and semifinished products supplied by another firm and which are raw items for the present industry.

(ii) In-process inventories. They are semi-finished goods at various stages of manufacturing cycle.

(iii) Finished inventories. They are the finished goods lying in stock rooms and waiting dispatch.

(iv) Indirect inventories. They include lubricants and other items (like spare parts) needed for proper operation, repair and maintenance during manufacturing cycle.

24.4. INVENTORY MANAGEMENT

- To manage these various kinds of inventories two alternative control procedures can be used

(i) Order point system

- This has been the traditional approach to inventory control. In this system, the items are restocked when the inventory levels become low.
- Lot size and reorder point calculations are the more spectacular aspect of *inventory management*. Once the calculations are complete, the routing commences for checking deliveries and physical countpf the amount on hand.

(2) Materials Requirments Planning (MRP)

- MRP is sometimes thought of as an inventory control procedure. It is really more than that.
- MRP is the technique used to plan and control manufacturing inventories.
- MRP is a computational technique that converts the master schedule for end products into a detailed schedule for the raw material and components used in the end products.

The detailed schedule identifies the quantities of each raw material and component item. It also tells when each item must be ordered and delivered so as to meet the master schedule for the final products.

It is important that the proper *control procedure* be applied to each of the four types of inventory as explained earlier.

In general, *MRP* is appropriate control procedure for inventory type (*i*) and (*ii*) (*i.e.* raw materials, purchased components and in-process inventory).

Order point systems are often considered as the appropriate procedure to control inventory types (*iii*) and (*iv*) (*i.e.* finished goods, maintenance and repair parts, cutting tools and fixtures, plumbing supplies etc.).

24.5. INVENTORY CONTROL, ITS OBJECTIVES AND HOW TO ACHIEVE THEM

Inventory control aims at keeping track of inventories. In other words, inventories of required quality and in desired quantities should be made available to different departments as and when they need. This is achieved by,

(*a*) Purchasing material at an economical price, at proper time and in sufficient quantities so as not to run short of them at any instant.

(*b*) Providing a suitable and secure storage location.

(*c*) Providing enough storage space.

(*d*) A definite inventory identification system.

(*e*) Adequate and responsible store room staff.

(*f*) Suitable requisition procedure.

(*g*) Up-to-date and accurate record keeping.

(*h*) Periodic inventory check up.

(*i*) Division of inventory under *A*, *B* and *C* items, exercising the control accordingly and removing obsolete inventroy.

A good control over the inventories offers the following Advantages

(*a*) One does not face shortage of materials.

(*b*) Materials of good quality and procured in time minimises defects in finished goods.

(*c*) Delays in production schedules are avoided.

(*d*) Production targets are achieved.

(*e*) Accurate delivery dates can be ascertained and the industry builds up reputation and better relations with customers.

24.6. FUNCTIONS OF INVENTORIES

Inventories

1. Separate different operations from one another and make them independent, so that each operation (starting from raw material to finished product) can be performed economically. For example, ordering of raw material can be carried out independently of the finished goods distribution and both of these operations can be made low cost operations say by ordering raw material and distributing finished goods in one big lot, than in small batch sizes. Besides economy, the men and machinery also can be better utilized if the operations are separated and carried out in various departments than if coupled and tied at one place.

2. Maintain smooth and efficient production flow.

3. Purchase in desired quantities and thus nullify the effects of changes in prices or supply.

4. Keep a process continually operating.

5. Create motivational effect. A person may be tempted to purchase more if inventories are displayed in bulk.

24.7. ECONOMIC ORDER QUANTITY

Concept. A problem which always remains is that how much material may be ordered at a time. An industry making bolts will definitely like to know the length of steel bars to be purchased at any one time. This length of steel bars is called "Economic Order Quantity" and an economic order quantity is one which permits lowest cost per unit and is most advantageous.

Before calculating economic order quantity it is necessary to become familiar with terms like maximum inventory, minimum inventory, standard order and reorder point, which are known as *Quantity Standards*. Figure 24.1 shows different quantity standards.

Starting from an instant when inventory OA is in the stores, it (inventory) consumes gradually in quantity from A along AD at a uniform rate. It is preknown that it takes L number of days between initiating order and receiving the required inventory. Therefore as the quantity reaches point B, purchase requisition is initiated which takes from B to C, that is time R. From C to D is the inventory procurement time P. At the point D when only reserve stock is left, the ordered material is supposed to reach and again the total quantity shoots to its maximum value, *i.e.* the point $A'(A=A')$.

Maximum Quantity OA is the upper or maximum limit to which the inventory can be kept in the stores at any time.

Minimum Quantity OE is the lower or minimum limit of the inventory which must be kept in the stores at any time.

The purpose should be to hold enough and not excessive stock of material. *Stock holding:*

(*a*) Avoids running out of stock.

(*b*) Helps creating a buffer stock which may be utilized if the material falls below the minimum level.

(*c*) Makes sure the predecided delivery dates.

(*d*) Provides quick availability of materials.

(*e*) Takes care of price fluctuations and shortage of inventory in the market.

(*f*) Advises regarding, obsolete and slow moving items.

(*g*) Helps in standardization and thus reducing the variety of items to be handled.

Standard Order. ($A'D$) is the difference between maximum and minimum quantity and it is known as economical purchase inventory size.

Reorder Point (B) indicates that it is high time to initiate a purchase order and if not done so the inventory may exhaust, and even reserve stock utilized before the new material arrives.

From B^1 to D^1 it is *as lead time* (L) and it may be calculated on the basis of past experience. It includes :

(*a*) time to prepare purchase requisition and placing the order ;

(*b*) time taken to deliver purchase order to the seller;

(*c*) time for seller (vendor) to get or prepare inventory; and

(*d*) time for the inventory to be dispatched from the ventor's end and to reach the customer.

Time, (*a*) above is known as requisition time (R) and (*b*) + (*c*) + (*d*) is the procurement time (P).

The economic lot size for an order or the economic order quantity depends upon two types of costs :

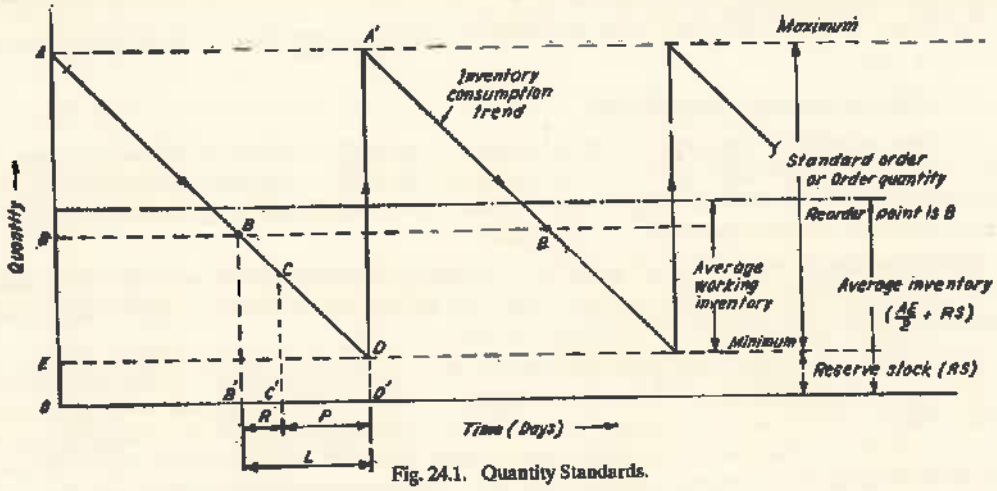


Fig. 24.1. Quantity Standards.

(*a*) *Inventory procurement costs, which consist of expenditure connected with*

1. receiving quotations;
2. processing purchase requisition;
3. following up and expediting purchase order;
4. receiving material and then inspecting it; and
5. processing seller's (vendor's) invoice.

Procurement costs decrease as the order quantity increases (see Fig. 24.2)

(*b*) Carrying costs, which vary with quantity ordered, base on average inventory and consist of :

1. interest on capital investment;
2. cost of storage facility, up-keep of material, record keeping etc ;
3. cost involving deterioration and obsolescence ; and
4. cost of insurance, property tax, etc.

Carrying costs are almost directly proportional to the order size or lot size or order quantity,

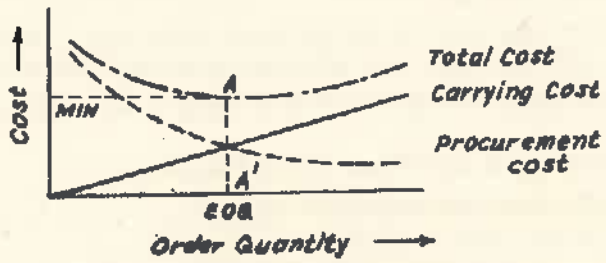


Fig. 24.2. Relationship between cost and quantity

In Fig. 24.2 the procurement costs and inventory carrying costs have been plotted with respect to quantity in lot. Total cost is calculated by adding procurement cost and carrying cost. Total cost is minimum at the point *A* and thus *A'* represents the economic order quantity or economic lot size.

Another method of finding *E.O.Q.* that is by mathematical means, is given below :

Let Q is the economic lot size or *E.O.Q.*

C is the cost for one item.

I is the cost of carrying inventory in percentage per period, including insurance, obsolescence, taxes etc.

P is the procurement cost associated with one order.

and U is total quantity used per period say annually.

Number of purchase orders to be furnished

$$= \frac{\text{Total quantity}}{E.O.Q.} = \frac{U}{Q}$$

Total procurement cost = Number of purchase orders x cost involved in one purchase or procurement

$$= \frac{U}{Q} \times P \qquad ...(a)$$

Average annual inventroy $= Q/2$

Inventory carrying cost = Average inventory × cost per item × cost of carrying inventory in percent per period.

$$= \frac{Q}{2} \times C \times I \qquad ...(b)$$

Total cost, $T = (a) + (b)$

$$T = \frac{U \times P}{Q} + \frac{Q}{2} \times C \times I$$

$$T = U.P.Q^{-1} + \frac{Q}{2} \times C \times I$$

To minimize the total cost, differentiate T, *w.r.t.*, Q and put it equal to zero

$$\frac{dT}{dQ} = \frac{d}{dQ} \left(U.P.Q^{-1} + \frac{Q}{2} \times C \times I \right)$$

$$0 = -U.P.Q^{-2} + C.I/2 \text{ or } UP/Q^2 = C.I/2$$

$$Q^2 = 2U.P./C.I.$$

$$Q = \sqrt{\frac{2\,U.P.}{C.I.}} \qquad ...(i)$$

***Example 24.1** : Given that*

(*i*) Annual usage, U=60 units

(*ii*) procurement cost, P=Rs.15 per order

(*iii*) cost per piece, C=Rs. 100

(*iv*) cost of carrying inventory I, a percentage including expenditure on obsolescence, taxes, insurance, deterioration etc. = 10%. Calculate *E.O.Q.*

Solution :

$$Q = \sqrt{\frac{2\,U.P}{C.I}} \text{ ; substituting the values}$$

$$Q = \sqrt{\frac{2 \times 60 \times 15}{100 \times (10/100)}} = 13.41$$

Therefore, number of order per year = $\frac{60}{13.41}$ = 4.47 say 5.

Hence Q or E.O.Q = $\frac{60}{5}$ = 12 units (Ans.) (rounded)

The readers may try the following problems.

Problem : 24.1 : The rate of use of a particular raw material from stores is 20 units per year. The cost of placing and receiving an order is Rs. 40. The cost of each unit is Rs 100. The cost of carrying inventory in per cent per year is 0.16 and it depends upon the average stock. Determine the economic order quantity. If the lead time is 3 months, calculate the reorder point [**Ans.** 10, 5 units]

Problem : 24.2 : Find Economic Order Quantity from the following data :

Average annual demand	= 30,000 units
Inventory carrying cost	= 12% of the unit value per year
Cost of placing on order	= Rs. 70
Cost of unit	= Rs 2

[**Ans.** 4183,4286 (rounded figure)]

Problem : 24.3 : A factory uses two pieces per day of a rod 6 mm in diameter and 150 mm long in one of their manufacturing processes. The rod costs Rs. 3 each and the total expenses involved in purchasing and receiving them are Rs. 50 per order. The annual inventory carrying cost per item is Re. 1. The procurement period is 3 days and minimum stock kept is 8 pieces. Find out,

(*i*) Standard ordering quantity,
(*ii*) Reorder point, and
(*iii*) maximum stock,

[**Ans.** (*i*) 245,200 (rounded), (*ii*) 14, and (*iii*) 208]

24.8. INVENTORY MODELS

Concept

- Inventory models determine when and how much inventory to carry.
- Inventory models handle chiefly two decisions.
  (1) How much to order at one time, and
  (2) When to order this quantity to minimize total costs.
- Lowest-cost decision rules for inventory management pertain to either buying products from ouside or producing them within the company.
- *Simple inventory models* assume no delivery delay and that demand is known.
- *Probabilistic models* handle situations of risk and uncertainty.

Types of inventory models

(1) Simple EOQ model,
(2) EOQ model with stockouts allowed,
(3) Inventory models under risk.

(1) Simple EOQ model

- The simple EOQ model can be used if the demand is known with certainty.
- The demand and lead time are known.
- The item will be purchased from outside (the firm) and that demand will continue well into the future.
- It is also assumed that not only the demand is known with certainty, but that is the same from day to day and that stockouts, are not allowed. Under these assumptions, Fig 24.3 depicts the inventory position through time.

- If we start to observe the inventory position immediately after receipt of an order, the quantity in stock Q decreases steadily until a lead time's supply is reached. If *lead time* (L) is 5 days and demand is 4 (pieces) per day, a lead time's supply is 20 pieces or units. Therefore when 20 units remain in the store, an order is placed. This is called the *re-order point*. Exactly 5 days after the order is placed, the stock is replenished and the cycle repeats itself.

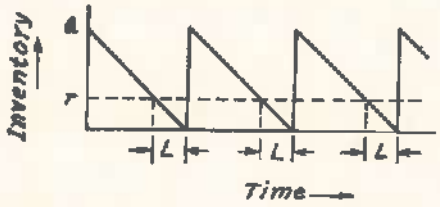


Fig. 24.3. Time pattern for inventory level for simple EOQ model.

- for further details refer article 24.7.

(2) EOQ Model with stockout allowed

- *Stockout* means runnning out of stock.
- In simple EOQ model, the stock was always available.
- The *out of stock* position will lead to a *back order*. This situation is frequently found in mailing-order houses where an item is temporarily out-of-stock and the customer is willing to wait until it is replenished.The firm does suffer some cost in this situation, since, at the very least, some expediting and extra communication (perhaps in the form of telephone calls or postcards) with the customer, must take place. In addition to the explicit costs, repeated backorders will certainly lead to an erosion of goodwill.

In some situations, backorders may be economically justified. For instance, with very high-value items such as commercial jet planes, no invetory is carried and a backorder state always exists.

- The second possible outcome of an out-of stock position is the *lost sales*. Here the cost is much more severe. In this case, the customer places an order, receives an out-of-stock response, and takes his business elsewhere. The company must take into account the likelihood that the customer will not return and that thererfore the profit on future sales might also be lost. In addition, the loss in goodwill that this will precipitate may also persuade others to purchase elsewhere.
- Since backorder and lost sales costs are hard to estimate, service levels are frequently specified. For exmaple, management may feel that stockouts should not occur more than 2% of the time.
- Fig 24.4 shows time pattern of inventory levels when stockouts are incurred.

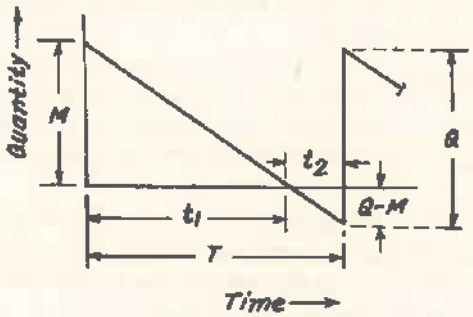


Fig. 24.4. EOQ Model with stokouts allowed.

In this case

$$Q = \sqrt{\frac{2UP}{CI}}\sqrt{\frac{CI+B}{B}} \quad \text{and } M = \frac{QB}{CI+B}$$

where Q is Economic order quantity

U is Annual use

P is Procurement cost per order

C is cost per piece

I is cost of carrying inventory, a percentage—including insurance, obsolescence, taxes etc.

B is cost incurred for every backorder

M is maximum inventory.

Example 24.2

Find Q and M from the following data :

U= 10,000 units, P= Rs. 100 per order, C = Rs. 10 per unit

B=Rs 15 per each backorder incurred, I = 20%

Solution

$$Q = \sqrt{\frac{2UP}{CI}}\sqrt{\frac{CI+B}{B}}$$

$$= \sqrt{\frac{2\times10{,}000\times100}{10\times\left(\frac{20}{100}\right)}}\sqrt{\frac{10\times\left(\frac{20}{100}\right)+15}{15}} = 1000\times1.064=1064 \text{ (Ans)}$$

$$M = \frac{QB}{CI+B} = \frac{1064\times15}{10\times\left(\frac{20}{100}\right)+15} = 938.82 \text{ (Ans)}$$

(3) Inventory model under risk

- In the simple EOQ model it was assumed that demand and lead time were both known with certainty. Under this condition, whenever inventory levels reached a lead time's worth of demand, an order was placed. Then as the stock was finally depleted, a replenishment order would arrive.
- We did find, however, that if backorders had a *finite* cost, a reorder level below the average lead time demand may be appropriate. This strategy would result in some desired number of backorders. We can, therefore, conclude that the purpose of reorder levels is not to prevent stockouts, but to keep them within desired limits.
- In the case of *fluctuating demand,* it may be quite logical to set reorder levels above the average lead time demand; for if we reorder when there is only enough in stock to meet the average demand during lead time, an out-of stock position will occur whenever demand exceeds this average value. To protect from undesirably large stockout situations, *safety stocks* (reserves) are maintained.

  They will provide the cushion needed whenever demand exceeds this average.
- Safety stocks (OS) can be defined as the difference between the reorder level and the average lead time demand (Fig. 24.5) Therefore as the reorder point is raised, the safety stock increases and the likelihood of a stockout during any cycle decreases.
- Fig. 24.5 shows the inventory pattern through time for a particular item which exhibits fluctuating demand.

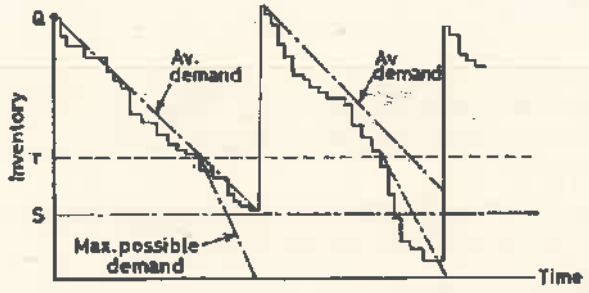


Fig 24.5. Inventory levels under conditions of fluctuating demand.

– An order is placed whenever stock levels fall to 'r'. On the average, stock will be depleted to 's' when the replenishment order arrives. During the first cycle we see that demand was about average; however in the second cycle (Fig. 24.5) the demand was much greater than average. Protecting the system from a stockout during the lead time, was a safety stock maintained at *S*. If more protection was desired, the level of 'r' could have been increased. With a higer 'r', the safety stock would have been larger and the chances of a stockout occurring in any one cycle would have been lower.

Table 24.1

Lead time demand, u	*p(u)*	*Probability that demand will exceed u*
43	0.00	1.00
44	0.02	0.98
45	0.03	0.95
46	0.04	0.91
48	0.09	0.74
50	0.10	0.54
52	0.10	0.33
54	0.08	0.16
56	0.05	0.04
58	0.01	0.00

– Table 24.1, was compiled from data collected over several periods.

When $p(u) = 0.02$, it implies that for 2% of these periods demand was 44, in 3% of them, demand was 45 and so on.

The last column in Table 24.1 illustrates the probability that demand will exceed any of these levels, *u*. For example, the probability that demand will exceed 56 units is 0.04. The last column will be very useful for setting safety stocks when a service criterion is given.

– In many cases, it might be quite difficult to determine the actual cost of a stockout. An indirect way to assess this is to specify a service level. For example, the manager of the product line whose lead time was recorded in Table 24.1 might feel that the likelihood of a stockout should not exceed 4% during any one cycle. Therefore, the reorder point should be set at $r = 56$. We would, therefore, expect an out-of-stock situation to occur in only one out of 25 ordering periods.

24.9. ABC ANALYSIS

24.9.1. Necessity

As the size of the industry increases, the number of items to be purchased and then to be taken care of also increases. Purchase and control of all items at a time and in bulk much before their use, irrespective of their usage value, price or procurement problems, blocks and involves a lot of money and man hours, and is therfore uneconomical.

ABC analysis helps segregating the items from one another and tells how much valued the item is and controlling it to what extent is in the interest of the organisation.

24.9.2. Procedural Steps

1. Identify all the items used in an industry.

2. List all the items as per their value.

3. Count the number of high valued, medium valued and low valued items.

4. Find the percentage of high, medium and low valued items. High valued items normally contribute for 70% or so of the total inventory cost and medium and low valued items, 20 and 10% respectively.

5. A graph can be plotted between percent of items (on *X*-axis) and per cent of total inventory cost (on *Y*-axis). Figure 24.6 shows such a graph.

It can be seen that 70% of the total inventory cost is against 10% of the total items (called *A*-items), 20% against 20% of the items (*B*-items) and 10% against a big bulk, *i.e.* 70% of the items (called *C*-items).

Thus *ABC* analysis furnishes the following information :

1. *A*-items are high valued but are limited or few in number. They need careful and close inventory control. Minimum and maximum limits, and reorder point is set for *A* items. Such items should be thought of in advance and purchased well in time. A detailed record of their receipt and issues should be kept, and proper handling and storage facilities should be provided for them.

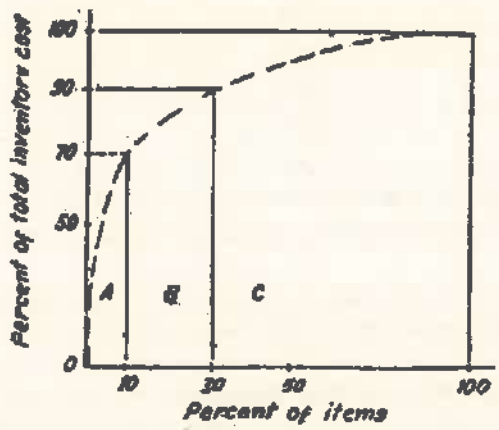


Fig. 24.6. ABC analysis.

Such items being costly are purchased in small quantities oftenly and just before their use. This of-course increases the procurement costs and involves a little risk of non-availability. However, the locked up inventory cost decreases and the problems of storage and care taking are minimized.

A-items generally account for 70-80% of the total inventory cost and they constitute about 10% of the total items.

2. *B*-items are medium valued and their number lies in between A and C-items. Such items need moderate control. They are more important than C-items. They are purchased on the basis of past requiements, a record of receipts and issues is kept and a procurement order is placed as soon as the quantity touches reorder point. These items being comparatively less costly, a safety stock of up to 3 months may be kept, whereas it needs a stock of fortnight or so in case of *A* items. *B*-items also require careful storage and handling.

In brief, *B*-items need every care but not so intensive as is required for *A*-items.

B-items generally account for 20 to 15% of the total inventory cost and constitute about 15 to 20 % of the total items.

3. *C*-items are low valued, but maximum numbered items.

These items do not need any control, rather controlling them is uneconomical. These are the least important items like clips, all pins, washers, rubber bands, etc. They are generally procured just befor they finish. No expediting is necessary, no records are normally kept and a safety stock of 3 months or even more can be purchased at an instant. Future requirements of such items are never calculated and a two bin system is sufficient to hint procurement.

C-items generally account for 10 to 5% of the total inventory cost and they constitute about 75% of the total items.

24.10. MATERIAL REQUIREMENTS PLANNING (MRP)

Introduction

- As explained earlier, MRP is a computational technique that converts the *master schedule* for end products into a *detailed schedule* for raw material and components used in the end products. The detailed schedule identifies the quantities of each raw material and component items. It also tells when each item must be ordered and delivered so as to meet the master schedule for the final products.

  The purpose of MRP is to ensure that materials and components are available in the right quantities and at the right time so that finished products can be completed according to the master production schedule.
- MRP is often considered to be a subset of inventory control. It is an effective tool for minimizing unnecessary inventory investment.

  MRP is also useful in production scheduling and purchasing of materials.
- The concept of MRP is relatively straight forward. What complicates the application of the technique is the sheer magnitude of the data to be processed.

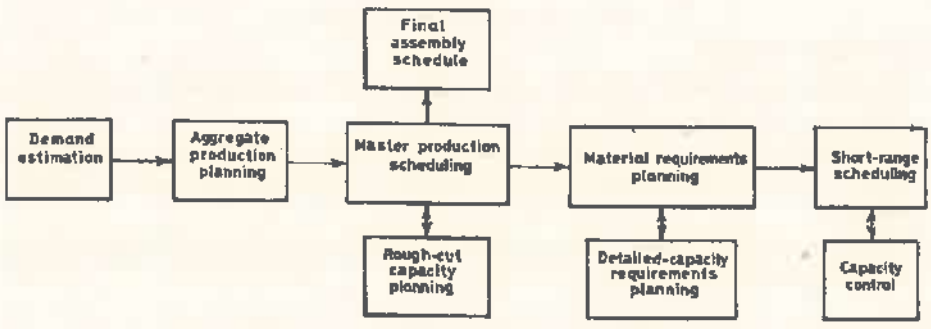


Fig 24.7. Production Planning and Scheduling Process

Functions

An MRP system has three major *Functions/uses* :

1. Control of inventory levels,
2. Assignment of priorities for components, (depending upon their delivery dates) and
3. Determination of *capacity requirements* at a detailed level.

Capacity requirements planning (CRP) is a system for determining if a planned production schedule can be accomplished with available capacity and, if not, making adjustments as necessary.

Inputs to MRP

– MRP converts the master production schedule into the detailed schedule for raw materials and components. For the MRP program to perform its function, it must operate on the data contained in the master schedule. However, this is only one of three sources of input data on which MRP relies. The three inputs to MRP are :-

1. The master production schedule and other order data.
2. The bill-of-material file, which defines the product structure.
3. The inventory record file.

Fig 24.8 shows the flow of data into the MRP processor and its conversion into useful output reports.

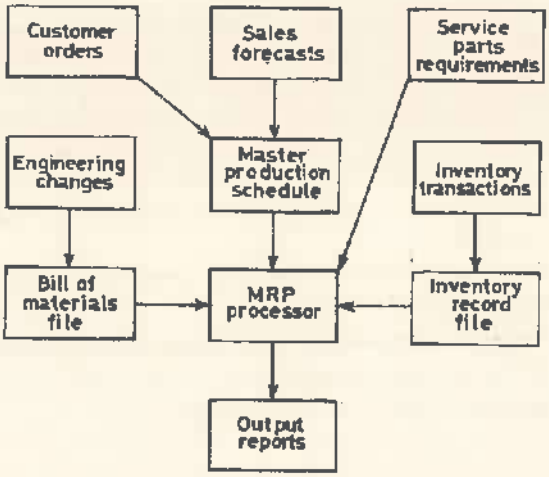


Fig. 24.8. Structure of an MRP system.

Master production schedule

– The master schedule is based on an accurate estimate of demand for the firm's product, together with a realistic assessment of its production capacity.

– The master production schedule (Fig. 24.9) is a list of what end products are to be produced, how many of each product is to be produced, and when the products are likely to be ready for shipment.

– The general format of a master production schedule is illustrated in Fig 24.9. It may show weekly or monthly delivery schedules.

Week number	6	7	8	9	10
Product P1			50		100
Product P2		70	80	25	
etc.					

Fig. 24.9. Master production schedule for products P_1 and P_2 showing week delivery quantities.

Bill-of-materials file

- In order to compute the raw material and component requirements for end products listed in the master schedule, *the product structure* must be known. This is specified by the *bill-of-materials* which is a list of component parts and sub-assemblies that make up each product. Putting all these assembly lists together, we have the bill-of-materials file (BOM).
- Fig 24.10 shows the structure of an assembled product. It shows, subassembly S_1 is the *Parent* of components C_1, C_2 and C_3. Product P_1 is the parent of sub assemblies S_1 and S_2 and so on.

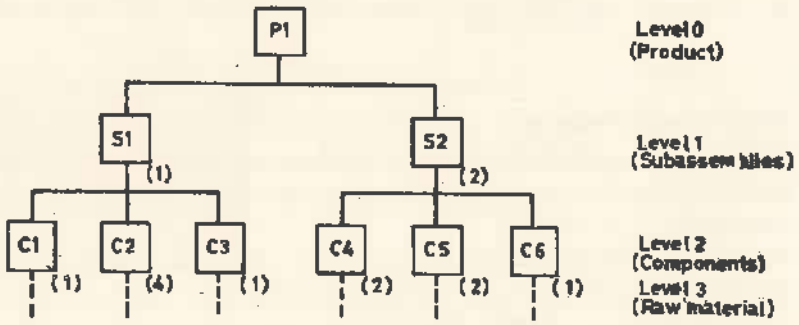


Fig 24.10. Product structure for product P_1

The product structure must also specify how many of each item are included in its parent. This is accomplished in Fig. 24.10 by the number in parentheses to the rigth and below each block. For example, subassembly S_1 contains four of components C_2 and one each of components C_1 and C_3.

Inventory record file

- It is mandatory in MRP to have accurate current data on inventory status. This is accomplished by utilising a computerized inventory system which maintains the *inventory record file* or *item master file*. (Fig. 24.11)
- A definition of the lead time for the raw material, components and assemblies must be established in the inventory record file. The ordering lead time can be determined from purchasing records. The manufacturing lead time can be determined from the process route sheets.

It is important that the inputs to the MRP processor be kept current. The bill-of-materials file must be maintained by feeding any engineering changes that affect the product structure into the BOM. Similarly, the inventory record file is maintained by inputing the inventory transactions to the file.

Working of MRP

- The MPR processor (Fig 24.8) operates on data contained in the master schedule, the bill-of-materials file and the inventory record file.

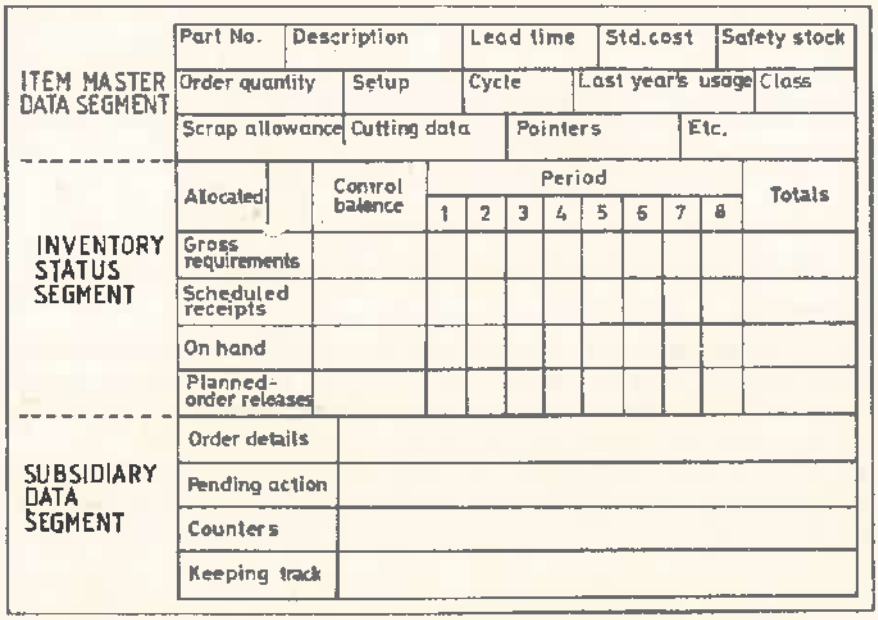


Fig. 24.11. Record of an inventory item.

- The *master schedule* specifies a period-by-period list of final products required.

  The *BOM* defines what materials and components are needed for each product.

  The *inventory record file* contains information on the current and future inventory status of each component.

- The MRP program computer—how many of each component and raw material are needed by *exploding* the end product requirements into successively lower levels in the product structure.

  Referring to master schedule (Fig 24.9), 50 units of product P_1 explode into 50 units of subassembly S_1 and 100 units of S_2 and components : C_1 =50, C_2=200, C_3=50, C_4=200, C_5=200 and C_6=100 units. The quantities of raw materials for these components would be determined in a similar manner.

- There are several *factors* that must be considered in the MRP parts and materials explosion.

(1) Components and subassemblies already existing in the stock must be considered for determining requirements for meeting the master schedule.

(2) The MRP processor must determine when to start assembling the subassemblies by offseting the due dates for these items by their respective manufacturing lead times. Similarly, the component due dates must be offset by their manufacturing lead times.

The MRP program performs these lead-time-offset calculations from data obtained in the inventory record file and from route-sheet data.

(3) Some components and many raw materials are common to several products. The MRP processor must collect these common use items during the part explosion. The total quantities for each common use item are then combined into a single net requirement for the item.

(4) Since master production schedule provides time-phased delivery requirements for the end products, this time phasing must be carried through the calculations of the individual component and raw material requirements.

MRP Output reports

– The MRP program generates a variety of outputs that can be used in the planning and management of plant operations. These outputs include :

(*a*) **Primary outputs**

(1) Order release notice, to place orders that have been planned by the MRP system.

(2) Reports showing planned orders to be released in future periods.

(3) Rescheduling notices, indicating changes in due dates for open orders.

(4) Cancellation notices, indicating cancellation of open orders because of changes in the master schedule.

(5) Reports on inventory status.

(*b*) **Secondary outputs**

(1) Performance reports of various types, indicating costs, item usage, actual versus planned lead times etc.

(2) Exception reports, showing deviations from schedule, orders that are overdue, scrap and so on.

(3) Inventory forecasts, indicating projected inventory levels in future periods.

Benefits of MRP

(1) Reduction in inventory.

(2) Improved customer service—late orders are reduced as much as 90%.

(3) Quicker response to changes in demand.

(4) Better machine utilization.

(5) Greater productivity.

24.11. MANUFACTURING RESOURCE PLANNING (MRP II)

– MRP was originally developed as a computer system for planning material orders.

Manufacturing personnel soon discovered that capacity planning and scheduling could be integrated with MRP and the closed loop MRP concept was born. More sophisticated software packages evolved into complete manufacturing control systems.

– The use of an MRP-based system to plan all the resources of a manufacturing company is called *MRP II.*

MRP II includes strategic financial planning as well as production planning through the use of simulation capabilities to answer what-if questions. What-if capabilities are routinely used to evaluate alternative plans.

– MRP II is a total company system, in which functional groups interact commonly and formally and make joint decisions. Finally, the system is *user-transparent.* Users at all levels understand and accept the logic and realism of the system and need not work outside the formal system.

– Fig 24.12 shows one such system—MRPS: *Manufacturing Resource Planning System* developed by CINCOM systems, Inc. MRPS includes the vertical dimension of production planning, master production scheduling, MRP and shop floor control. The system also expands horizontally to include inventory control, purchasing and other planning considerations.

24.12. OPERATING CYCLE

– The *operating cycle* refers to the *length of time* necessary to complete the following cycle of events :

1. Convert cash into inventory.
2. Convert inventory into receivables.
3. Convert receivable into cash.

– In phase 1, cash is used to produce inventory. For manufacturing firms, this phase would start with the purchase of raw materials and would conclude with the manufacturing process delivering goods to inventory.

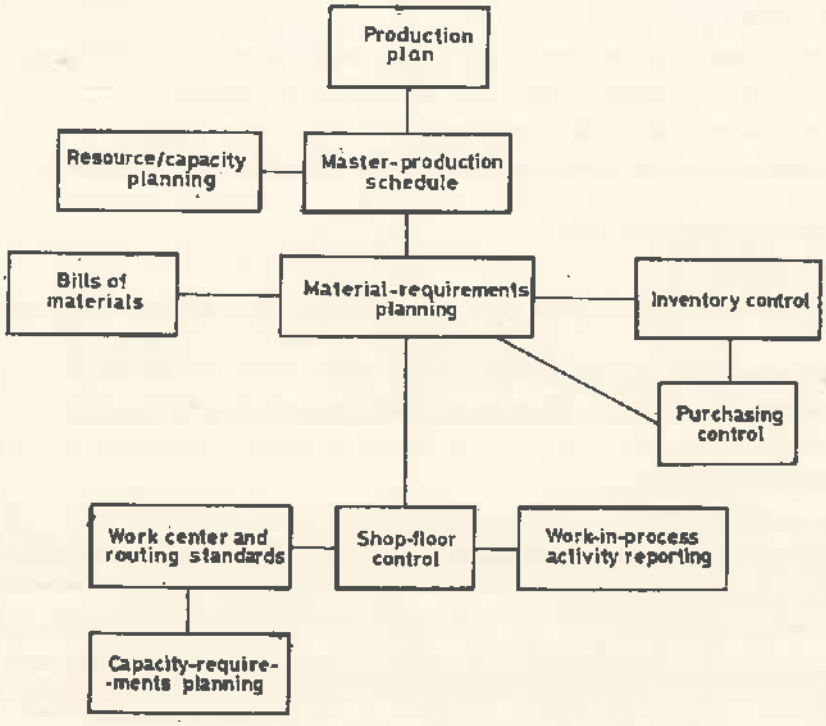


Fig. 24.12. The structure of MRPS.

– In the second phase of the cycle the inventory is converted into receivables as sales are made to customers.

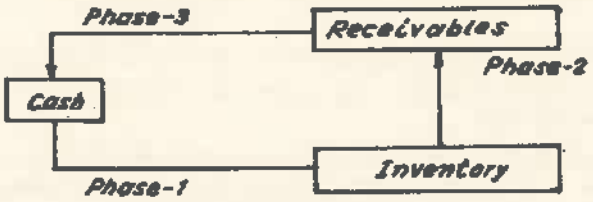


Fig. 24.13. Operating cycle.

– The last phase of the operating cycle, phase 3, sees the *receivables* being collected and the operating cycle is complete.

Firms that have no *credit terms* (cash and carry firms) would have no phase 2 since they will sell only on cash. *Receivables* are *notes* and *acceptances receivables*. These are short term promissory instruments of indebtedness that reflect obligations owed the firm.

SHEETAL GAUTAM

25

Material Handling

25.1. INTRODUCTION AND DEFINITION

Starting from the time, the raw material enters the factory gate and goes out of the factory gate in the form of finished products, it is handled at all stages in between, no matter it is in the stores or on the shop floor. It has been estimated that average material handling cost is roughly 20 to 60% of the total production cost and the ratio between the weight of handled material to produce an item and the weight of the finished item may vary between 40 to 50. A component may be handled even 50 times or more before it changes to finished product. It, thus, becomes clear that the cost of production of an item can be lowered considerably by making a saving in the material handling cost.

Material handling involves the movements of materials, manually or mechanically in batches or one item at a time within the plant. The movement may be horizontal, vertical or the combination of horizontal and vertical.

Material handling emphasizes upon the need of installing efficient and safe methods and equipments for material handling. It has been found that 35 to 40% of the plant accidents are the results of bad methods of material handling.

25.2. FUNCTIONS AND PRINCIPLES OF MATERIAL HANDLING

The two main functions of material handling section are :

1. To choose production machinery and assist in plant layout so as to eliminate as far as possible the need of material handling ; and

2. To choose most appropriate material handling equipment which is safe and can fulfil material handling requirements at the minimum possible overall cost :

In general, the functions and principles of good material handling are as follows :

(*a*) Minimize the movements involved in a production operation ,

(*b*) Using the principles of containerization, unit load or palletization, aim at moving optimum number of pieces in one unit.

(*c*) Minimize the distances moved, by adopting shortest routes.

(*d*) Employ mechanical aids in place of manual labour in order to speed up the material movements.

(*e*) Changes in sequence of production operations may be suggested in order to minimize back tracking and duplicate handling.

(*f*) Safe, standard, efficient, effective, appropriate, flexible and proper sized material handling equipment should be selected.

(*g*) Handling equipments arrangement should minimze distances moved by products and at the same time handling equipments should not interfere with the production line.

(*h*) Utilize gravity for assisting material movements wherever possible.

(*i*) Design containers, packages, drums etc., to economize handling and to reduce damage to the materials in transit.

(*f*) Material handling equipments should periodically be resorted to check ups, repairs and maintenance.

25.3. ENGINEERING AND ECONOMIC FACTORS

The two most important factors for analysing or solving a material handling problem are :

1. Engineering factors, and
2. Economic factors.

25.3.1 The Engineering Factors taken into Consideration

(*a*) The conditions of existing building and plant layout,

(*b*) Production processes and equipments.

(*c*) Nature of materials and products to be handled, and

(*d*) The existing material handling equipments.

(*a*) If a material handling system is to be formulated for an existing building and facility layout, one has to study various features of the building, like door locations and sizes, ceiling heights, roof and floor strengths, stairs, columns, and width of aisles, etc. Unfavourable features may restrict the use of fast and most suitable material handling equipments. One has to strike a balance and decide which feature of the building or existing layout is to be kept as it is and which others can be modified to advantage.

(*b*) It involves the type of production equipment, processes, method of production, quantities of materials involved in handling, sequence of operations, etc. On the basis of these factors an optimum system of material handling can be evolved or at least some factors can be modified to achieve a better material handling system.

(*c*) Much depends upon the nature of raw materials, materials in process, quantities to be handled and distances to be travelled by them. A flexible, safe, and economical material handling system is developed taking into consideration the conditions, fragility and bulk of the materials involved.

(*d*) The usefulness and effectiveness of existing material handling equipment is evaluated from its performance of handling different products. If found necessary, additional material handling equipments are purchased to reinforce the material handling operations.

25.3.2. Economic Factors. The cost of material handling equipment, operating costs, repair and maintenance costs, taxes, insurance and depreciation costs are considered for economic analysis. A material handling system with the lowest prospective cost is selected.

The operating costs are reduced by, purchasing flexible material handling systems, increasing the amount of material to be handled at one time, minimizing the idle time for the equipment, increasing speed of handling and by acquiring material handling equipments of standard design.

A material handling system is said to be economical if the cost of handling per unit weight of the material for a particular movement is minimum. Economy in material handling can be achieved by employing gravity aided movements, minimizing the distances of material travel, and by using such systems in which the product from the machine directly falls over material handling equipment (say a conveyor or chute) and is taken to its destination without any assistance from the machine operator.

Proper periodic inspection, repair and maintenance of a material handling equipment increases its life, adds to its reliability, smoothens the flow of material and economizes the production system.

25.4. RELATIONSHIP TO PLANT LAYOUT

Material handling and plant layout are closely interrelated, and a reciprocal relationship exists between the two. An effective layout involves least material handling and less costly material handling equipments. It permits, material handling without any loss of time, with minimum delays and least back tracking. The total number of movements and the distances moved in one movement are also considerably

reduced in a properly designed plant layout. In a poorly planned layout, the aisle's/sub-aisle's widths or ceiling heights may not be sufficient to accommodate efficient material handling equipments; even if used somehow or other, the back tracking or duplication of material movements may not permit the material handling system to be economical.

On the other hand, an efficient material handling system helps building an effective plant layout around itself. Various departments are located such that the material handling is minimized. Space requirements are considerably reduced. Material movements are much faster and more economical. Bottlenecks and points of congestion are removed. Machines and workers do not remain idle due to lack of material. Production line flow becomes smooth.

25.5. SELECTION OF MATERIAL HANDLING EQUIPMENT

A wide variety of material handling equipments is in the market; some equipments are for general purpose use and others are of special purpose use. The choice of a particular equipment depends upon the specific requirements or the conditions of an industry. Naturally, the best equipment will be one which permits smooth and continuous production flow, involves less accidents, reduces production cycle time, promotes better working conditions, incurs less fatigue to the operators and brings down the total material handling costs.

The following factors may be considered while selecting a material handling equipment :

(a) Material to be moved. The size of material, its shape, weight, delicacy, nature (solid, liquid, gas) and its chances of getting damaged during handling, etc., should be considered.

(b) Plant buildings and layout. Widths of aisles, ineqality in floor levels, width of the doors, height of the ceiling, strength of floor and walls, columns and pillars etc., to a great extent influence the choice of a material handling equipment. For example, low ceiling heights may not permit stacking of palletized materials, weak roofs limit the use of overhead conveyors and steps between two floors will not allow trucks to operate.

(c) Type of production machines. Different machines have different outputs per unit time. The material handling equipment should be able to handle the maximum output.

(d) Type of material flow pattern. A vertical flow pattern will require elevators, conveyors, pipes etc., whereas horizontal flow pattern will need trucks, overhead bridge cranes, conveyors, etc.

(e) Type of production. The type of production affects to a large extent the selection of the material handling equipments. Conveyors are more suitable for mass production on fixed routes and powered trucks for batch production; because conveyors though costly, can handle more volume of production per unit time as compared to trucks, whereas a truck is a more flexible equipment.

(*f*) Cost of material handling equipment.

(*g*) Handling costs.

(*h*) Life of the equipment.

(*i*) Amount of care and maintenance required for the material handling equipment.

25.6. MAINTENANCE OF MATERIAL HANDLING EQUIPMENTS

The proper maintenance of material handling equipments is extremely essential for preventing the occurrence of bottlenecks or points of congestions. Production line flow can be maintained only if the material handling equipment is in the proper working order.

Preventive maintenance is by far one of the best maintenance techniques suggested for material handling equipments.

By preventive maintenance, the equipments can be kept running thereby minimizing costly interruptions in the production schedule. A little periodic inspection and minor adjustments may be enough to prevent equipment breakdown. Preventive maintenance consists of frequent inspections and

examination of the material handling equipments, with special attention to the components requiring it. The aim is to uncover conditions leading to breakdown or harmful depreciation. Preventive maintenance also includes lubrication, adjustment, or repair while the equipment is still in a minor stage of defect.

Three stages of preventive maintenance are :

(*a*) Inspection,

(*b*) Repair, and

(*c*) Overhaul.

The maintenance system for a few material handling equipments like cranes, hoists, and coveyors has been discussed below :

25.6.1. Hoists and Cranes

(a) Inspection. All parts, open or covered are inspected for wear and tear. Worn out or unworkable components like wire ropes, wheels, bearings, bolts, etc., are removed. Brakes are adjusted and lubrication is provided wherever necessary.

(b) Repair. The repairable parts of the system, after inspection are corrected for small repairs and minor defects are rectified. Systems like open gear transmission, couplings, riveted, and bolted joints, trolley, brakes, guards, etc., may be repaired.

(c) Overhaul. Overhauling involves dismantling the complete-mechanism and replacing all damaged components. Crane structure, buffers, rails, open gear transmission, pulley blocks, etc., may be replaced and various sub-mechanisms may be alligned and adjusted.

25.6.2. Conveyors

(a) Inspection. Belts or rollers are inspected for tensions and wear and tear. Gear box is properly lubricated, various fasteners are tightened and safety guards are checked.

(b) Repairs. Rollers and belts are checked, adjusted or repaired. Couplings, packings, safety guards, steel structures, gear transmission, bearings, fastener joints, threaded components, etc., are adjusted or repaired as per their conditions.

(c) Overhaul. The conveyor system is completely dismantled. Components, worn out and beyond repair like belts, bearings, packings, oil seals, rollers, drums, fasteners, and couplings are replaced. Structures, safety guards, etc., may be repaired as per their conditions.

25.6.3. Repair Cycle

A typical repair cycle may be as follows :

(*a*) New Equipment (*b*) Inspection-1
(*c*) Inspection-2 (*d*) Inspection-3
(*e*) Repair-1 (*f*) Inspection-4
(*g*) Inspection-5 (*h*) Inspection-6
(*i*) Repair-2 (*j*) Inspection-7
(*k*) Inspection-8 (*l*) Inspection-9
(*m*) Repair-3 (*n*) Inspection-10
(*o*) Inspection-11 (*p*) Inspection-12
(*q*) Repair-4 (*r*) Inspection-13
(*s*) Inspection-14 (*t*) Inspection-15
(*u*) Overhaul-1

This cycle involves 15 inspections, 4 repairs and 1 overhaul. The time duration between two stages

say (*c*) or (*d*) and (*e*) may range from 1 month to 6 months or even more, depending upon the type of material handling equipment and the time for which it has been used.

25.7. TYPES OF MATERIAL HANDLING EQUIPMENTS

25.7.1 Introduction. A wide range of material transporting and handling equipments are available–suitable to most of the industrial requirements. Such equipments though need a high capital investment. prove very paying in the long run. They

(1) minimize the total handling time;

(2) promote, easier, safe and cleaner handling;

(3) eliminate idle time of workers and machines which would be there, otherwise, while waiting for the materials for necessary operations;

(4) make material movements fast;

(5) decrease fatigue incurred by the workers;

(6) add to safety;

(7) locate, and stock materials better and in less space; and

(8) lastly their operations can be automated to increase production.

25.7.2. Characteristics of Material Handling Equipments. Every material handling equipment possesses certain characteristics with respect to

- Materials
  - Bulk 1
  - Packaged 2.
- Movement
  - Vertical 3
  - Horizontal 4
  - Combination of vertical and horizontal 5.
- Supervision required
  - Close 6
  - Little 7
  - Equipment is automatic or semi-automatic 8.
- Path followed
  - Variable 9
  - Fixed 10
  - Fixed area 11.
- Speed
  - Variable 12
  - Fixed 13
  - Either fixed or variable 14.
- Power required for the operation of equipment
  - Electricity 15
  - I.C. Engine 16
  - Manual 17
  - Gravity 18.



Fig. 25.1.
Two wheeled truck.

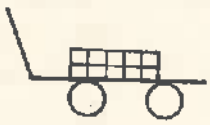


Fig. 25.2
Four wheeled truck.

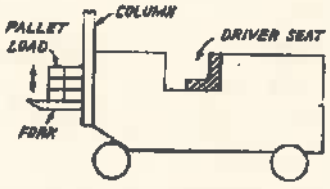


Fig. 25.3
Fork lift truck.

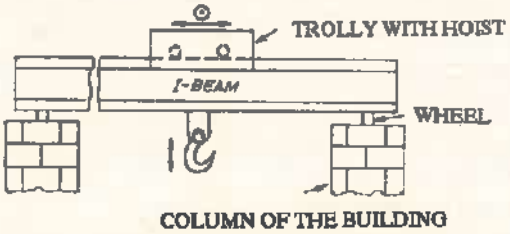


Fig. 25.4. Overhead bridge crane.

25.7.3. Classification of Material Handling Equipments

(*a*) *Industrial Trucks*
Flexible, versatile and most extensively used.

- Manual
  - 2 Wheeled (Fig. 25.1)
  - 3 Wheeled
  - 4 Wheeled (Fig. 25.2)

  Characteristics
  CH : 1, 2, 4, 6, 9, 12, 17

  Excellent for intermittent small distance movements.
- Powered
  - Driver walk (Driver remains on ground)
    - Platform type — CH : 2, 4, 6, 9, 12, 15, 16
    - Pallet lift
    - High lift fork — 1, 2, 4, 5, 6, 9, 12, 15, 16
  - Driver ride (Driver on the truck)
    - Platform
      - Low lift — CH : 1, 2, 4, 6, 9, 12, 15, 16
      - High lift — CH : 1, 2, 4, 5, 6, 9, 12, 15, 16
    - Pallet lift — CH : 2, 4, 6, 9, 12, 15, 16
    - Telescopic fork lift (fork-lifts by the principle of telescopic tubes) — CH : 1, 2, 4, 5, 6, 9, 12, 15, 16

In FORK LIFT TRUCK (see Fig. 25.3) the forks are attached to a column on the truck. Forks can be lifted to the desired height along with the material (boxes, etc.) on them and the material can be stacked at the proper place, even very close to the roof. Fork lift trucks are used for short distances (40 to 70 metres) travel and find indoor applications normally

(*b*) *Cranes*

- Overhead bridge crane (Fig. 25.4) — CH : 1, 2, 5, 6, 11, 15
- Jib crane (Fig. 25.5) — CH : same as for overhead crane.
- Gantry crane (Fig. 25.6) — CH : 2, 5, 6, 11, 14, 15

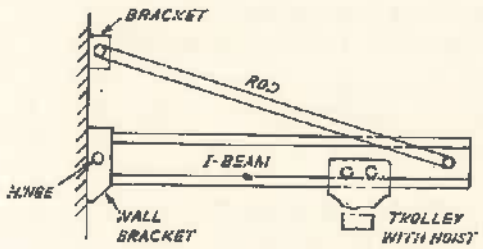


Fig. 25.5. Jib crane.

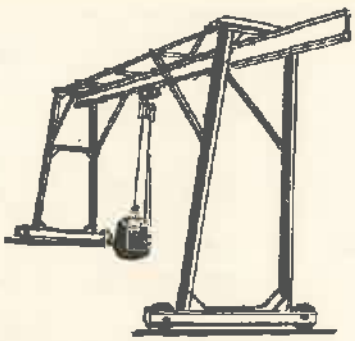


Fig. 25.6. Gantry crane.

CRANES are employed for lifting and lowering bulky items and packages or cases. They find applications in heavy engineering and generally in intermittent type of production. They provide overhead movements. The crane hook can move in a rectangular area (overhead bridge crane) or a circular area (jib crane). An overhead bridge crane finds applications in most of the industries, making engines, compressors, pressure vessels, foundries, steel mills, etc. A jib crane is preferred where lifting of the jobs is required in a few locations only or where bridge crane cannot be erected; for example, outside near the wall of the building. In a jib crane the hoist unit may be mounted on an I-section jib which is in turn supported on a column. A gantry crane acts as an auxiliary to bridge crane. It is on wheels and can be moved at the place of use.

(*c*) *Hoists*
- Chain type (manual) — CH : 1, 2, 3, 6, 11, 12, 17
- Pneumatic — CH : 1, 2, 3, 6, 11, 12, 15
- Electrical — CH : 1, 2, 3, 6, 11, 12, 15

HOIST may be mounted on a single rail. It finds applications in wire drawing and many other factories employing chemical cleaning of material, etc.



Fig. 25.7. Electrical hoist.

(*d*) *Monorail*
- Trolley — CH : 2, 4, 5, 7, 10, 15
- Carrier — CH : 1, 2, 4 , 5, 7, 10, 15

MONORAIL is an I-section beam attached to the ceiling and having either a trolley or carrier moving along it. The material can be transferred from one place to another along the beam. It is employed for intermittent type material handling in machine shop and other shops.

CONVEYORS are employed to transport materials, over a fixed path which may be horizontal or inclined (up or down), to different locations in a factory. They prove economical if the flow of material is continuous.

In a ***belt conveyor***, the belt may be flat or of trough shape to hold (granular) materials which may tend to fall from the flat belt. The belt material may be rubber covered canvas, steel, plain fabric or woven wire (high temperature use). A fixed conveyor is used on the mass production shop floor whereas portable conveyors are preferred for intermittent jobs like unloading of a freight car, etc.

(e) Conveyors

- Belt conveyor (See Fig. 25.8)
  - Flat CH : 1, 2, 3, 4, 5, 8, 10, 14, 15, 16
  - Troughed CH : 1, 3, 4, 5, 8, 10, 15, 16
  - Fixed/Portable CH : 1, 2, 3, 4. 5, 8, 10, 14, 15, 16.
- Roller gravity
  - Spiral CH : 2, 3, 4, 5, 8, 10, 12, 18
  - Fixed CH : 2, 4, 5, 8, 10, 12, 18
  - Portable CH : 2, 4, 5, 8, 10, 12, 18
- Roller line (See Fig. 25.9)
  - Chain drive CH : 2, 4, 5, 8, 10, 14, 15
  - Belt drive CH : 2, 4, 5, 8, 10, 14, 15
- Drag
  - Screw CH : 1, 3, 4, 5, 8, 10, 13, 15
  - Pusher bar CH : 2, 3, 4, 5, 8, 10, 13, 15
  - Overhead chain CH : 1, 2, 4, 5, 7, 10, 13, 15
- Bucket CH : 1, 3, 5, 8, 10, 13, 15, 18
- Chain or cable CH : 1, 2, 4, 5, 8, 10, 13, 14, 15 (Fig. 25.10)
- Pipe line (pneumatic).

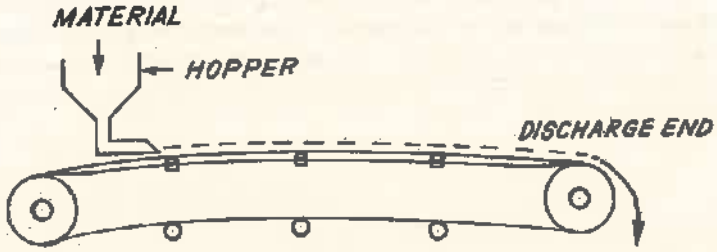


Fig. 25.8. Belt conveyor.

Roller conveyors may be gravity aided or powered and are employed for transporting products having flat bottoms. Bigger jobs can be handled as they are, whereas small items are put in boxes, tins or pallets before being transferred. Roller conveyors can move the material along straight or curved paths. Gravity type conveyors should be preferred as compared to line conveyors wherever practical. Gravity conveyor is easy to set up as it does not involve any power drive. Packages of hosiery goods, steel sheets, etc., can be transferred using gravity conveyors.

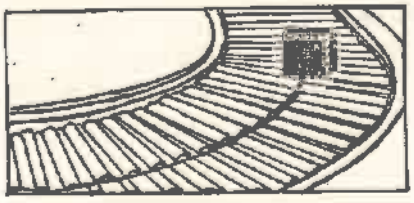


Fig. 25.9. Roller conveyor.

Belt conveyors are substituted for roller conveyors when the parts are small and are required to be transferred separately, from one station to another.

The mechanism of transporting the materials in a drag conveyor can be a screw (as in automatic feed in poultry farms), a pusher bar, a scraper (for moving granular or powder materials) or an overhead endless chain along a fixed path. The chain has chain links which push the material forward.

A ***bucket conveyor*** moves the granular materials or powder or liquid. The buckets may be mounted on a chain or belt.

A ***chain conveyor*** (Fig. 25.10) consists of overhead mounted endless chain. It is supported from the ceiling and has a fixed path to travel. It saves valuable floor space. The arrangement is such that the lifting

mechanism (may be an electromagnet or a hook) lowers down for loading and unloading of the products. Chain conveyors are used in refrigeration industries for painting and plating of the refrigerator shells. In another application a telescopic mast (pole) may join its upper end with the overhead chain conveyor and the lower end with a trolley; so that as the endless chain moves, the trolley (with the material in it) also moves in the direction in which chain travels.

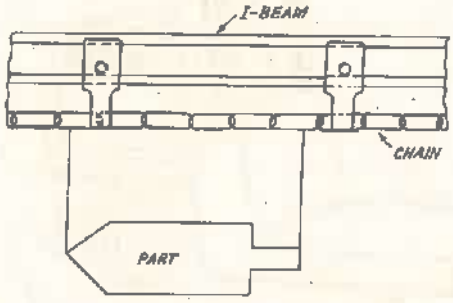


Fig. 25.10. Chain conveyor.

Pipe line conveyors are used for transporting granular (wheat) or pulverized materials (salt) through the pipes. Gravity or air flow moves the material ahead.

(f) Slides and chutes
- Straight, Spiral, Wood/steel — CH : 1, 2 3, 5, 7, 10, 13, 18
- Vibrating — CH : 1, 3, 5, 7, 8, 10, 13, 15

They transfer small jobs which can slide down under gravity. Vibrating slides transport materials up an incline also (cigarette factories). Chutes have sheet metal or roller base for transferring components down the incline. Chutes generally feed parts (which they receive from, say sheet metal presses) to the conveyor which takes the parts to their destination.

(g) *Lifts :* In multistorey plants, material is lifted up and transported by lifts. It is a fast and flexible equipment for floor to floor travel. Buckets or trays can be mounted on the endless chain running from the ground floor to the top floor. The material can be loaded in the trays automatically.

(h) Tractors and Trailers : Tractors, three wheeled or four wheeled (CH: 1,2,4,6,9,12,15,16) employ I.C. Engine drive and are generally used for outdoor applications. Material is loaded in the trailers (CH: 1,2,4,6,9,14) which are attached to the towing tractor. Trailers can either be uncoupled from the tractor train, or the material loaded in them can be dumped out, at respective stations. Tractor train is very helpful in big industries.

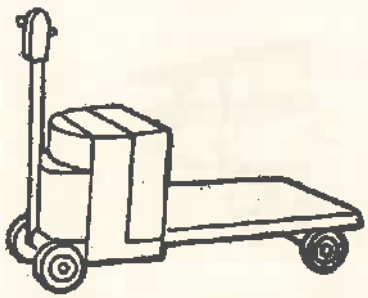


Fig. 25.11. Platform truck (low-lift type).

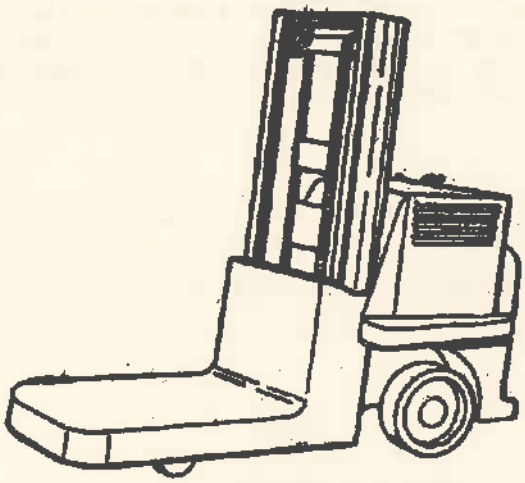


Fig. 25.12. Platform truck (high-lift type).

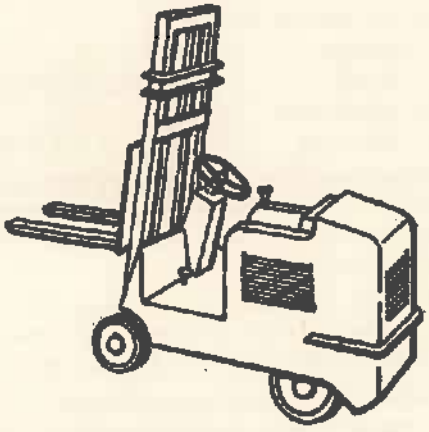


Fig. 25.13. Fork truck (counterbalance type).



Fig. 25.14. Chain hoist.



Fig. 25.15. Electric hoist.

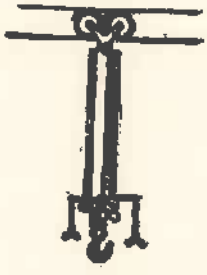


Fig. 25.16. Air hoist.

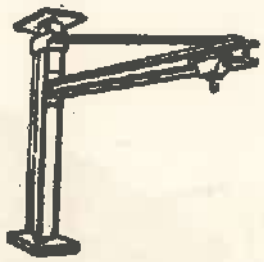


Fig. 25.17. Jib crane.

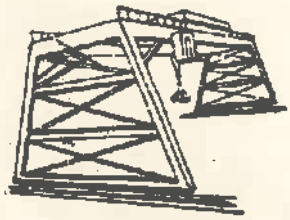


Fig. 25. 18. Gantry crane.

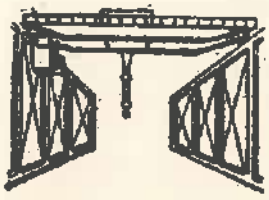


Fig. 25.19. Bridge crane.

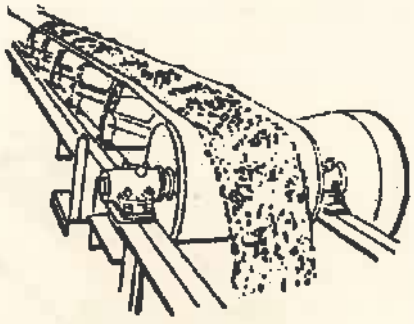


Fig. 25.20. Belt conveyor.

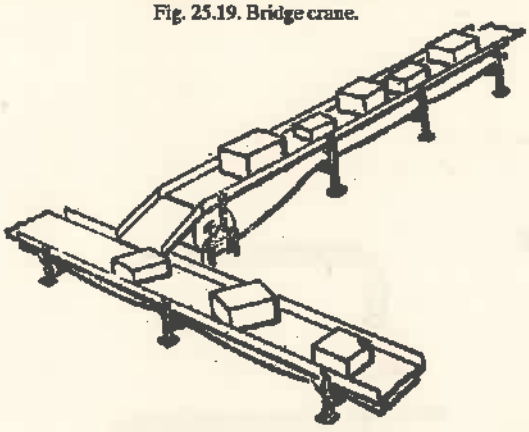


Fig. 25.21. Belt conveyor.

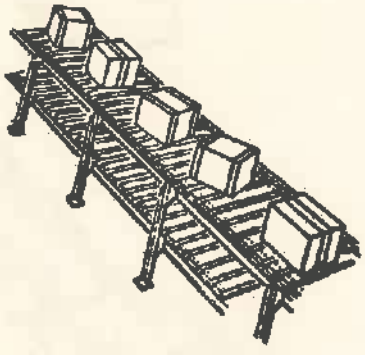


Fig. 25.22. Slat conveyor.



Fig. 25.23. Roller conveyor.

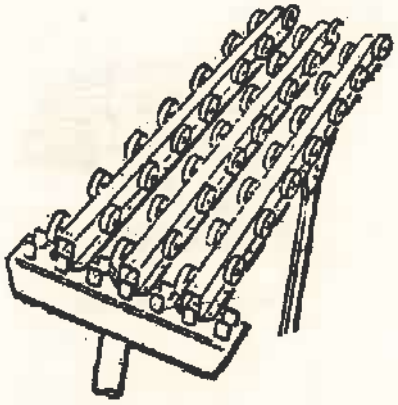


Fig. 25.24. Wheel conveyor.

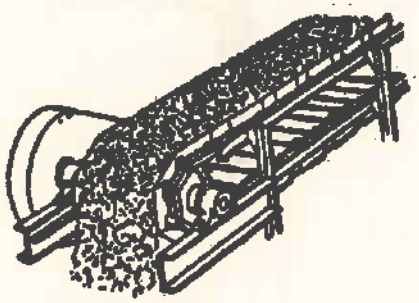


Fig. 25.25. Apron conveyor.

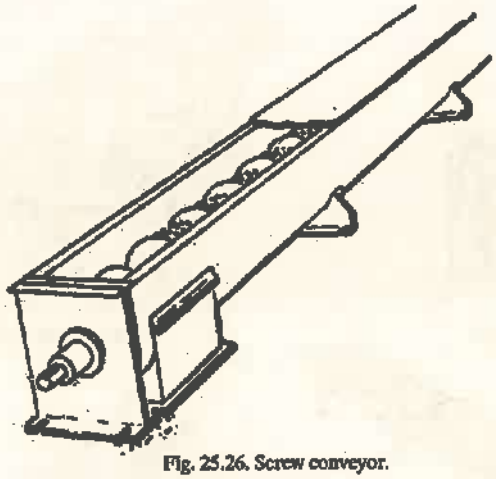


Fig. 25.26. Screw conveyor.

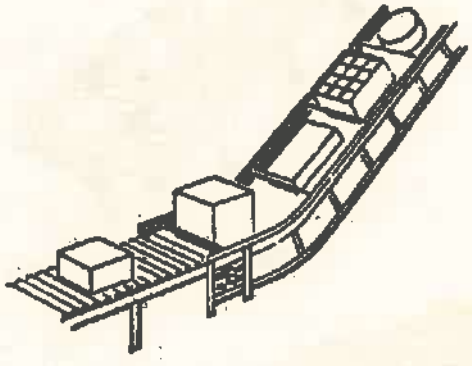


Fig. 25.27. Pusher bar conveyor.

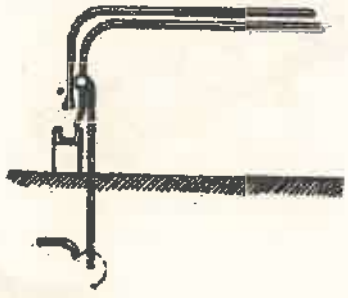


Fig. 25.28. Pneumatic conveyor.

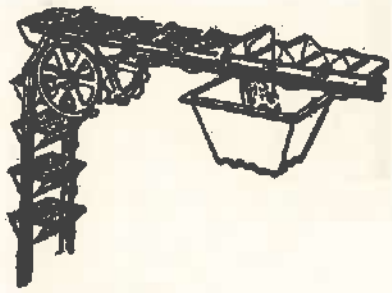


Fig. 25.29. Pivoted bucket conveyor.

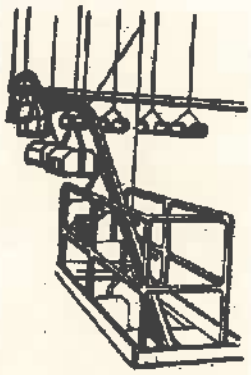


Fig. 25.30. Trolley conveyor.

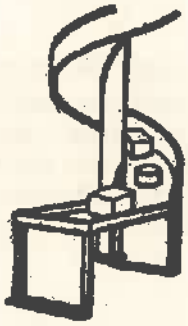


Fig. 25.31. Spiral chute.

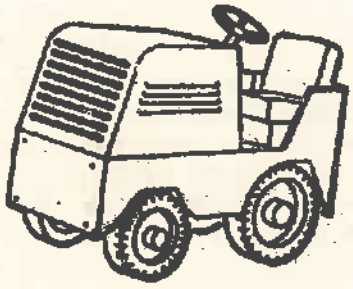


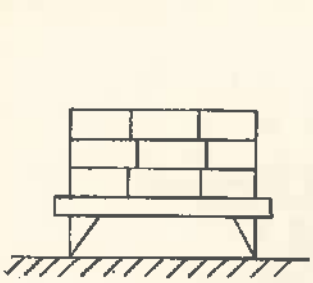
Fig. 25.32. Industrial tractor.

25.8. PRINCIPLE OF UNIT LOAD AND CONCEPT OF CONTAINERIZATION AND PALLETIZATION

It is easier and faster to move hundred small parts say castings or cardboard sheets by grouping them in one unit than moving them individually one by one. This principle of unit load can also be explained like this. If the bearer of a hotel removes cups, plates and other crockery from a table by placing them in a tray, it is called material handling by unit loads. Definitely, he would have spent much more time and efforts in removing all the crockery by one cup or one plate at a time.

By using available machines (like one for strapping steel strips around cotton bales), fork lift trucks, skids and pallets (see Fig. 25.33), it is easy to handle materials in unit loads and stack them neatly and properly (even as high as the ceiling) thereby reducing the storage space requirements.

Depending upon the types of items to be transferred, a suitable pallet can be designed. For example, items irregular in shape and liable to be damaged by crushing utilize a post pallet (See Fig. 25.34) whereas small jobs can be placed in wire mesh box (See Fig. 25.35).



A skid with load

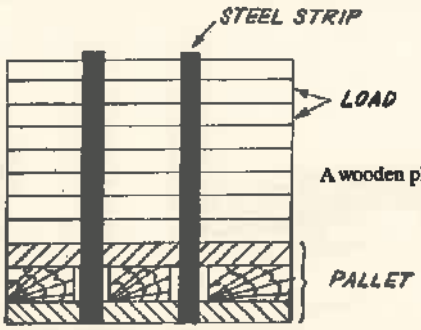


Fig. 25.33. Skid and pallet.

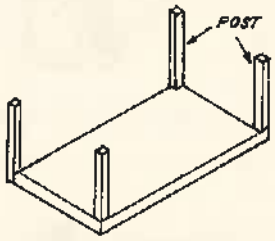


Fig. 25.34. Pallet with 4 posts.

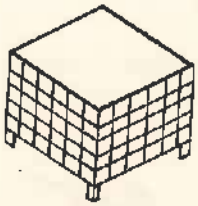


Fig. 25.35. Wire mesh box.

Containerization uses principle of unit load. In this system, big metal containers have number of small products filled in them. These containers are placed on the truck or in the trailers which are pulled by tractors or trucks. Afterwards, the containers can be loaded on railway trailers and can be taken to places from where, with the help of cranes, they can be shipped. Items like refrigerators, air-conditioners or televisions can be sent to distant places using the principle of containerization. The system is much safer and involves a lot of saving.

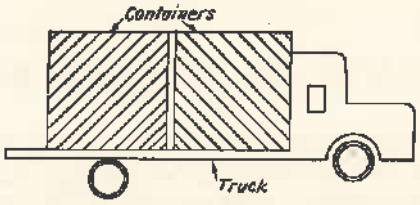


Fig. 25.36. Truck with containers.

26

Financial Management

26.1. CONCEPT AND DEFINITION

- During the life of a business enterprise, there are financial events that receive considerable attention. An issue of ordinary shares is an example.
- By concentrating on discernible financial events, discussions on finance of an enterprise have tended to look at the raising and deployment of finance.

  Funds required for running the business are raised through a combination of direct revenue from sales, loans from banks, sales of securities and bonds, etc.
- Funds raised as above are deployed among competing uses within the enterprise's activities.
- *Financial Management* can be looked upon as the study of relationship between the raising of finance and the deployment of finance.
- *Financial Management* involves decisions pertaining to

(*i*) Investment (proposals) policies,

(*ii*) Methods of financing, and

(*iii*) Dividend decisions.

(*i*) *Investment Policies* dictate the process associated with capital budgeting and expenditures. Proposals (to spend money) may involve expenditures such as on, product development, additional test facility, etc. All proposals received, are ranked and (investment) decisions are taken whether to sanction money for these proposed ventures or not.

(*ii*) A proper mix of short-and long-term financing is ensured in order to provide necessary funds for proposed ventures at a minimum risk to the enterprise.

(*iii*) Dividend decisions affect the

(*a*) Amount paid to stockholders in cash. Stock-holders must get some benefit, otherwise they may sell their shares.

(*b*) Distribution of additional shares of stock, etc.

- Any valid study of financial management is necessarily concerned with financial dynamics ; dynamics indicates an attempt of not using static theory for solving problems of continuous nature.
- Lastly, it may be said that the financial function of any business enterprise tries to maximize the value of that business to its owners.

26.2. PURPOSE OF INVESTMENT

In a business enterprise, money is invested for the following purposes :

(*i*) To procure land, buildings or for making expansion of the existing plant.

(*ii*) For getting raw material, machinery, instruments, tools etc.

(*iii*) For purchasing material transporting vehicles.

(*iv*) On water, power, gas and other supplies for running the enterprise.

(*v*) For administrative and selling services.

(*vi*) On development projects and diversification of products.

(*vii*) For increasing company's manufacturing capability.

(*viii*) Research work, *e.g.*, on cost reduction, etc.

(*ix*) For paying salaries of direct and indirect workers.

(*x*) To organise the business.

26.3. TYPES OF CAPITAL

26.3.1 Capital

- Capital is the life-blood of a business enterprise.
- Capital is a universal lubricant which keeps enterprise dynamic.
- *Capital* designates physical sources when applied to production and (it means) money when applied to finance.
- Capital, in its meaning, covers all the elements (*e.g.*, money, land, building, machinery, materials, etc.) a businessman needs to start an enterprise.
- Capital is the measure of the amount of resources of an enterprise.
- Capital develops products, keeps workers and machines at work, encourages management to make progress and create value.

26.3.2 Types of Capital

Capital may be of the following two types :

1. Fixed or Block capital.
2. Working or Current Capital.

- *Fixed Capital* is associated with long term assets whereas *Working Capital* pertains to current operations.
- For running an industry, two types of capital are needed. One for purchasing fixed assests such as land, building, machinery, etc. and is known as *fixed capital*, whereas the other which is required for day-to-day needs is labelled as *working capital.*

26.3.3. Fixed Capital

- When an industrial enterprise is started from the ground up it requires capital to make/purchase

  Land,

  Building,

  Equipment and Machinery,

  Tools, and

  Furniture, etc.

Assets of this type are used over and over again for a number of years and are commonly termed *Fixed Capital.*

26.3.4. Working Capital

- Once fixed assets, *e.g.*, building, equipment, machinery, etc., have been purchased, the enterprise needs funds to meet its day-to-day needs and expenditures such as
  * Purchase of raw material and supplies.
  * Payment of employee wages.
  * Storage costs.

* Advertisement and selling expenses.
* Equipment and plant maintenance costs.
* Transportation and shipping expenses.
* Expenditures during the time lag between the sale of the products and payment for them.

Funds required to cover these costs are commonly called *working capital.*

For details refer article 26.4.

26.4. WORKING CAPITAL

Definition

- *Working Capital* refers to a firm's investment in short term assets – cash, short term securities, accounts receivable and inventories.
- *Net Working Capital* is defined as current assets minus current liabilities.
- *Working Capital management* refers to all aspects of the administration of both current assets and current liabilities.
- *Working capital* is needed in any business because of the time lag between paying for materials and operating costs, and getting the money back again (together with added profit) from the customer.

Sources of Working Capital

(1) Funds from business operations.

(2) Other incomes such as from dividends, transfer fees, donations, interest from investments made in other companies, etc.

(3) Sale of non-current assets such as useless and obsolete plant and machinery.

(4) Long-term borrowings.

(5) Issue of additional equity capital or preference share capital.

Uses of Working Capital

1. Loss from business operations would decrease the working capital.

2. The purchase of non-current assets generally causes a decrease in current assets or increase in current liabilities. Therefore, it should appear as the use of funds.

3. The retirement of long-term liabilities such as payment to preference shareholders and debenture holders involves the use of cash.

4. Dividend to shareholders.

5. Interest to lenders.

26.5. SOURCES OF FINANCE

26.5.1 Introduction

- In order to start an industrial concern, *i.e.*, to produce and to sell, there must be adequate finance for purchasing fixed assets (building, machinery, etc.), raw materials and other supplies.
- There should also be sufficient finance to meet day-to-day expenditures of the enterprise.
- Thus the very first question which arises before starting an industrial concern is how much finance will be needed and how it will be provided or from what source it will be procured.
- The sources of finance may be categorized as follows :

26.5.2. Internal Sources

1. Retained equity earnings.

2. Depreciation provisions.
3. Deferred taxation.
4. Personal funds saved or inherited.

26.5.3. External Sources

(a) Permanent or long term sources of finance

5. Savings.
6. Loans.
7. Share Capital.
8. Debentures.
9. Corporate bonds.
10. Public deposits.
11. Taking in partners.

(b) Medium term sources of finance

12. Bank loans.
13. Hire purchase.
14. Sale and lease back.
15. Equipment leasing.
16. Profit plow back.

(c) Short term sources of finance

17. Credit facilities.
18. Trade credit.

(d) Specialist Institutions

19. Industrial financial corporation.
20. State financial corporation.
21. Industrial development corporation.
22. Insurance companies, etc.

- It should be noted that internal sources of finance or fund supply,
  (*i*) provide more than half of the total funds available from all sources ; and
  (*ii*) form a necessary and integral part of the continuing activity of a business.
- Various internal and external sources of raising finance have been briefly discussed below :

1. Retained Equity Earnings

- This implies retaining the earnings of the shareholders for internal reinvestment. Every rupee retained is a rupee with-held from distribution to existing shareholders.
- While doing so, management must do something to maintain the interest of shareholders.

2. Depreciation Provisions

- Depreciation provisions represent the maintenance of a capital stock to replace the existing machinery when it becomes uneconomical to use.
- Depreciation provision is a major source of internally generated funds.

3. Deferred Taxation

– Due to the time-lag between the earning of profit and payment of the appropriate taxation, the funds, represented by the tax liability, are available for use.

4. Personal Funds Saved or Inherited

In order to win confidence of external financiers, it is very necessary that the would-be owner must have assets of his own to invest in the firm.

5. Savings

– People save a percentage of their salary for a 'rainy day'.
– With the money thus saved, people purchase life insurance, buy stocks and bonds, buy shares or deposit in a bank.
– Thus saved money is made available to business enterprises for further use and investment.
– It may be said that almost all capital for investment in business and industry comes from savings of people.

6. Loans

– Money can be borrowed from the following sources for starting or expanding the business,

(*i*) Friends and relations

(*ii*) Money lending institutions

(*iii*) Commercial and other banks, etc.

– When money is borrowed, it becomes obligatory that the interest should be paid in time and the loan be paid back on the mutually agreed date.

7. Shares

– Funds are collected by issuing shares to public.
– The number of authorized shares that can be issued and the value of each share is specified. This is decided on the basis of the capital to be collected by issuing shares.
– Shares are issued for raising funds either when starting a new concern or when it is decided to expand and improve upon the existing one.
– The main division of share capital is into :

1. Preference shares

– Preference shares, as the name implies, have some preferential rights over other types of shares, *e.g.,* dividend is first paid on preference shares and then on ordinary shares.
– Preference shares are entitled to a fixed dividend out of the profit.
– If the company faces a difficult period and is unable to pay dividends, quite possible, the preference shareholders may exert their powers and take over control from ordinary shareholders. This happens when the preference dividends are in arrears.
– Preference shares may be further classed as

(a) Cumulative preference shares. They are entitled to a fixed annual dividend. If this full dividend cannot be paid in any year (because of less profits to company), the rest of deficit can be paid out of future profits, (*i.e.,* profits of next year).

(b) Non-cumulative preference shares. They are entitled to a fixed annual dividend, but the shareholders cannot ask for arrears from future profits if in any year the company fails to make enough profits to pay fixed dividends for that year.

(c) Participating preference shares. They are entitled to a fixed annual dividend plus something from the surplus left after paying dividend to ordinary shareholders.

2. Ordinary shares

Ordinary shareholders are generally paid a higher rate of dividend than that of preference shareholders but they carry greater risks.

- Dividend on ordinary shares is paid only after doing so on preference shares.
- There is no limit of dividend in case of ordinary shares. Ordinary shareholders may get very high rewards in one prosperous year of increased business and no dividend if the business encounters a difficult period.
- The ordinary shares may sometimes be called as *Equity Shares or Equities.*

3. Deferred Shares

- Deferred shares are issued to founders or promoters of the business enterprise.
- Dividend on deferred shares is paid in the last, *i.e.,* first of all, dividend on preference shares is distributed, then it is paid on ordinary shares and in the end whatever profit is left is shared by the deferred shareholders.

8. Debentures

- Business corporations having good record of earnings and favourable prospects of expansion, in search for outside (external) funds to support operations and growth, may raise capital by borrowing it on a formal document known as a *Debenture.*
- Debenture is a certificate of indebtedness issued by the corporation. A fixed rate interest is paid on debentures and the amount is repayable after the stated number of years.
- The essential relationship between the company and the (bond) debentureholder is that of debtor-creditor.
- Debentures are generally un-secured bonds which have no claim on any specific asset of the company but are backed by the earning power and general credit of the company as viewed by the investor. For this reason, only companies with a very good profit record and a high financial standing can hope to sell unsecured bonds or debentures.
- The issue of debentures can be a very useful method of raising finance at reasonable cost.
- *Characteristics of debentures and the difference from shares*

	Debentures	*Shares*
1.	A debentureholder is a creditor only and has no control over the affairs of the company.	1. A shareholder is an owner of the company, *i.e.,* he has ownership interest in the company.
2.	A fixed rate interest is paid on debentures.	2. Dividend is paid on shares.
3.	Interest is paid whether the company runs in profit or loss.	3. It bases upon the type of share whether the annual dividend is paid or not, (depending upon the profit/loss incurred by the company).
4.	A debentureholder gets his money back after the stated number of years.	4. Money of the shareholder is not refunded to him.
5.	In the event of liquidation of the company, a debentureholder will get his money before the shareholder gets something.	

9. Corporate bonds

– Corporate bonds are of two types

1. *Unsecured bonds* or *Debentures* as discussed above, and

2. *Secured bonds,* in which case some form of claim on the assets of the corporation is tied if the corporation fails to pay interest to the investor or does not return his money back after the stated number of years.

Mortgage bonds are examples of secured bonds.

10. Public Deposits

– Public may be asked to deposit their money directly with the company for a fixed long/short period ranging from half a year to seven years.

11. Taking in partners

– Capital may be raised by adding partners in the business who are ready to invest in the firm.

12. Bank loans

– Short term loans are easily available from commercial and other banks on reasonable interest rates.

13. Hire purchase

– The hirer makes a deposit, he gets the machinery (goods), etc., he needs and then he pays a number of periodical money instalments. At the end of a period when all the instalments have been paid, the possession of the goods passes to the hirer.

14. Sale and lease back

– For getting funds, a company may sell some of its property to an investment company with a right to lease back at an agreed rent.

15. Equipment leasing

Many types of fixed assets such as land, equipment, machinery, etc., can be obtained on lease for a number of years on rental basis.

16. Profit plowback

The whole profit is not distributed to shareholders or owners as dividends, rather a portion of it is retained in the business and used to finance expansion and growth of the concern.

17. Credit facilities

A useful source of short-term finance is to obtain goods and services on credit.

18. Trade credit

Trade credit is the financial assistance available from other firms with whom the business has dealings. Most important are the suppliers of inventory which is constantly being replaced.

19. Special institutions

Finance may be obtained by borrowing from an

insurance company;

investment company;

industrial development corporation, etc.

26.6 RESERVE

- Setting up of *reserves* for working capital are very necessary for sound financial administration in order

  to cover credit losses ;

  to liquidate debts ;

  to offset price fluctuations on inventories ;

  to provide for improvement and expansion ;

  for depreciation and obsolescence ;

  for taxes ; and

  against contingencies such as fire, theft and other unexpected liabilities.
- Reserves ensure stability and financial strength to an enterprise.
- Reserves may be classified as

  (*i*) Specific reserves ┐ ——— ┌ Revenue reserves
  (*ii*) General reserves ┘ └ Capital reserves.
- Reserve is not deducted before arriving at the profit, rather it is an appropriation of profit, *i.e.,* reserve account represents the fund to which a part of profit has been allocated.
- *Revenue reserves* are intended to meet commitments which are expected to arise in future such as distributions as-dividends (in future), research and development, to cover possible future losses on exchange, etc.
- *Capital reserves* are made for the purpose of permanently increasing the capital of the concern. Capital reserves are not distributed as dividends.
- The above discussed were specific reserves. It has been observed that many large industrial concerns replace a number of specific reserves by one bulk account and call it *General Reserve.*

26.7. SURPLUS

- A company's cash position experiences various degrees of shortage, balance and surplus over time periods.
- The function of financial manager is to maintain balance so that situations of cash surplus or of cash rationing do not arise.
- The attitude towards a situation of cash surplus will depend upon the nature of surplus.
- Policies may be determined for appraising investment opportunities while the suplus is there ; the aim is to restore the balance.
- The existence of surplus liquid resources, that is, cash and short-term securities will appear in the balance-sheets of the concern and it can be studied how the liquid position has been changing over years.
- Surplus funds may be deployed as follows :

(*i*) Invest the surplus in increased dividends. But once dividends are increased by distributing short-term cash surplus, the shareholders may not be happy if they get less dividend in future when there are no surplus funds with the concern for distributing to them as increased dividends.

(*ii*) Invest the surplus in liquidity, *i.e.,* hold on to the surplus as a policy decision. Such holding of surplus is good for the concern because then, it can be used to meet some non-discretionary expenditures at the time of need.

(*iii*) Surplus funds may also be invested in the equity (ordinary shares) of other companies.

26.8. FINANCIAL ACCOUNTING AND BOOK-KEEPING

26.8.1 Financial Accounting

– Financial accounting is concerned with external transactions *i.e.,* it records all dealings with outside the concern.

Purchase, sale, services, etc. whether for cash or credit are covered in financial accounting.

– *Financial accounting covers*

1. Cash accounts–cash receipts and payments.
2. Personal accounts–credit given and taken.
3. Real accounts–property bought and sold.
4. Nominal accounts–Expenses incurred.

– *Financial accounting meets following objectives*

1. Stock exchange requirements.
2. Legal requirements.
3. Tax requirements.
4. Safeguarding shareholders.
5. Dividend policy.

– *Financial accounting*

1. is a legal necessity;
2. is vital for showing the indebtedness of a concern;
3. serves as evidence of credit worthiness; and
4. serves as a report on Management's social obligations. It deals with matters of interest (such as wages, etc.) to workers and trade unions.

26.9. BOOK-KEEPING

Introduction and necessity of

– It is apparent that in the accounting department there is a large amount of routine work to be performed.

– Cash accounting must be strictly controlled and the various day books and ledgers must be entered.

– As the size of the business grows, no businessman can remember all his transactions and thus he realises the necessity of proper book-keeping.

– Book-keeping is also necessary in order to satisfy the income-tax authorities.

– Proper book-keeping or properly maintained business records show :

(*i*) All purchases, sales and returns in the financial year.

(*ii*) Quantity and value of goods available with the concern.

(*iii*) Transactions with creditors and debtors.

(*iv*) Information about assets and liabilities of the concern.

(*v*) Profit and loss accounts.

(*vi*) Cash available with the concern.

(*vii*) The financial soundness of the concern.

Definition of

Book-keeping may be defined as the art and science of recording all the dealings related to money, goods and services in a systematic manner so that any information pertaining to the business can be easily supplied to the management or the owner of the concern.

Systems of Book-keeping

The following two systems of book-keeping may be used :

1. Single entry system.
2. Double entry system.

1. Single Entry System

- Every transaction is between two persons or two concerns.
- Every transaction, thus, affects two accounts.
- Single entry system records only one side of the transaction and hence it does not provide complete information about a transaction.
- This system of book-keeping is not generally used.

2. Double Entry System

- Double entry system records both the sides of the transaction and thus provides complete information of the business transaction.
- The two sides of a business transaction are

(*i*) The credit side.

(*ii*) The debit side.

- In double entry system, the value of an asset will appear on the left hand side and the value of liability on the right hand side of an account.

26.10. SOME TERMS USED IN BOOK-KEEPING

1. Capital is amount of cash, fixed assets and other goods which one invests in a business.

2. Transaction

The monetary dealing between two persons or two parties is called a transaction.

3. Trade discount

It is a discount or a % deduction from the list price which a seller gives to the purchaser, for example 10 to 15% discount on the printed price of the book is available to a student who buys any book.

4. Drawing

Drawing implies the withdrawal of money by the owner from his business for his personal use.

5. Sales returns

When a customer who has purchased certain goods, returns some of them (due to some reason) to the firm, it is called sales returns.

The reason of return may be either the goods are defective, or they are not in right quantity, etc.

6. Purchase returns

If a firm returns to the vendor the goods purchased from him (due to some reason), it is known as purchase returns.

7. Commission

It is a kind of a remuneration given by a firm to a person for his services rendered to the firm.

8. Cash and credit trade

- It is a *cash trade* when a person buys and sells goods for cash only.
- it is a *credit trade* when a person makes both cash and credit sales and purchases.

9. Debtor

One (person or firm) who owes money to others, *i.e.,* he has to pay money to others.

10. Creditor

One to whom others owe money, *i.e.,* he has to get money from others.

11. Bad debt

A bad debt is one which becomes irrecoverable, for some reason, for example if the debtor dies without leaving any property behind.

12. Turnover

Turnover implies the total (credit and cash) sales of a business.

13. Assets

14. Liabilities

26.11. ASSETS

Definition

- Assets are the resources of the business enterprise, *e.g.,* properties, equipment, stocks, debtors, cash, etc.
- Assets thus, include both money and right to future services.

Types

Assets are conventionally classified on the balance sheet in three major categories, namely :

(*a*) Current assets.

(*b*) Fixed assets.

(*c*) Other assets.

(*a*) Current assets

- Current assets include cash and other assets that, under normal business conditions, can be converted into cash within a short time frame (*i.e.,* 1 year or less).
- Current assets may be consumed in immediate day-to-day operations of the business.
- Current assets include :

(*i*) Cash in hand,

(*ii*) Cash in bank,

(*iii*) Notes receivable,

(*iv*) Investment,

(*v*) Debtors,

(*vi*) Accounts receivable,

(*vii*) All inventories, and

(*viii*) Funds in checking accounts.

(*b*) Fixed assets

- Fixed assets have relatively permanent existence and are not readily converted into cash.
- Fixed assets are held for the purpose of earning income and they are not sold in the course of trading.

– Fixed assets are used in the operations of business.
– Fixed assets include :

(*i*) Land,
(*ii*) Building,
(*iii*) Equipment and machinery,
(*iv*) Furniture, and
(*v*) Transport vehicles.

(*c*) Other assets

– Other assets are those which do not fall into either current assets or fixed assets categories.
– Other assets include

(*i*) Patents,
(*ii*) Copyrights,
(*iii*) Franchises,
(*iv*) Goodwill,
(*v*) Investment in the securities of other companies which management intends to hold for a long time.
(*vi*) Investments in bond sinking funds.
(*vii*) investments in pension funds, etc.

N.B.: *i, ii, iii* and *iv* above are called *Intangible assets* and *v, vi,* and *vii* are known as *Long-term investments.*

26.12. LIABILITIES

Definition

– Those from whom a business enterprise borrows are known as creditors. The creditors have a claim on the business enterprise until they are paid : these claims are termed *Liabilities.*
– Thus liabilities constitute claims against the business enterprise.

Types of

Liabilities may be categorised as

1. Current liabilities,
2. Fixed liabilities, and
3. Contingent liabilities.

1. Current liabilities

– Debts which are expected to be settled within 1 year or less are shown as current liabilities.
– Current liabilites include :

(*i*) A bank overdraft,
(*ii*) Short term loans,
(*iii*) Trade credit,
(*iv*) Notes payable,
(*v*) Wages of employees,
(*vi*) Unearned revenues, *e.g.,* rent or interest received in advance.

2. Fixed liabilities. They are of three types :

(*i*) *Owner's capital, i.e.,* the amount owed by the business to the proprietors.

(*ii*) *Long term debts* or loans to the business ; such as, in the case of a company, bonds, debentures, etc.

Long term debts fall due after more than one year in the future.

(*iii*) *Capital reserves.* Where amounts are allocated out of surpluses with a view to increase the permanent capital of the business, such allocations are credited to a *capital reserve* account which henceforth froms a part of the fixed capital of the concern.

3. Contingent liabilities

- A contingent liability arises if, for example, a person/firm becomes a party to a bill of exchange.
- The contingent liability becomes a real liability if the principle debtor or the acceptor of the bill fails to pay.
- Contingent liabilities include guarantees entered into by the business.
- Contingent liabilities are not entered in an account forming part of double entry system, but they have to be noted on the balance-sheet of limited companies.

26.13. THE JOURNAL AND THE LEDGER

Introduction

- Every business transaction is recorded on the same day (it takes place) in a book called the JOURNAL. Thus, a *journal* is simply a chronological listing of transactions. The journal constitutes the original record of transactions.
- A journal records many accounts related to many persons or firms and thus it is very difficult to trace easily the accounts/transactions related to one person/firm.
- From the journal, the transactions related to each person or firm are sorted out, classified, and entered in a book called LEDGER. Thus,

(*i*) Ledger contains the same information (as given in journal) but properly arranged according to each person/firm it is related to.

(*ii*) In other words, the ledger furnishes a record of transactions grouped according to accounts. Each account reveals the effect of all transactions involving that particular item.

(*iii*) The ledger is split into two halves ; the debit (Dr.) side being on the left and the credit (Cr.) side on the right.

- Fig. 26.1 and 26.2 show an extract from a *journal* and a Ledger respectively.

Example 26.1: Record the following transactions, in a journal and then post the journal entries in the ledger of cash accounts, goods account and capital account.

Transactions		
May 1, 1977	Opened a hardware shop with	Rs. 10,000
May 3, 1977	Brought grinding wheels worth	Rs. 6,000
May 5, 1977	Sold grinding wheels to 'A'	Rs. 4,000
May 6, 1977	Commission paid	Rs. 50
May 9, 1977	Paid to bank	Rs. 1,000
May 12, 1977	Shop rent paid	Rs. 300
May 14, 1977	Purchased conduit pipes	Rs. 3,000
May 16, 1977	Conduit pipes sold	Rs. 2,000
May 17, 1977	Bought welding electrodes	Rs. 1,000

Solution : (See Fig. 26.1 to 26.4)

– The transactions have been recorded in the journal (refer Fig. 26.1). The next step is to transfer the amounts to the respective ledger accounts through a process known as *Posting*. Posting is the process of sorting and collecting the journal entries to various accounts and their recording in the respective ledger accounts. Fig. 26.2 to 26.4 show respective ledgers.

26.14. TRIAL BALANCE

– After posting all journal entries into the ledger, a statement called *Trial Balance* is prepared to check the accuracy of posting into the ledger.

– Trial balance checks the arithmetical accuracy of the entries.

– Trial balance is simply a list of the accounts and their balances at any given date.

– Trial balance is used to test the equality of balances because at any time the debits and credits should be equal in value.

– Besides checking the accuracy of posting into the ledger, the trial balance prepares material for formulating financial statements such as profit and Loss Account and Balance Sheet.

– Fig. 26.5 shows *Trial Balance* prepared from the Ledgers (Fig. 26.2 to 26.4).

JOURNAL

Date 1977	*Accounts*		*Ref. L.F.*	*Debit (Dr.) Rs.*	*Credit (Cr.) Rs.*
May 1	Cash A/c	Dr.		10,000	
	To Capital A/c				10,000
May 3	Goods A/c	Dr.		6,000	
	To Cash A/c				6,000
May 5	Cash A/c	Dr.		4,000	
	To Goods A/c				4,000
May 6	Commission A/c	Dr.		50	
	To cash A/c				50
May 9	Bank A/c	Dr.		1,000	
	To cash A/c				1,000
May 12	Rent A/c	Dr.		300	
	To cash A/c				300
May 14	Goods A/c	Dr.		3,000	
	To cash A/c				3,000
May 16	Cash A/c	Dr.		2,000	
	To Goods A/c				2,000
May 17	Goods A/c	Dr.		1,000	
	To cash A/c				1,000
	Total			27,350	27,350

1. Ref. column is meant for recording the folio of the ledger on which particular account will appear.

Fig. 26.1

LEDGER-CASH ACCOUNT

Debit, Dr.			*Credit, Cr.*		
Date	*Particulars*	*Amount Rs.*	*Date*	*Particulars*	*Amount Rs.*
May 1	To Capital	10,000	May 3	By Goods	6,000
May 5	To Goods	4,000	May 6	By Commission	50
May 16	To Goods	2,000	May 9	By Bank	1,000
			May 12	By Rent	300
			May 14	By Goods	3,000
			May 17	By Goods	1.000
				By Balance c/d	4,650
		16,000			16,000

Fig. 26.2

LEDGER-GOODS ACCOUNT

Debit, Dr.			*Credit, Cr.*		
Date	*Particulars*	*Amount Rs.*	*Date*	*Particulars*	*Amount Rs.*
May 3	To Cash	6,000	May 5	By Cash	4,000
May 14	To Cash	3,000	May 16	By Cash	2,000
May 17	To Cash	1,000		By Balance c/d	4,000
		10,000			10,000

Fig. 26.3

LEDGER–CAPITAL ACCOUNT

Debit, Dr.			*Credit, Cr.*		
Date	*Particulars*	*Amount Rs.*	*Date*	*Particulars*	*Amount Rs.*
April 30	To Balance b/d	10,000	May 1	By Cash	10,000
		10,000			10,000

Fig.26.4

c/d ..... Carried down

b/d ..... Brought down

TRIAL BALANCE

Ledger Account	*Debit, Dr. Rs.*	*Credit, Cr. Rs.*
Cash Account	4,650 *	
Goods Account	4,000 **	
Capital Account		10,000
.....	.....	.....
.....	.....	.....
.....	.....	.....
Total	Rs. Z	Rs. Z

* Balance of cash account.

** Balance of goods account-Refer Ledgers.

Fig. 26.5

– A trial balance discloses the following types of errors :

(*i*) An item posted two times.

(*ii*) A mistake in posting.

(*iii*) A mistake in addition.

(*iv*) An item left from being posted.

(*v*) Money values wrongly recorded (*i.e.*, Rs. 160.0 in place of Rs. 1,600).

– A trial balance will not disclose the following types of errors.

(*i*) *Errors of Commission*—Errors in posting to wrong accounts or compensating errors (*i.e.*, mistake of same amount on debit and credit side.)

(*ii*) *Errors of Omission*—items completely omitted from the books of account.

(*iii*) *Errors of principle*—errors due to lack of knowledge of accounting principles, *i.e.*, treating revenue items as capital, etc.

26.15. TRADING ACCOUNT

– The trading account shows the gross profit or gross loss on trading for the period covered.

– The trading account shows debit on the left hand side and credit on the right hand side (refer Fig.26.6).

– The debit side includes opening stock, the purchase, direct expenses, etc.

– The credit side marks sales, closing stock, etc.

– The difference between debit and credit sides shows either gross profit or gross loss.

– Fig. 26.6 illustrates trading account.

TRADING ACCOUNT

Debit, Dr.			*Credit, Cr.*		
Date	*Particulars*	*Amount Rs.*	*Date*	*Particulars*	*Amount Rs.*
March 1, 1977	To Stock (opening)	10,000	March 20	By Sales	13,000
March 3	To purchase	6,000	March 25	Less returns from customers	(−)300
March 10	To wages	500			
March 15	To carriage & octroi	100	March 31, 1977	To stock (closing)	4500
	To gross profit	600			
		17,200			17,200

Fig. 26.6

26.16. FINANCIAL STATEMENT

Introduction and Significance

- Financial statement of a business enterprise constitutes the general purpose, external reports of that enterprise.
- Financial statements are prepared for both internal dissemination within the corporation and for external distribution to the shareholders, creditors, the government and others having an interest in the financial position of the corporation.
- Financial statements have *significance* because :

(*i*) They are of interest to managers, owners, the lenders, the employees, the creditors and almost everybody who is concerned with the business.

(*ii*) Many business decisions are made only after consulting the financial statements or after financially justifying the move.

- Financial statements usually include
  1. Income statements (or the profit-and-loss statement)
  2. Balance sheet.

Profit and Loss Statement

- Income statement or profit and loss statement is a statement of revenues and expenses for a specified period of time.
- The income statement reports the results of operations of a given period.
- The statement starts with a report of the income for the period, from which are deducted all the costs incurred as a result of operations.
- The net figure is the profit or loss for the period.
- Fig. 26.7 shows a simplified income statement or profit and loss account.

Balance Sheet

- A balance sheet is a statement showing the financial status of the company at any given time.
- A balance sheet is a statement of assets, liabilities and capital (or net worth) at a specified date.

In other words, the balance sheet shows a summary of the sources of the (business) enterprise resources and of the investment of those resources in various assets.

- Balance sheets are prepared at least annually but may be done so more often and on specific occasions when the need exists in connection with making decisions concerning large project investments, dividend distribution, etc.

Fig. 26.8 shows a simplified balance sheet.

A.B.C. Co.
Income Statement
Month Ended March 31, 1977

Revenues :		
Sales		Rs. 50,000
Expenses :		
Cost of goods sold	Rs. 25000	
Selling expenses	Rs. 8000	
Administrative expenses	Rs. 10000	
Total expenses		Rs. 43,000
Income tax		Rs. 5,000
Net income (or Net profit)		Rs. 38,000

Fig. 26.7. Profit and Loss Statement.

A.B.C. Co.
Balance Sheet
March 31, 1991

LIABILITIES	Rs.	ASSETS	Rs.
Current Liabilities :		**Current Assets :**	
Creditors for expenses	.....	Cash in hand	.....
Trade creditors	.....	Cash at bank	.....
Bills payable	.....	Bills receivable	.....
Bank overdraft	.....	Debtors	.....
		Inventory	.....
Long-term Liabilities :		**Investments :**	
Long-term loan	.....	**Fixed assets :**	
Mortgage on property	.....	Furniture and fittings	.....
Owner equity		Plant and machinery	.....
Capital	.....	Building	.....
Retained profits	.....	Land	.....
		Goodwill	.....

Fig. 26.8 Balance Sheet of a Corporation

26.17. FINANCIAL RATIOS

- Much of the *financial information* is reported in the firm's *financial statements*.
- Many diverse groups of people are keenly interested in the information found in the firm's financial statements. They study the statements carefully, interpreting the information that relates to their particular interest in the company.
- The principal idea in analyzing *financial ratios* is that there are several key ratios, obtainable from the firm's financial statements, that reveal the financial and non-financial health of the firm. In general, we will look at *four* categories of ratios, each attempting to measure a particular aspect of the *firm's position* and *performance*.

1. Liquidity ratios — Current ratio, Quick ratio
2. Activity ratios
3. Leverage ratios--Debt equity ratio
4. Profitability ratios.

- *Liquidity ratios* reflect the firm's ability to meet scheduled short-term obligations.
- *Activity ratios* measure how well the firm is managing various classes of assets (like inventory and fixed assets).
- *Leverage ratios* show how much debt the firm has used to finance its investments.
- *Profitability ratios* are designed to reflect the profitability of the firm.

1. Liquidity ratios

- For the firm to remain *alive*, it must be able to pay its bills as they become due. Liquidity ratios measure the extent to which the firm can meat its immediate obligations.
- Liquidity ratios also reflect the firm's ability to meet short term financial contingencies that might arise.
- There are *two* commonly used liquidity ratios :

(*a*) Current ratio, which relates current assets to current liabilities. *Current assets* include cash, bank balances, marketable securities (like stocks and bonds), accounts receivable and inventory.

Current liabilities include accounts payable, bank loans, taxes payable and other accrued expenses.

$$\text{Current ratio} = \frac{\text{Current assets}}{\text{Current liabilities}} \qquad ...(i)$$

Relatively high values of the current ratios are interpreted as an indication that the firm is liquid and in good position to meet its current obligations and vice-versa.

(*b*) Quick ratio

Inventory is typically the least liquid component of current assets; the quick ratio is the same as the current ratio only with inventory subtracted from the numerator.

$$\text{Quick ratio} = \frac{\text{Current assets} - \text{Inventory}}{\text{Current liabilities}} \qquad ...(ii)$$

Like the current ratio, the quick ratio or *acid-test ratio* is meant to reflect the firm's stability to pay its short term obligations and the higher the quick ratio, the more liquid the firm's position.

2. Activity ratios

- Activity ratios are called *turnover ratios* because they show how rapidly assets are being converted (turned over) into sales.

- High *turnover* ratios are generally associated with good asset management and *vice-versa*.
- *Inventory turnover* shows how efficiently the firm's inventory is being managed. It is a rough measure of how many times per year the inventory level is replaced (turned over).

$$\text{Inventory turn over} = \frac{\text{Sales}}{\text{Inventory}} \qquad \text{...(iii)}$$

Generally higher than average inventory turnovers are suggestive of good inventory management and *vice-versa*.

- The *collection period* attempts to measure how efficient the firm's collection policy is by calculating how long it takes to collect the firm's accounts receivable.

$$\text{Collection period} = \frac{\text{Receivables} \times 365 \text{ days}}{\text{Sales}}$$

Collection period figure (assume it calculates to be 40 days) really means this : Assuming all sales are made on credit, how many days worth of sales are tied up in receivables?

Shorter collection periods are usually viewed as an indication that the firm's receivables policy is fairly effective.

- *Fixed assets turnover* ratio is sales divided by fixed assets. This ratio is a measure of how well the firm uses its long term (fixed) assets.

$$\text{Fixed assets turnover} = \frac{\text{Sales}}{\text{Fixed assets}}$$

In general, higher than average fixed assets turnover ratios are supposed to reflect better than average fixed asset management and *vice versa*.

- *Total assets turnover* is defined as sales divided by total assets.

$$\text{Total assets turnover} = \frac{\text{Sales}}{\text{Total assets}}$$

In principle, high total assets turnover ratios are supposed to indicate successful asset management and *vice versa*.

3. Leverage ratios

- Leverage ratios indicate to what extent the firm has financed its investments by borrowing.
- Leverage ratios reflect the financial risk posture of the firm ; the more extensive the use of debt, the larger the firm's leverage ratios and more risk present in the firm.
- While there are many leverage ratios, we will only look at two : the *debt equity ratio* and *times interest earned*.
- *Debt equity ratio* is the ratio of the total *debt* in the firm, both long-term and short term to *equity*, where equity is the sum of common and preferred stockholders' equity.

$$\text{Debt-equity ratio} = \frac{\text{Total debt}}{\text{Equity}}$$

A high ratio means that the firm has liberally used debt (has borrowed) to finance its assets and vice versa.

Any ratio over 1.0 means the firm has used more debt than equity to finance its investments.

- *Times interest earned* is the sum of net income before taxes and interest expense divided by interest expense. It is supposed to measure how ably the firm can meet its interest obligations.

$$\text{Times interest earned} = \frac{\text{Net income before taxes} + \text{Interest expense}}{\text{Interest expense}}$$

4. Profitability Ratios

— These ratios tell the story about the firm's past profitability.

— Profitability ratios are:—

$$(a)\ \textit{Profit Margin} = \frac{\text{Net income}}{\text{Net Sales}}$$

The profit margin is an important ratio because it describes how well a rupee of sales is *squeezed* by the firm into profit.

$$(b)\ \textit{Return on assets} = \frac{\text{Net income}}{\text{Total Assets}}$$

The intent of this ratio is to measure how profitably the firm has used its assets.

$$(c)\ \textit{Return on equity} = \frac{\text{Net income}}{\text{Equity}}$$

It indicates what kind of rate of return was earned on the book value of the owner's equity.

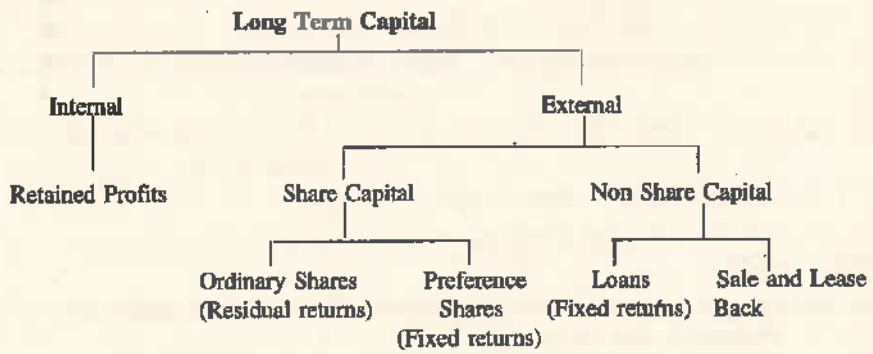
26.18 SOURCES OF FINANCE

Introduction

— The *business finance* is an activity concerned with raising and administering of funds used in business.

— The capital requirements of on industrial unit can be divided into three categories, namely

1. Long term capital (Fig. 26.9)
2. Medium term capital (Fig. 26.10)
3. Short term capital (Fig. 26.11)



Legend : Can be of different types.

1. Deferred, Voting or Non-Voting.
2. Participating, Cumulative or Non-cumulative, Redeemable or Irredeemable.
3. Secured or Unsecured, Convertible or Non-convertible, Redeemable or Irredeemable.

Fig. 26.9 Methods of raising long term capital

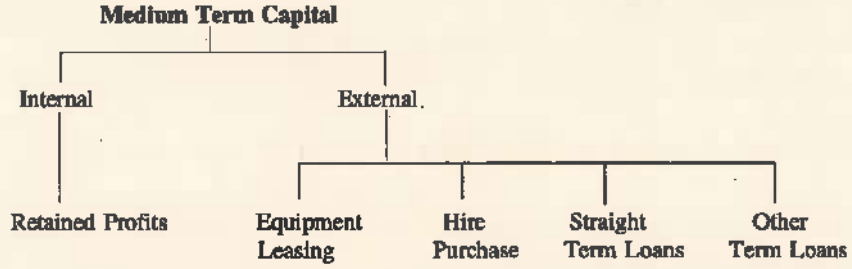


Fig. 26.10 Methods of raising medium term capital

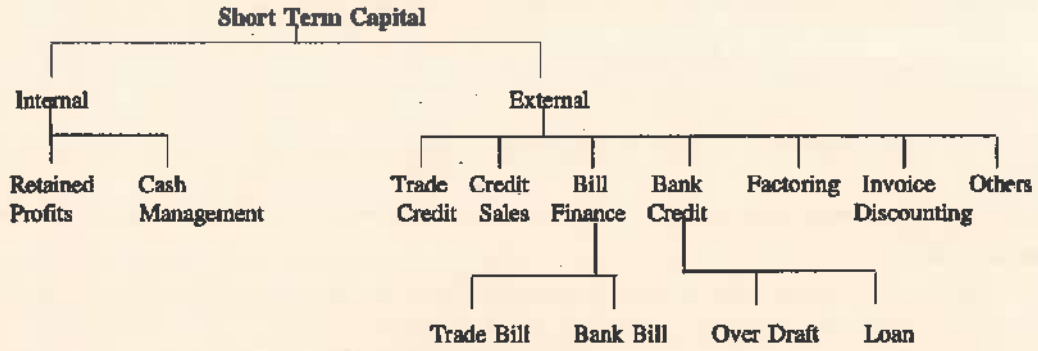


Fig. 26.11 Methods of raising short term capital

General sources of capital areas

(1) *Private* – Individuals, family, friends

(2) *Credit* – Suppliers

(3) *Profits* – General reserves, special reserves

(4) *Private sector institutions* – Banks, Insurance Companies, Industrial and Commercial Finance Corporation.

(5) *Public Authorities* – Industry Act 1972, National Research and Development Corporation

(6) *General Public* – New Issues

(7) *Others* – Pension funds etc.

Time Periods

The time periods associated with the methods and sources of capital are:

1. Permanent and Long Term.
2. Medium Term.
3. Short Term.

There are no clear cut demarcating lines between these various periods of time but it is common, from the view of financial managers of firms, to associate them with the following periods :

1. *Permanent* : Finance that is not expected to be repaid as long as the business operates.

   Long Term: Finance originally scheduled to be repaid over a period of five years or longer.

2. *Medium Term*: Finance to be repaid in more than one but less than five years.

3. *Short Term*: Finance originally scheduled for repayment in less than one year.

Which period is selected by the firm will depend upon a number of things such as the reason for which it is being used, the financial institutions providing the capital and the terms associated with the form of lending.

(1) *Long term funds are required for*

Fixed Assets —Land and Buildings
Factory and Machinery
Fixtures and Fittings

(2) *Medium term funds are required for*

Fixed Assets —Movable and Mobile
Furniture
Motor vehicles

(3) *Short term funds are required for*

Current Expenses — Direct and Indirect production expenses
Current Assets — Raw material
Work in progress
stock.

(1) Preference Shares

— There are many varieties of these, each with differing rights and benefits. The holders of preference shares are usually entitled to a dividend at a fixed percentage out of profits in priority to any other class of shareholder and usually have preferential right to the return of their capital when a company is wound up. However, these shares rarely carry voting rights.

(2) Debentures

— These are not shares in the company and therefore the holder to a debenture is not an owner of the company. Debentures are basically securities which have been issued by the company in consideration for a loan. They carry fixed interest rates and give no right to voting in company meeting. Since debenture holders are creditors of the company they rank with other creditors before shareholders in the assets of the wound-up company.

(3) Ordinary Shares

— Holders of these shares have an equal right to share in the profits and the assets of a "wound up" company after prior claims of Preference shareholders and Debenture holders have been met. Normally these shares also carry voting rights.

— Whilst ordinary share capital tends to dominate the capital structure of the joint stock company the majority of companies in the U.K. have adopted other forms of capital. The basic reason for this is that the ordinary shareholder whilst accepting the risks of a company failure desires the best return possible on his investment. If the company can borrow money from other sources at low interest rates, the difference between the return the company makes by using that money and the interest they have to pay to borrow it, adds to the profits of the ordinary shareholder.

— Secondly, raising money by issuing securities which confer a variety of rights and benefits on the investor, will widen the appeal of such securities and improve the revenue raising prospects of the company. A brief sketch of some of these *other securities* and their characteristics follows :

— **The equity shareholders**, a term which signifies their being entitled to the equity of the business, i.e. the profits and assets remaining after the prior claims of all fixed interest bearing stocks have been met, may rightly expect voting powers which give them some say in the running of the business, but by various methods they are sometimes divested of this.

(4) Non-voting Ordinary shares

— The issue of non-voting shares is held by some to be justified in certain circumstances, *for example* where it is desired to retain control in the hands of the original shareholders. Capital transfer tax has caused problems in this respect when it has been necessary to sell certain shares in a company, and various schemes have been devised to overcome this; but if an issue of, say, one for one of non-voting shares is made, no disturbance of the original control need take place. It is also maintained that necessary capital may be obtained without the risk of a take-over bid, as the controlling shares may be retained while no incentive is given to buy up the non-voting shares.

— A *further justification* for the issue of *non-voting Ordinary shares is* claimed in that the market for the company's shares is widened.

It would seem that the objections raised outweigh the advantage claimed for such shares since they appear to be undemocratic, there being holders of equity share capital having to bear their shares of the risks but having little or no chance of exercising any power in the control of the company. Moreover, virtually complete control may be gained by a minority of the shareholders.

(5) Redeemable equity shares

— Redeemable equity shares may be issued which must be cancelled on redemption. The rules as to their redemption is as for redeemable preference shares. These could be useful to a company which desires to obtain capital for a certain project or projects in which the shareholders may participate in the increased profits. When the projects have repaid themselves, the shares may be redeemed.

— Although such shares may form only a small proportion of the total share capital they can prove very remunerative to the holders, as they may be entitled under the Articles to a very high rate of dividend. They may also confer the same voting rights as Ordinary shares or may be stated to be convertible to Ordinary shares after the lapse of a certain period.

(6) Stock

Fully paid shares may be converted into stock or stock units. Although stock may not be

issued directly, it has the advantage of allowing transfer fractionally, whereas shares must always be transferred in whole units and consequently according to their numbers. Since stock is not numbered, a considerable saving in clerical work is afforded by its use.

(7) Retained Profits

— In general, *internal funds* are a more important source of finance for small firms than for large, mainly because small firms are reluctant to seek finance from outside. Moreover smaller companies are not able to raise capital from outside sources easily. Nevertheless firms of all types and sizes *plough back profits into the business*. Prior to World War I the expansion of most firms came from *retained profits*. Since that time the rapid rise in taxation and the rapid pace of inflation have combined to make it more difficult for firms to rely on this method. Today, although less important, it still must be considered as being very important.

The term *retained profits*, as would be explained by an accountant, consists simply of the amount of net profit that has not been taken by taxation or used for the payment of dividends to shareholders.

— *Ploughing back profits*. An efficient company will usually ensure that not all its profits are distributed and adequate funds are ploughed back into the business by creating reserves or sinking funds for such matters as replacement of assets or acquisition of new ones.

Where reserves or sinking funds are set aside for specific purposes and not merely for strengthening the business as a whole, to ensure that such sums are available when required and to avoid their becoming absorbed in various assets of the business, they are usually invested outside the company and realised as and when required.

(8) Loan Capital

— Where capital is required but not of a permanent nature, it may be obtained by borrowing either on long term *loans* or for more immediate repayment.

— The most important method of raising capital on a long term basis is by means of *Debentures*.

— A Debenture is a document given by a company in acknowledgement of a debt, undertaking to repay the stated sum on or before a certain date, and in the meantime to pay interest at a fixed rate, usually in half-yearly intervals.

(a) *"Simple"* or "naked" Debentures

Such Debentures offer no charge on the assets of the company as security for the loan and in the event of winding up, the holders of such Debentures rank *pari passu* with ordinary unsecured creditors and can claim no priority or repayment.

(b) *Mortgage Debentures*

Debentures more usually give a charge over the assets of the company and in such a case are termed "Mortgage Debentures". The charge may be a fixed charge, that is, on certain assets of the company, or a floating charge. Not infrequently a charge may be conferred on some specified assets of the company in the form of a fixed charge, and in addition a floating charge may be given on the whole of the company's undertaking.

In the case of a fixed charge, the effect is to lease the property charged to the Debenture holders, so restricting the company's right to deal in the property in any way until such

time as the Debentures are redeemed.

Where a floating charge exists the property may be dealt with as if no such charge existed. If the company makes some default on a condition in the deed and action is taken by one or more of the Debenture holders to enforce the security, the charge crystallises, or in other words becomes fixed on the assets as they then exist.

(c) *Debenture stock*

Debenture stock constitutes, as do Debentures, evidence of a debt, but instead of each lender holding a separate bond he has a certificate entitling him to a specified portion of one loan.

(d) *Bearer Debentures*

Debentures payable to bearer are transferable by delivery and any bonafide transferee for value becomes the legal owner of them.

Debentures are frequently issued at a discount and may be redeemable at a premium.

(9) **Sale and Lease Back**

— Some companies own their premises whereas others operate in rented property and buildings. The former organisations have the opportunity to use this method to obtain finance; the latter do not.

— The normal procedure is for the firm to sell their factory or other property, for example, a warehouse or retail outlet, to an organisation who would undertake to lease back the property to the seller for a long period of time. The seller receives a sum of money which it intends to invest, and the purchaser receives the title to the property and a negotiated annual rental. The leases vary from a common period of 40 to 50 years and sometimes for much longer periods. Rents are reviewed and revised at intervals normally ranging from 5 to 7 years but usually never longer than 14 to 15 years.

— For this method it is essential, from the purchaser's point of view, that the property is an attractive investment. From the seller's point it may be attractive because the rental may be lower than the interest they would have to pay had they raised their capital from a mortgage debenture.

— If a company wishes to expand and to obtain immediate resources, this method of obtaining funds may be used, but it must always be borne in mind that the additional rental charges have to be met over a period of years when profits may fluctuate and the company's own position, from the point of view of fixed assets, is not so strong.

— **Some basic advantages associated with this method are :**

1. The method can be used to obtain funds for other investment opportunities. The argument used is that the properties sold under this method do not make profits for the firm; that it is the turnover of working assets that makes the profits. Thus the sale and leasing back of non-profitable property to invest in more working assets enhances the expansion and profits of the firm.
2. The firm is able to increase tax deductions and can, as a result, improve its cash flows.
3. It is possible to raise more funds from the sale of a specific property than it could through mortgaging the property.

— **The disadvantages are :**

1. The flexibility of the firm can be reduced if the lease does not allow them to modify the property.

2. At the termination of the lease any residual value remains with the owner.
3. The rental paid is a fixed charge against income.

For more information on the various aspects of leasing refer to the section on equipment leasing.

— *Sources of Sale and Lease Back*

Insurance companies, Property investment companies, pension funds, Finance houses etc.

(10) Equipment Leasing

— This method of obtaining finance is analogous to that of renting a property.

— The procedure employed is that the *financial institution* will purchase the asset desired by a *customer* from the supplier and then as the lessor (owner of the asset) will lease it to the customer (the lessee) in return for specified equal payments for a stated period of time. The initial lease is usually up to five years.

Source of equipment leasing

Mainly from finance houses, specialist leasing companies, leasing departments or subsidiaries of manufacturers.

(11) Hire Purchase

— Hire purchase is a method of obtaining finance from a financial company to purchase an equipment/machinery/vehicle etc., on medium length terms. The user can use the machinery without paying outright its price; rather he can earn out of the (use of) machinery and pay to the financial company in terms of hire purchase instalments.

— The procedure for hire purchase is similar to equipment leasing.

— The financial institution purchases the asset on behalf of the customer from the supplier (or dealer) and hires it to the customer. The finance provided is for a specified asset. A deposit is made by the customer and the balance due is spread by equal instalments at specified dates over a fixed period of time usually up to 5 years (or more even). The reason for the longer period of time is that the working life of the asset is longer than usual.

— The hire purchase company ensures itself security and reduces the risk it takes when entering into a hire purchase agreement by :

(i) Asking for a deposit, and

(ii) By shortening the period of time for repayments.

Upon satisfactory completion of the payments the hirer is given the option to purchase the asset for a small sum, and in the majority of cases this is done. It is this option to purchase which is the main *difference* between *hire purchase* and *equipment leasing*.

— Small firms tend to hire purchase farm equipment, tractors, motor vehicles, machine tools, printing machines etc.

— *The advantages of hire purchase are* that (i) the customer has to make payments from revenue, it need not raise finance to purchase the asset (ii) the customer can conserve its financial resources, (iii) tax relief can be claimbed in respect of annual (wear and tear) allowances, (iv) the hire has option to purchase the asset.

— *The disadvantages associated with hire purchase are* that (i) a down payment is required (ii) the cost is considered to be expensive. For example, the flat (interest) rate may be, say, 15%, but the true rate may be almost twice this rate (iii) the hirer has to maintain asset in good order etc.

Sources of hire purchase

Mainly from finance houses, specialist hire purchase companies.

To a lesser extent from associates, subsidiaries and departments of clearing banks and merchant banks.

Term Loans (Straight)

— A term loan refers to a method of lending whereby the lender advances a fixed sum of money at a fixed rate of interest to the customer and the sum is repaid by him by regular instalments over a fixed period or paid in full at a given date.

— *Advantages of term loans as compared to Bank overdrafts*

(1) Term loans are not withdrawn because of changes on which the borrower has no control such as credit squeeze. (overdrafts can be withdrawn).

(2) Term loans are agreed to a fixed period and are not reduced. (Bankers can ask that overdrafts be paid on demand).

(3) Little time is taken to negotiate agreements. (overdrafts may require renegotiation every 3 to 6 months).

(4) Payments are made from revenue.

(5) Normally more money can be raised than by the overdraft method.

(6) Tends to be cheaper than hire purchase or equipment leasing from the financial (rather than servicing) point of view.

(7) Ownership of the asset can be immediate, as opposed to hire purchase and equipment leasing.

(8) The asset can be used as security for raising additional finance.

— *Disadvantages associated with term loan*

(1) They are not cheap. The longer the period the greater the risk to the lender and this is reflected in the interest rates charged.

(2) They are more difficult than overdrafts to borrow. Lenders require a higher standard of credit worthiness.

(3) Term loans must be repaid regardless of the firm's business position.

(4) Repayments must be met on due date and thus lack the flexibility associated with overdrafts.

(5) Large repayments can create abnormal cash drain.

Sources of term loans (straight)

Clearing banks, Merchant banks, Finance houses etc.

Term Loans (others)

— These loans are other than straight term loans. In most respects they take the same form as straight term loans but vary in that the terms and conditions of the loan are tailored to fit the particular circumstances of each case.

Another difference is that the rates charged can change when they are reviewed every six months.

Sources of term loans (others)

Mainly secondary banks, for example, merchant banks.

Cash Management

— Cash is a commodity which businesses too often seek from external sources without first taking a closer look at home. Generally large companies have large cash resources and carefully manage their cash. Smaller companis are usually short of cash and generally are poor managers of their cash. There is a need for firms to improve their knowledge on cash collection and disbursement. This requires a thorough examination of the company's system of processing cash.

— Cash collection refers to ways of speeding up incoming cash and establishing procedures by which reductions in cost can be made. Getting invoices to customers as early as possible is one way to speed incoming cash.

— An invoice sent out early can result in cash being paid a day or more early and thus build up the cash available. When measured over the year the total sum available can be quite considerable. Cash is in hand, discounts can be obtained and less need to raise money from external sources are the results of the speed up in invoicing.

— Improvements in disbursing cash may also be possible. A cheque paid to your creditor may be delayed by a day or more without losing discounts or credit rating. Or, in drawing a cheque an analysis should be made on the time it takes to post it, the time it takes the post office to deliver it (the greater the distance the greater the time or the more obscure the location the greater the time?), the time taken by the creditor in handling the cheque before presentation to their bank and the time taken by the banks in clearing the cheque. Perhaps 4, 5 or more days use of this money may be available to your firm, but accurate clearing times must be established.

— *Positive cash management* means cash is available for use by your firm where before it was considered that it did not exist; *hidden cash*. The use of this cash creates savings throughout the year; savings are greater the larger the number of times invoices are sent to your customers in the year; the same idea applies to cheques sent to your suppliers. The result is that the minimum cash balance kept in your current account may not have to be as large as it was, and the amount of interest saved by not having to use external sources may be quite substantial.

— *Positive cash management* means that cash flows must be understood, cash and potential cash should be identified, and that cash should not be wasted, for example, holding unnecessary sums of cash in current accounts when it could be put to work and make money for the company.

Trade Credit

— Trade credit is a natural method of obtaining finance in that it arises from ordinary business transactions.

— Trade credit is an arrangement between a firm purchasing materials or supplies and its suppliers whereby the supplier delivers the goods and then agrees to defer payment of the debt. The supplier (creditor) shows this on his balance sheet in the form of a credit item whereas the receiver of the goods (debtor) will show it as a debit item on his balance sheet. It is quite normal for the deferment period to be around one month.

— Nearly every firm receives credit from its supplier and most give credit to their customers. The exception to this statement is in non-manufacturing firms especially those in the cash retail trade. To small and large firms the use of trade credit is an important source of working capital, but the extent to which it is given is mainly determined by the industry and not the size of firm. The importance of this method is that it is normally the largest single category of short term credit; even larger than Bank credit.

— Terms are usually arranged by the supplier to induce the customer to pay the debt before the due date. For example, a discount of 2% may be obtained if the debt is payable before 10 days, but between 11 and 30 days, the payment is net.

Advantages

(1) Normally free from expenses (free of interest rate).

(2) Flexible, convenient and informal.

(3) Useful in promoting sales.

(4) Can, with wise use, promote sound customer relations.

Disadvantages

(1) Can be risky method. Control of firm can be lost, if the debtor fails to pay large debt to a single supplier.

(2) Excessive credit given may force firm to borrow money.

(3) Every debtor is a potential source of loss of cash. Bad debts.

Credit Sale

— A *credit sale* refers to the method of selling whereby the customer agrees to purchase goods and pay by instalments. Ownership of goods passes to the purchaser immediately. In the seller's books the purchaser becomes an unsecured debtor.

— This method is similar to hire purchase but possibly not so expensive.

The *similarity to hire purchase* is that the goods are capital goods and the buyer enters into an agreement and agrees to pay off the debt in equal instalments.

It *differs* from hire purchase in that the length of credit time is normally from about 6 months to a year and ownership is immediate.

Bill Finance

— The term *bill* refers to a *bill of exchange* which is nothing more than a special form of cheque which has been *post dated* usually 90 days forward. On occasion it could be for 30 days or even 180 days.

— In law, a bill is "an unconditional order in writing, addressed by one person to another, signed by the person giving it, requiring the person to whom it is addressed to pay on demand or at a fixed or determinate future time, a sum certain in money to or to the order of a specified person or to the bearer".

— *Bills can be classified* under two main headings

(1) Trade bills (2) Bank bills

— The *Trade bill* relates to a bill drawn by a seller of goods (drawer) addressed to the buyer of goods (drawer) who, when receiving it, either writes across the face 'accepted' and signes it or pays a commission to a financial institution to accept it on his behalf. As soon as it has been accepted the person accepting it substitutes his credit for that of the drawer. He accepts liability to pay the bill on the due date.

— The *Bank bill* refers to a bill drawn by a person seaking finance to purchase goods and expecting to pay the bill on the due date.

— Trade bills are not normally as acceptable for discounting as are bank bills.

Bank Credit

— *Bank credit* refers to *overdrafts* and *short term bank loans.*

The source for bank credit are banks who rely for their funds largely from their depositors in the form of current and deposit accounts which can be withdrawn, respectively, on demand and very short notice.

— An *overdraft* is an agreement made by a banker whereby the bank agrees to honour cheques drawn on a *current account* up to a stated sum when that account has insufficient funds to meet such cheques. The rate of interest charged is on the amount of the total loan used.

For most companies (and individuals) it is the easiest and most convenient form of borrowing, and for many small businessmen, it is the most important external source of finance outside their normal trading activities.

— A *loan* for a short period of time is a method whereby the bank credits the customer's current account with a deposit to a stated amount for a given period of time (as may be arranged) for example, a year, nine months or for a shorter period.

The rate of interest charged, unlike the rates charged on to overdrafts, is calculated on the total amount *provided.* Loans of this type are a cheap way of raising finance compared with many other methods, but, they are not as important nor so convenient (in terms of interest payments) as overdrafts.

Factoring

— *Factoring* refers to the purchase of a firm's book debts by a *factor.* The *factor* which is a specialised type of privately owned finance company that purchases accounts receivables, receives payments directly from the buyer of goods, quite unlike *invoice discounting.*

The only *common element* between factoring and invoice discounting is that they both are involved in the purchase of book debts.

— *Basically, there are two types of factoring*

(1) *Without recourse* — a method whereby the factor has no claim on his client, the seller of the receivables, should the factor not be able to obtain payment from the customer. Most factoring is of this type.

(2) *With recourse* — a method whereby the factor can claim payment from his client should the customer, who owes the debt, not pay.

— The factoring company combines book-keeping, credit insurance and the supply of finance; the latter being the main function.

Advantages

(i) Funds can be obtained almost immediately. Liabilities can be paid and cash accumulated.

(ii) Debts can be paid promptly for the best possible cash discounts.

(iii) The problem of the client's creditors urging debts be paid soonest are removed.

(iv) The clients' credit image is improved.

Disadvantages

(i) A restrictive method for most small firms.

(ii) Arrangements are for an extended period and not for 2 or 3 months duration.

(iii) The client uses a highly liquid asset as security.

(iv) When invoices are large in number the administrative costs may be high.

(v) A great deal of confidential business information is passed on to the factor.

Invoice Discounting

— Also known as *confidential invoice discounting*, because the discount firm makes no notification to the buyer of goods that the seller of the goods has borrowed money against their debt.

The discount firm has no contact with the buyer; the seller collects the debt and it is the seller the discount firm goes to, to collect the face value of the debt.

— Borrowing against receivables or book debt may be the answer for a company that is really in need of cash or for a company who has considerable amount of working capital tied up in receivables.

It is considered to be very expensive, so companies are often advised to exhaust other possible sources of finance first.

Advantages

(1) Same as (i) to (iv) as mentioned under *factoring*.

(2) The client's debtors are not informed of the financial arrangement.

(3) It is flexible in that the client can discount his debts, up to an agreed limit, as and when he desires.

26.19 CAPITAL (Refer article 26.3 also)

Concept

— Capital is an important factor of production.

— Capital is that part of *wealth* which helps in production of further wealth, e.g., seeds, machinery etc. An electric fan in the house is a *wealth* but a fan in an office or factory is a *capital*.

— *Capital* may be *classified* as

(i) *Physical capital*, like immovable property, seeds, fertilizers, business capital like goodwill of the firm etc.

(ii) *Financial capital* like bonds, shares, etc.

Features of Capital

— Capital is produced by man by saving wealth.

— Capital is a factor of production.

— Capital is transferable from one person/place to another.

— Constant use of capital leads to its depreciation.

— Capital is mobile as it can be moved from one occupation to another.

— Supply of capital as a factor of production can be easily increased or decreased.

— One has to toil hard to accumulate capital. It is man-made and not a free gift of the nature.

— Capital is the outcome of saving because saving when used in productive activities is called capital.

Types of Capital

(1) *Fixed or block capital* — it is required to purchase building, machinery, tools etc.

(2) *Working or current capital* — it is required to meet day-to-day needs and expenditures such as purchase of raw material, payment of employee wages etc. (refer page 26-2)

26.20 WORKING CAPITAL (Refer article 26.4 also)

Concept

— Working capital means *current assets*.

— *Current assets* means assets which can be converted into cash within an accounting year and includes cash, short term securities, bills receivable, stock etc.

— *Gross working capital* refers to the firm's total investment in current assets.

— *Net working capital* = current assets – current liabilities.

— The term *working capital is commonly used* for the capital which is required for day-to-day working in a business concern, such as for purchasing raw material, for meeting day-to-day expenditure on employee salaries, wages, rents, advertising etc. (*Refer article 26.34*)

Classification

Working capital may be *classified* as follows :

(1) ***On the basis of concept***

Working capital may be classified as

(i) Gross working capital

(ii) Net working capital

These terms have been discussed above.

(2) ***On the basis of periodicity of requirement***

Working capital may be

(i) *Fixed* or *permanent* working capital — Regular working capital; Reserve margin or Cushion working capital

(ii) *Variable* working capital — Seasonal working capital; Special working capital

Permanent (or Fixed) Working Capital

— This capital is permanently locked up in the current assets to carry out the business smoothly.

— This investment in current assets is of the permanent nature and will increase as the size of business expands.

— Permanent working capital is that minimum amount of investment in raw materials, work-in-process inventory, finished goods, stores and spares, accounts receivable and cash balance which a firm is required to have in order to carry on a desirable level of business activity.

— Such an amount cannot be reduced if the firm wants to carry on the business operations without interruption.

— It is that minimum amount which is absolutely essential throughout the year on a continuous basis for maintaining the circulation of current assets.

— *Minimum cash* is required for making payment of wages, salaries, and other expenses; *minimum stock* is required to maintain regular supplies and *minimum investment* in debtors is essential on account of credit sales according to the period of credit allowed to the customers.

— Since the requirement of *permanent* or *hard core working capital* is on a permanent basis, such working capital should be financed out of *long-term funds.*

Characteristics of permanent working capital

(1) The size of permanent working capital grows with the growth of business.

(2) It keeps on changing its form from one current asset to another.

(3) As long as the firm is a going concern, working capital cannot be substantially reduced.

(a) **Regular Working Capital**

It is the minimum amount of liquid capital needed to keep up the circulation of the capital from cash to inventories, to receivable and again to cash.

This would include sufficient minimum bank balance to discount all bills, maintain adequate supply of raw materials etc.

(b) **Reserve Margin or Cushion Working Capital**

It is the *excess over the needs* or regular working capital that should be kept in reserve for *contingencies* that may arise at any time.

These *contingencies* include rising prices, strikes, special operations such as experiments with new products etc.

Variable Working Capital

— Variable working capital requires changes with the increase or decrease in the volume of production or business.

— Variable working capital can be classified as

(i) *Seasonal working capital*

(ii) *Special working capital*

— The working capital required to meet the *seasonal needs* of the industry or business is known as **seasonal working capital.** *For example,* if an enterprise is marketing woollen garments, it needs more money for that purpose during winter months than in summer season. Similar is the case with a factory/business engaged in the production or marketing or coolers, refrigerators or air-conditioners. They are all Seasonal products.

— **Special working capital** is that part of the variable working capital which is meant for meeting the special business operations such as extensive marketing compaigns, experiments with products or methods of production, etc.

The *distinction between fixed and variable working capital* is of great significance particularly in raising the funds for an enterprise. *Fixed working capital* should be raised in the same way as fixed capital is procured.

Variable working capital is procured out of short-term borrowings from the bank or from the public.

26.21 CAPITALISATION

Concept

— Capitalisation refers to the total *long-term funds* made available to the company. Examples of long-term funds are : Equity shares, preference shares, debentures, retained earnings etc.

— *To elaborate - Capitalisation* is the sum total of all long-term securities issued by a company and the surplus not meant for distribution. Thus *capitalisation* comprises of :-

(1) The value of *shares* of different classes i.e., ordinary shares and preference shares.

(2) The value of all *surplus* whether earned surplus or capital surplus.

(3) The value of *bonds* and *securities* issued by a company still not redeemed.

(4) The value of *long-term loans* secured by the company other than bonds and securities.

The *earned surplus* means undistributed profits accumulated over a period of time in the form of reserves and meant for utilisation for company's long-term requirement. *Capital surplus* means all other reserves except earned surplus.

Need for Capitalisation

— *The need for capitalisation arises* :

(1) At the time of incorporation of a company.

(2) At the time of expansion of the existing company;

(3) At the time of recapitalisation and reorganisation of capital ; and

(4) At the time of amalgamation and absorption of two companies.

— The funds should be made available in an adequate quantity. Funds/Capitalisation if it is improper would lead to a stage of *over-capitalisation* or *under-capitalisation*-both of which are bad for the company.

Over Capitalisation

— An overcapitalised firm can be compared to a (fat) man who has got fat more than required and suffers from variety of diseases.

— *Over-capitalisation* implies that the total capital of the company (owned capital plus borrowed capital) is in *excess* of the *level of proper capitalisation*.

The level of proper capitalisation is the *requirements* of the company which can be considered to be just *appropriate*.

Whether the requirement is *appropriate* or *inappropriate*, it can be determined on the basis of the *earning capacity* of the company.

If the *earning capacity* of the company has *gone down* (due to internal or external factors), a state of over-capitalisation exists.

— Thus, a *company* is said to be *over-capitalised*, when its earnings are not large enough to yield a fair return on the amount of stocks and bonds that have been issued. Or, when the amount of securities outstanding, exceeds the current value of assets.

Also, when a company has consistently been unable to earn the prevailing rate of return on its outstanding securities (considering the earnings of similar companies in the same industry and the degree of risk involved), it is said to be over-capitalised.

— Over-capitalisation does not necessarily mean *abundance of capital*.

Causes of overcapitalisation

(i) More shares and/or debentures might have been issued, resulting in availability of

surplus funds that can not be profitably employed, but dividend shall have to be paid on such excess capital also.

(ii) Rate of interest on borrowings might be higher than the rate of earnings of the company.

(iii) Wrong estimate of the earnings of the company. If future earning is *over-estimated*, the market value of shares will fall below the purchase price because shareholders will not get what they had been promised by the company.

(iv) Floating the company under inflationary conditions will lead to over-capitalisation because of purchase of assets at high prices.

(v) Payment of high promotional expenses, i.e., if the remuneration paid to promoters etc., is very high.

(vi) Provision of depreciation lass than justified. So company will find it difficult to replace the assets (machinery etc) with the funds made available by depreciation provision.

(vii) Insufficient and extravagant management of the company. Liberal payment of dividend and low retention of earnings for self financing.

(viii) Time lag between installation of machinery and starting production.

(ix) High tax rates and excessive tax payment also results in over-capitalisation.

Effects of over-capitalisation

(i) Less earnings of the company, leading to reduction of rate of dividend and hence decrease in market value of its shares.

(ii) Shareholders of the company get less dividends.

(iii) Employees are denied increase in salaries.

(iv) Prices of company products may go high.

(v) Company finds it difficult to raise capital, because in present situation of over-capitalisation, it finds it difficult to pay a fair rate of return to its investors.

(vi) To save their skin, directors of the company may resort to unfair practices like manipulation of the books of accounts to show artificial prosperity.

Remedial Measures to Correct Over-capitalisation

(i) All avoidable costs should be avoided e.g., purchase of new vehicles, air-conditioners, sophisticated office furniture etc.

(ii) Wastage and extravagance should be avoided.

(iii) Earning capacity should be increased by minimizing scrap and by increasing efficiency of workers.

(iv) The par value of shares or the number of shares may be reduced (to eliminate watered stock).

(v) Debentures and cumulative preference shares carrying higher rate of interest and dividend should be redeemed or their holders may be persuaded to take new debentures at lower rate of interest.

Under-capitalisation

— *Under-capitalisation* is *reverse* of the *over-capitalisation.*

— A corporation may be *under-capitalised* when the rate of profits it is making on the total capital is exceptionally high, in relation to the return enjoyed by similar situated companies in the same industry,

OR, When it has *insufficient* or *too little* capital to conduct its business.

Causes of Under-capitalisation

(1) A company which is *floated during depression* will find itself under-capitalised during boom period. The reason being that the assets were acquired at lower cost and the return during inflation will be high.

(2) If the company is working at a *high degree of efficiency* it will earn more profits which will push up the real value of the shares in the market, indicating under-capitalisation.

(3) The promoters of the company at the time of preparing financial plan may *under estimate future earnings* or make *under-estimation of capital requirements.*

If the earnings, later on, prove to be higher than the estimated figure, the company will become under-capitalised.

(4) The company may follow a conservative dividend policy (i.e., moderate rate of dividend) thereby leading to enough funds for business expansion, machinery replacement etc. This will lead to higher rates of earnings and hence under-capitalisation.

(5) The promoters of the company in a desire to keep control over the affairs of the concern may issue lesser number of shares and prefer to manage with their own capital or through cheap borrowings and retained earnings, it may lead the company to under-capitalisation after some time.

Effects of Under-capitalisation

(1) Seeing the high rate of earning and profits of the company, the employees/workers shall start demanding high salaries.

(2) High profits of the company may encourage others to enter the same business line leading to sever competition.

(3) Customers may feel that they are being exploited by the company.

(4) Company will have to pay more taxes.

Where under-capitalisation arises due to inadequacy of funds:

(5) At times, company may be compelled to raise funds at higher rates of interest.

(6) Due to inadequacy of capital, once the company runs into rough weather, it may lack working capital and hence a constant danger of failure of business.

Remedial Measures to Control Under-capitalisation

(1) The existing shareholders may be alloted *shares of higher face (par) value* in exchange for the old shares. This procedure will bring down the rate of earning per rupee of share value but will not affect the amount of dividend per share.

(2) The *shares* may be *splitted up.* It has the effect of reducing the dividend per share. In other words, the *par value* of shares may be reduced by sub-dividing the shares.

(3) The management may issue *bonus shares* to *equity* shareholders. This measure shall capitalise the earnings/products, thus increase the capitalisation and the number of shares. Dividend per share and rate of earnings will be reduced.

(4) To remove the state of under-capitalisation, fresh (more) shares and debentures may be issued.

26.22 CAPITAL STRUCTURE

26.22.1 Meaning and Concept

— For any *business* (investment) *project*, it is essential to estimate the amount of *capital* likely to be required for the business.

— After having determined the *finance* required for a project to be undertaken, the question arises what shall be the *sources of finance*, i.e., *what are the securities* to be *issued* and what shall be the *proportion* of various *securities*.

— *The main types of securities are*

1. Ordinary shares (or Equity shares)
2. Preference shares
3. Debentures (Refer page 26-5 for details)

— *Capital structure* refers to the mix or proportion of different sources of financing to the total capitalisation.

In other words, capital structure refers to the proportion of Equity capital, Preference capital, Reserves, Debentures and other *long-term* debts to the total capitalisation *(refer pages 26-4 to 26-8)*.

So, *capital structure* signifies the *kind* and *proportion* of different securities for raising *long-term finance*.

— *Capital structure* involves the decision about the *form of capitalisation* i.e, the *types of securities* to be issued and the relative *proportion* of each type.

— *Capital structure* refers to the *make up of the capitalisation*. It decides the *proportion* of funds to be raised by

(i) *issue of ownership capital* (i.e., ordinary share capital and preference share capital) and

(ii) the amount to be raised by *borrowings* (i.e., debentures, bonds, public deposits etc.) taking into account the cost of capital (i.e., dividend or interest) and its *impact* on income and stability of the company.

A company should maintain a fair balance in two types of securities i.e. *ordinary shares* (*variable cost bearing securities*) and other securities (*bearing fixed cost*).

— *Capital structure may consist of*

(i) Only equity shares (also known as ordinary shares)

(ii) Equity shares and preference shares

(iii) Equity shares, preference shares and debentures

(iv) Equity shares and debentures.

— *Capital structure* differs from *Financial structure* and *Assets structure*.

While *Financial structure* refers to total *liabilities*, *Assets structure* refers to total *assets*, *capital structure* refers to *total assets less current liabilities*.

— *Capital structure theories* explain the theoretical relationship between cost of capital and the value of a firm.

The important theories are

1. Net income (NI) approach
2. Net operating income (NOI) approach
3. Modigliani and Miller (MM) approach, and
4. Traditional approach.

— *Capital structure planning* refers to the designing of an appropriate capital structure in the context of the facts and circumstances of each firm.

— *The optimum capital structure* may be defined as that capital structure or combination of debt and equity that leads to the maximum value of the firm.

26.22.2 Balanced or Optimum Capital Structure

— *Capital structure* refers to the composition of various long term sources of funds such as debentures, ordinary shares, preference shares, reserve and surplus etc.

— An *optimum or balanced capital structure* means an ideal combination of *borrowed* * *and owned* ** *capital that may attain the marginal goal i.e., maximization* of market value per share or *minimization* of cost of capital.

The market value will be maximized or the cost of capital will be minimized when the real cost of each source of funds is the same.

— *A sound/ideal optimum structure is one which*

(1) Maximises the worth or value of the concern.

(2) Minimizes the cost of funds.

(3) Maximizes the benefit to the shareholders, by giving best earning per share and maximum market price of the shares in the long run.

(4) Is fair to employees, creditors and others.

26.22.3 Essentials (Characteristics of an Optimum Capital Structure

— The *optimum capital structure* can be properly *defined* as that *security mix* (i.e. of different types of securities such as ordinary shares, preference shares, debentures etc.) which *minimises* the *firm's cost of capital* and *maximises firm's value.*

— Following are the essentials or characteristics of an optimum capital structure.

(1) Simplicity

The capital structure should be simple so that even less educated businessmen are able to understand it. For simplicity, at least in the beginning, the concern should resort to minimum types of securities as a source of finance. The investors will also respond quickly.

(2) Flexibility

The capital structure should be flexible so that whenever the circumstances so warrant, it is capable of being altered. For example, a sound capital structure should be such that the capital can be increased or reduced when the concern wants to expand or limit its activities respectively.

Usually the *increase* in capital is not a problem but *reduction* of capital is very difficult.

Equity capital is considered to be something sacred which cannot be reduced except in accordance with the provisions of Companies Act, 1956.

Flexibility can be introduced into capital structure by opting for redeemable preference shares or redeemable debentures as one of the securities to be issued for raising finance.

(3) Profitability

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* Debentures, loan etc.,

** Ordinary and preference share capital and retained earnings (reserves and surplus)

An optimum capital structure is one that is most profitable to the company. The cost of financing should be the minimum and the earnings per share should be maximum.

(4) Solvency

In an optimum capital structure, *debts* should only be a reasonable proportion of the total capital employed in the business because extensively used and huge debts always threaten the solvency of the company.

(5) Control

Sound capital structure should provide maximum control of the equity shareholders on the company's affairs. When owners want to have control over the business, debt is preferred to equity.

(6) Conservation

The capital structure should be conservative in the sense that the *debts* shall not be raised beyond a certain limit so that the company is in a position to repay the principal sum together with the interest due thereon in time.

(7) The capital structure selected should be most *economical.*

(8) *Future contingencies* should be anticipated and a provision be made in the capital structure to meet them.

(9) *Sufficient funds* should be there with the company for different operations. Both surplus or scarcity of capital have adverse effect on the profitability of the concern.

(10) *Securities* proposed to be issued should offer some attractions to the investors either in relation to income, control or convertibility.

(11) Both *types of securities* i.e., ownership and creditorship, should be issued to secure a *balanced leverage.*

Normally, debentures are issued when rate of interest is low and shares, when rate of capitalisation is higher.

26.22.4 Objectives of Optimum Capital Structure

(A) Economic Objectives

(1) Minimisation of Costs

Funds should be raised at the *lowest* possible *cost* in terms of interest, dividend and the relationship of earnings to the prices of shares.

(2) Minimisation of Risks

Business risks, management risks, tax risks, trade cycle risks, purchase risks, interest rate risks, etc., should be minimized by making suitable adjustments.

(3) Maximisation of Return

Equity shareholders should get maximum return. It may be achieved by minimizing the cost of issue and the cost of financing.

(4) Preservation of Control

The control of equity shareholders on company's affairs should be preserved by proper balance between *voting right capital* (equity capital) and *limited voting (or non-voting) right capital* (preference shares and debentures).

(5) Proper Liquidity

Liquidity is necessary for the solvency of the company, therefore, a proper balance between fixed assets and the liquid assets should be maintained.

(6) **Full Utilisation**

Full utilisation of available capital should be made at minimum cost. For this, there should be a proper coordination between the quantum of capital and the financial requirements of the business.

(B) Other Objectives

(1) **Simplicity**

The capital structure should be simple. In the beginning a company should raise only the ownership capital i.e., equity share capital that will enhance the credit of the company.

(2) **Flexibility**

The capital structure (design) should be flexible so that it can be altered as per the requirements or need of the company.

26.22.5 Factors Determining Capital Structure

— Everytime when the company wants to expand or grow, more finances are required and the problem is there in respect to the suitable sources of finance. Thus, a decision as regards capital structure is taken, considering the following factors.

(1) ***Trading on equity***

When the *debt* and *preference share* capital are used as main sources of finance, the *situation* is termed as *trading on equity*.

Under such a case, an enterprise *earns* a higher rate of return on capital employed than the rate of interest *payable* on borrowed funds.

The *earning per share increases* without a corresponding increase in the equity shareholder's investment.

(2) ***Control of business***

Normally, the promoters want to retain with them the control of the affairs of the business company. So, majority of equity share capital is held by the promoters or their near relatives and a large proportion of fund is raised by the issue of debentures and preference shares because debenture holders and preference shareholders usually do not have any voting right as enjoyed by the equity shareholders.

(3) ***Nature of business***

While designing capital structure, nature of business must be taken into account.

Public utility concerns may enjoy advantages of fixed interest securities like bonds and debentures because of their monopoly and stability of income.

But, on the other hand, *manufacturing concerns* do not enjoy such advantages and rely to a great extent on *equity* share capital.

(4) ***Size of business***

Small companies have to depend on owned capital whereas large companies do not find much difficulty in raising long-term funds/loans.

(5) ***Period of Finance***

If funds are required for ten years or so, debentures are preferred to shares, whereas if the requirement of funds is permanent, equity shares are more appropriate to be

issued. If the funds are required for five years or so, they may be arranged through borrowings because these can easily be repaid as soon as company's financial position improves.

(6) ***Cost of Capital***

The cost of a source of finance should be minimum. The cost of capital is found on the basis of the return expected by the supplier of the particular source of finance. Expected return depends on the extent of risk which is assumed by various suppliers of finances.

Usually *debt* is cheaper than *equity* because debt holders assume less risk than shareholders.

Preference share capital is also cheaper than equity capital, but debt is still cheaper as it involves tax advantage in respect of deductibility of interest.

(7) ***Purpose of financing***

If funds are to be raised for *production/manufacturing* purposes, debt may be a proper source of finance.

For *non-productive* purposes (e.g. constructing houses for employees) which will add nothing to the earning capacity of the company, funds may be raised by issue of shares or still better out of retained earnings, but in no case, out of borrowed funds.

(8) ***Choice of investors***

If the investors (i.e., the public) are not ready to buy preference shares or debentures even when the company feels that these are the most appropriate source of finance for them, these cannot be issued. Only that issue would be successful which has ready marketability.

(9) ***Need of investors***

An ideal capital structure is that which suits to the needs of different types of investors.

For example, some investors who prefer security of investment and stability of income usually go in for *debentures.*

Preference shares are liked by those who want a higher and stable income with enough safety of investment.

Equity shares will be taken by those who are ready to take risks for higher income and capital appreciation. Those who want to acquire control over the affairs of the company like equity shares.

(10) ***Future cash inflows***

The greater and more stable the expected future cash flows of the firm, the greater is the debt capacity of the company.

(11) ***Stability of sales***

The companies which have stable and increasing sales may resort to more debt financing without any difficulty.

(12) ***Legal restrictions***

Hands of the management are tied by the legal restrictions as regards the issue of different types of securities. For example, there is 4 : 1 ratio between debt and equity *and* 3 : 1 between equity and preferred stock.

(13) ***Cost of floatation***

Cost of floatation should also be taken into consideration while raising funds.

The cost of floating a debt is normally less than the cost of floating an equity issue.

(14) ***Flexibility/Elasticity of capital structure***

Capital structure should be flexible or elastic enough so as to provide for expansion for future development or to make it feasible to reduce the capital when it is not needed.

(15) ***Regular and Fixed income***

— The stability of capital structure of a company very much depends upon the possibility of regular and fixed income.

— If company wants sufficient *regular income* in future, debentures should be issued.

— Preference shares may be issued if the company wants that its average income for a few years may be equal to *or* in excess of the amount of dividend to be paid on such preference shares.

— If the company does not expect any regular income in future, it may issue equity shares.

26.32 DIFFERENCE BETWEEN CAPITAL, CAPITALISATION AND CAPITAL STRUCTURE

— **Capital** is that part of wealth which helps in production of further wealth (as in industries).

— **Capitalisation** refers to *total long-term funds* (such as equity shares, preference shares, debentures etc.) made available to a company, say an industry.

— **Capital structure** refers to the *proportion* of equity capital, preference capital, debentures etc, for raising long-term funds.

— *Capitalisation* refers to the companies and not to the firms or proprietorships.

— **Capitalisation** refers to the total amount of *capital* required to meet the *long-term* and *permanent* needs of the company, whereas **capital** includes both long-term and short term funds.

— *In other words, capital includes* all the loans (whether due to owners or to outsiders or whether long-term or short term) and reserves of the concern **whereas** *capitalisation includes* only long term loans and retained profits besides the share capital.

— Whereas **capitalisation** refers to *total long term funds* (available to the company) such as equity shares, preference shares, debentures, etc., the **capital structure** implies the *proportion or mix* of various long-term sources of funds such as equity shares, preference shares, debentures, loans etc., which should be made available to the company. *Capital structure* signifies the *type* and *proportion* of different securities for raising long-term finance.

26.24 CAPITAL GEARING

Concept

— Assume that a company can issue *three types* of securities, i.e., equity shares, preference shares and debentures. But what should be the *proportion* of these securities. For this purpose, we shall study *Capital Gearing*.

— **Capital Gearing** *determines* the *ratio* between the various types of securities to the total capitalisation.

— *Capital gearing may be determined* by ascertaining the ratio between the amount of *equity capital* (representing variable income bearing securities) and the *total amount* of securities (equity shares, preference shares and debentures) issued by the company.

As an example, if two companies, each having issued the total securities worth Rs. 10,00,000 have equity shares of Rs. 2,00,000 and Rs. 8,00,000 respectively, the first company is *highly geared* as the ratio between equity capital and total capitalisation is small i.e. 20%. But in the case of 2nd company, this ratio is 8,00,000/10,00,000 i.e., 80%, so it is *low geared*

The *higher the capital gearing* of a company, the more *speculative* will be its equity shares. The equity shareholders may either get higher dividend or no dividend.

If a *large amount of profit* is left after paying *interest* to debenture holders and *dividend* to preference shareholders, it can be distributed among the equity shareholders. Such a situation will increase the prices of shares in the stock exchange.

On the other hand, it may also happen that no profit is left after paying the debenture holders and preference shareholders.

Factors Affecting Capital Gearing

The following factors are considered while determining the ratio of different securities :

(1) Trading on Equity

(2) Control of business

(3) Flexibility of financial plan (Refer article for details)

(4) Choice of investors

(5) Cost of raising finance

(6) Capital market conditions

If market is running under depression, people do not want to take risk and so are not interested in equity shares. Debentures and preference shares which carry a fixed rate of return can be marketed more easily during depression.

It should, however, be noted that business control is centered in the hands of equity shareholders who have the voting right in the general body meeting to control the management of the company. Preference shareholders, if at all, possess very limited right of voting and debentureholders have no right of voting.

26.25 FACTORS AFFECTING REQUIREMENTS FOR WORKING CAPITAL

— In addition to the investment in a fixed asset, it is sometimes necessary to carry additional cash, receivables or inventories. This investment in working capital is treated as a cash outflow at the time it occurs.

— *The working capital needs of a firm are influenced by the following factors :*

(1) ***Nature of business***

A machine tool manufacturing concern which has a long operating cycle and sells largely on credit has a very substantial working capital requirement.

On the other hand a *service firm*, such as an electricity undertaking or a transport corporation with a short operating cycle and sales predominantly on cash basis, has a modest working capital requirement.

(2) ***Seasonality of operations***

A firm manufacturing seasonal products such as fans, coolers, woollen clothes etc., has

a highly fluctuating working capital requirement.

On the other hand, a firm manufacturing electric bulbs or tube-lights or televisions has fairly even sales round the year and hence a stable working capital need.

(3) ***Conditions of supply***

If the raw inventory required for production is easily available throughout the year, the firm can manage with a small capital being involved in inventory. However, if the raw material supply is scant and unpredictable, then, to ensure continuity of production, the firm has to keep a good stock of inventory which will involve large working capital.

(4) ***Marketing conditions***

If the market is strong and competition is weak, the firm can manage with smaller inventory of finished goods as customers can be served after a delay. In this situation, the firm can insist on cash selling or even can ask for advance payment. This will avoid lock up of funds in accounts receivable.

On the other hand, if many firms are making the same product (like T.V., Refrigerators, etc.) and the competition is high, the firm has to keep a larger inventory of finished goods so that its product is not out of stock at any time. In this situation, the working capital needs tend to be high.

26.26 RETURN ON INVESTMENT

— **Investment** may refer to *capital employed, total assets or owners equity* or *net worth.*

Again *capital employed* may be *gross capital* employed or *net capital* employed.

Also, *return* may be *pre-tax return* or *after-tax return. Return* may be expressed in terms of *net profit* or *operating profit. Therefore*:

(i) *Return on investment* may be computed in any one or more manners the businessman likes, but its interpretation must always be with reference to the context and terminology adopted as explained above.

(ii) Numerator and denominator of a *ratio* must always be uniform, implying thereby that the *base* must be common and there must be a correct matching of capital employed and earnings.

— *Return on Investment (ROI)* is also known as *Return on capital employed, Return on Assets, Rate of Return, Capital yield etc.*

— *In simple terms*

$$\text{Return on capital employed or Return on Investment} = \frac{\text{Net profit}}{\text{Capital employed}} \times 100 \quad ...(1)$$

$$= \frac{\text{Net profit}}{\text{Sales}} \times \frac{\text{Sales}}{\text{Capital employed}} \times 100 \quad ...(2)$$

— If capital employed taken is *gross* then

Gross capital employed = Fixed assets + current assets

— And, *net capital employed* = Gross capital employed – Current liabilities

$$\textit{Average capital employed} = \frac{\text{Opening capital employed} + \text{closing capital required}}{2}$$

— *The concept of Net profit may be*

(a) Net profits after taxes

(b) Net profits after interest and taxes, and

(c) Net profits after (taxes + interest – tax savings).

Example Calculate Rate of Investment from the following data:

Sales = Rs 1,80,000

Profit = Rs 18,000

Investment or capital employed = Rs 90,000

Solution Return on Investment or capital employed

$$= \frac{18,000}{90,000} \times 100 = 20\%$$

$$\text{Capital turnover} = \frac{1,80,000}{90,000} = 2 \text{ times}$$

$$\text{Net profit ratio} = \frac{18000}{1,80,000} \times 100 = 10\%$$

Return on capital employed = $2 \times 10\% = 20\%$.

26.27 INTERNATIONAL FINANCIAL MANAGEMENT

Introduction

— The last about fifteen years have witnessed a globalization of business, not only in foreign sales but also in manufacturing/service facilities and in finance.

— The motivation to invest capital in a foreign operation of course, is to provide a return in excess of that required. There may be gaps in foreign markets where excess returns can be earned. Domestically, competitive pressures may be such that only a normal rate of return can be earned.

— Although expansion into foreign markets is the reason for most investment abroad, there are *other reasons*. Some firms invest in order to produce more efficiently. Another country may offer lower labour and other costs, and a company will choose to locate production facilities there in the quest for lower operating costs. The electronics industry of U.S.A., has moved toward foreign production facilities for the saving. Finally, some companies invest abroad to secure necessary raw materials. Oil companies and mining companies in particular invest abroad for this reason. All of these pursuits—markets, production facilities, and raw materials—are in keeping with an objective of securing a higher rate of return than is possible through domestic operations alone.

International Capital Budgeting

The relevant cash inflows for a foreign investment are those that can be repatriated to the parent. If the expected return on investment is based on nonremittable cash flows that build up in a foreign subsidiary, the investment is unlikely to be attractive. If cash flows can be freely repatriated, however, capital budgeting is straightforward. The Indian firm would

1. estimate expected cash flows in the foreign currency
2. compute their rupee equivalents at the expected exchange rate (foreign currency per rupee)
3. determine the net present value of the project using the Indian required rate of return, adjusted upward or downward for any risk premium effect associated with the foreign investment

Although the calculations are straightforward, obviously much goes into the assumptions concerning projected cash flows, projected exchange rates, and the required rate of return.

Risk Factors

With respect to required returns, international diversification is a consideration. The key element is the correlation among projects in the asset portfolio. By combining projects with low degrees of correlation with each other, a firm is able to reduce risk in relation to expected return. Since domestic investment projects tend to be correlated with each other, most being highly dependent on the state of the economy, foreign investments have an advantage. The economic cycles of different countries do not tend to be completely synchronized, so it is possible to reduce risk.

Some of the things that make direct foreign investments different from domestic investments are *taxation* and *political risk*.

Taxation

— Owing to different tax laws and different treatments of foreign investment, the taxation of a multinational firm is complex and highly technical.

From time to time, various special tax incentives come into existence to help export industries, the Foreign Sales Corporation (FSC) being a current example. Other tax provisions, both U.S. and foreign, are constantly changing. The advice of tax experts and legal counsel, both foreign and domestic, should be sought at the time the foreign operation is organized.

Taxation By U.S. Government

If a U.S. corporation carries on business abroad through a branch or division, the income from that operation is reported on the company's U.S. tax form and is taxed in the same way as domestic income. If business is carried on through a foreign subsidiary, the income normally is not taxed in the United States until it is distributed to the parent in the form of dividends. The advantage here, of course, is that the tax is deferred until the parent receives a cash return. In the meantime, earnings are reinvested in the subsidiary to finance expansion. Unlike dividends from a domestic corporation (70 percent exempt), dividends received by a U.S. corporation from a foreign subsidiary are fully taxable.

Taxation By Foreign Governments

— Every country taxes income of foreign companies doing business in that country. The type of tax imposed varies. Some of these countries differentiate between income distributed to stockholders and undistributed income, with a lower tax on distributed income. Less-developed countries frequently have lower taxes and provide certain other tax incentives to encourage foreign investment. One method of taxation that has been prominent in Europe is the value-added tax, in essence a sales tax on each stage of production, which is taxed on the value added. It works this way: An aluminium fabricator buys aluminium sheets for $1,000, cuts, shapes, and otherwise works them into doors, which are sold for $1,800. The value added is $800, and the fabricator is taxed on this amount. If the fabricator sold its doors to a wholesaler who, in turn, sold them to retailers for $2,000 the value added would be $200 and taxed accordingly.

27

Cost Accounting and Control

27.1. INTRODUCTION

(a) Cost

Cost may be defined as the amount of expenditure (actual or notional) incurred on, or attributable to, a given thing.

The word *cost* is rarely used independently; it is always related to a particular thing, *e.g.*, number of goods produced, etc.

(b) Accounting

Accounting may be defined as the *art* and *science* of recording business transactions in a methodical manner so as to show

- the true state of affairs of a business at a particular instant of time, and
- the deficiency or surplus which has accrued during a specific time period.

Accounting uses words and figures to communicate the transactions which have been entered into.

(c) Cost Accounting (or Costing) and Need for it

- *Costing* is frequently looked upon as the operation of calculating the cost of an article (for sale) as a basis to fix its selling price.
- Costing implies the techniques and processes of ascertaining costs of given things or items.
- *Costing* involves

(*i*) classifying, recording and appropriate allocation of expenditure for the determination of the costs of products or services;

(*ii*) the relation of these costs to sales values; and

(*iii*) the ascertainment of profitability.

- Costing or cost accounting deals with the internal affairs of a business. It attempts to show the results of the operations carried out and emphasises throughout the measurement and achievement of efficiency.
- Through costing, the costs are ascertained by

(*i*) predetermined standards, combined with subsequent analysis of variances between those standards and the actual cost incurred; or

(*ii*) historically, that is, after they have been incurred;

(*iii*) the use of marginal methods of presentation for either (*i*) or (*ii*), involving the differentiation between *variable* and *fixed* costs.

Cost accounting may also be defined as the process of accounting for cost from the point at which expenditure is incurred to the establishment of its ultimate relationship with cost centres (*e.g.*, a location, item of equipment, person, etc.) and cost units (*e.g.*, a unit or quantity of product service, etc.).

- The cost accounting becomes the basis of *cost control systems* and *budgetry control plans* (refer chapter No. 28).

Cost control and budgetary control are both essential because they permit management to plan ahead and to know when to make changes in order to fulfill the plan related to the operation of a modern industrial unit.

– ***Cost accounting is necessary because it provides information for,***

(*i*) Determining, classifying and analysing the cost and income of a business enterprise.

(*ii*) Determining the prices to be quoted to customers.

(*iii*) Forming basis for managerial decisions that have to do with,

(*a*) Make or Buy (decision).

(*b*) To introduce a new product or to drop an existing one.

(*c*) To sell products in some more territories or to drop some present ones.

(*iv*) Cost control through accumulation and utilisation of cost data.

(*v*) Profitability of products.

(*vi*) Budgeting (Planning, co-ordination and control through budgets).

(*vii*) Standard costing.

(*viii*) Continuation of business.

(*ix*) Proper matching of costs with revenues.

(*x*) Control of materials and supplies.

(*xi*) Wages and overheads costs.

(*xii*) Establishing standards for measuring efficiency.

(*xiii*) Curtailment of losses due to seasonal conditions.

(*xiv*) Determining expansion and contraction policies (refer (*iii*) above).

(d) Cost Control, Necessity and Importance

– Cost accounting helps control of expenditure or cost.

– Cost control leads to efficiency in use of material, machinery and labour.

– The profit making capacity of a business is guided by the efficiency with which various costs are controlled.

– Cost control provides a basis for minimising the cost or cost-reduction.

– Costs and accounts are classified to make clear the nature of expenditure or cost. Cost control works through a comparison of actual costs against predetermined standards as regards material, labour, etc.

– Cost control and hence cost reduction is necessary in order to

(1) stand in competition in a specific product line;

(2) reduce the selling price of a product to broaden its market.

27.2. ELEMENTS OF COST

– The *costs* of an industrial enterprise may be divided into three *principle elements*, namely :

1. Material.
2. Labour.
3. Expense.

1. Material cost

– It is the cost of commodities supplied to an undertaking.

– It is of two types :

(*a*) *Direct material cost.*

(*b*) *Indirect material cost.*

(*a*) *Direct material cost*

– A direct material is one which goes into a salable product or its use is directly essential for the completion of that product, *e.g.*, a H.S.S. bit for making a turning tool for lathe; Fe, Ni, Cr. etc., to make alloy steels.

– The amount paid for or the money spent on direct materials is known as *Direct material cost.*

– Since, direct material used can be traced to a specific product and its cost becomes part of the prime cost, the direct material cost can be controlled in a positive way.

(*b*) *Indirect material cost*

– An indirect material is one which is necessary in the production process but is not directly used in the product itself, *e.g.*, it does not become an integral part of the product, *e.g.*, cotton waste, greases, oils, sandpaper, etc.

– The costs associated with indirect materials is called *Indirect material cost.*

The same material may be a direct material for one producer and an indirect material for another.

Some direct materials are in certain cases, used so little that it is not worth-while to identify and charge them as direct materials. Nails, glue and sometimes paints, are a few examples. Under such conditions, these materials are generally charged as indirect materials, or overheads.

2. Labour cost

It is the cost of remuneration (Wages, salaries, commissions, bonuses, etc.) of the employees of a concern or enterprise. Like material cost , labour cost is also classified as

(*a*) *Direct labour cost.*

(*b*) *Indirect labour cost.*

(*a*) *Direct labour cost*

– The direct labour cost is the cost of labour that can be identified directly with the manufacture of the product and allocated to, cost centres[1] or cost units[2].

– A direct labourer is one who converts the direct material into salable products; the wages, etc. of such employees constitute *Direct labour cost.*

– The wages of a welder fabricating a structure form a part of the total direct labour cost.

– Direct labour cost may be apportioned to the unit of cost or job either on the basis of time spent by a worker on the job or as a price for some physical measurement, (*e.g.*, quantity) of the product.

(*b*) *Indirect labour cost*

– It is that labour cost which cannot be allocated but which can be apportioned to, or absorbed by, cost centres or cost units.

– This is the cost of the labour that does not alter the construction, conformation, composition or condition of the direct material but is necessary for the progressive movement and handling of the product to the point of despatch. Examples of *Indirect* or *non-productive* workers are : maintenance men, helpers (in a machine shop or foundry), machine setters, supervisors and foremen, etc.

---

1. *Cost Centres* : A person, location or an equipment (or a group of these) for which costs may be ascertained and used for the purposes of cost control.

2. *Cost Unit* : A unit or quantity of product service or time (or a combination of these) in relation to which costs may be ascertained.

3. Expense

- It is a collective title which refers to all charges other than those incurred as direct result of employing workers or obtaining material.
- Expenses include the cost of services provided to an undertaking and the notional cost of the use of owned assets.
- Expenses may be of two types :

(a) Direct expenses.

(b) Indirect expenses.

(a) Direct expenses

- These are the expenses which can be identified with, and allocated to, cost centres or cost units.
- The following examples of direct expenses will clarify the idea :

(1) Costs of special layouts, designs or drawings produced for a specific job are the direct expenses of such a job, provided,

- layouts, designs or drawings are totally consumed on the job, or
- though they can be used again but there are hardly any chances of their being used again.

(2) Hire of special or single purpose machine tools or other equipments for completing a particular production order.

(b) Indirect expenses

- These are the expenses which cannot be allocated but which can be apportioned to, or absorbed by, cost centres or cost units.
- Examples of indirect expenses are

Rent of the building.

Insurance premium.

Telephone bill, etc.

(i) Fixed expenses

- Fixed expenses are those costs that tend to remain relatively constant regardless of the volume of production.
- Examples of fixed expenses are,

* Taxes on land and building.

* Depreciation arising from time.

* Rent.

(ii) Variable expenses

- Variable expenses are those which tend to vary directly with the volume of production.
- Examples of variable expenses are,

* Royalties paid on a volume basis (as in case of gramophone records),

* Depreciation arising from use.

27.3. PRIME COST

Prime cost = Direct material cost.
+ Direct labour cost.
+ (Variable) direct expenses.

- Prime cost is limited in its use to the manufacturing division of a business concern.

27.4. OVERHEADS

- *Indirect costs, Overheads, Oncost* and *Burden* are synonymous terms.
- Overheads are all expenses other than direct expenses.
- *Overhead* is defined as the cost of indirect material, indirect labour and such other indirect expenses, including services, as cannot coveniently be charged direct to specific cost units.
- The main groups into which *overhead* may be subdivided are

(*a*) Production or manufacturing overhead, including services.

(*b*) Administration overhead.

(*c*) Selling overhead.

(*d*) Distribution overhead.

(*e*) R & D overhead.

(*a*) Production or manufacturing overhead

- It includes all indirect expenses incurred by the concern from the receipt of the production order until its completion, *i.e.*, it being ready for despatch to the customer.
- Typical manufacturing overhead costs are :

1. Building expenses
   - Rent
   - Insurance
   - Repairs
   - Heating and lighting
   - Depreciation, etc.
2. Indirect labour.
   - Supervisors and foremen
   - Machine setters
   - General workers
   - Maintenance men
   - Shop clerk
   - Shop inspectors, etc.
3. Water, Fuel and Power (steam, gas, electric, pneumatic, hydraulic).
4. Consumable stores such as cotton waste, grease, etc.
5. Plant maintenance and depreciation.
6. Sundry expenses such as those of,
   * employment office,
   * security,
   * all forms of welfare,
   * recreation and rest rooms, etc.

(*b*) Administration overhead

- Administration overhead consists of expenses incurred in the direction, control and administration of an enterprises.
- Administration overhead is the expense of providing a general management and clerical service.
- Examples of administration overhead :

  Office rent.

  Salaries and wages of clerks.

  Director's, general manager's fees.

Insurance.
Legal costs.
Rates and Taxes.
Postage and telephones.
Audit fees.
Bank charges, etc.

(c) Selling overhead

- Selling overhead consists of expenses in order to maintain and increase the volume of sales.
- Selling overhead covers all expenses direct or indirect which are necessary to persuade consumers to buy.
- Examples of selling overhead :
  * Advertising.
  * Salaries and commission of sales managers, travellers and agents.
  * Rent of sales-rooms and offices.
  *Consumer service and service after sales, etc.

(d) Distribution Overhead

- Distribution overhead covers all expenses connected with transporting products to customers and storing them when necessary.
- Examples of distribution overhead :
  * Warehouse charges.
  * Cost of transporting goods thereto.
  * Loading and unloading charges.
  * Upkeep and running of delivery vehicles.
  * Salaries of clerks and labourers.
  * Depreciation, etc.

(e) Research and Development Overhead

- Much depends upon the nature of product or service being produced.
- R & D overhead is proportional to the size of R & D department.

27.5. FACTORY COST

Factory cost = Prime cost + Factory overhead
= Direct material cost
+ Direct labour cost
+ (Variable) direct expenses
+ Factory overhead.

27.6. TOTAL COST

Total cost = Factory cost + Selling overhead
+ Distribution overhead
+ Administration overhead.

27.7. SELLING PRICE

Selling price of a product

= Total cost ± Profit or loss

Fig. 27.1 shows the development of selling price of a product.

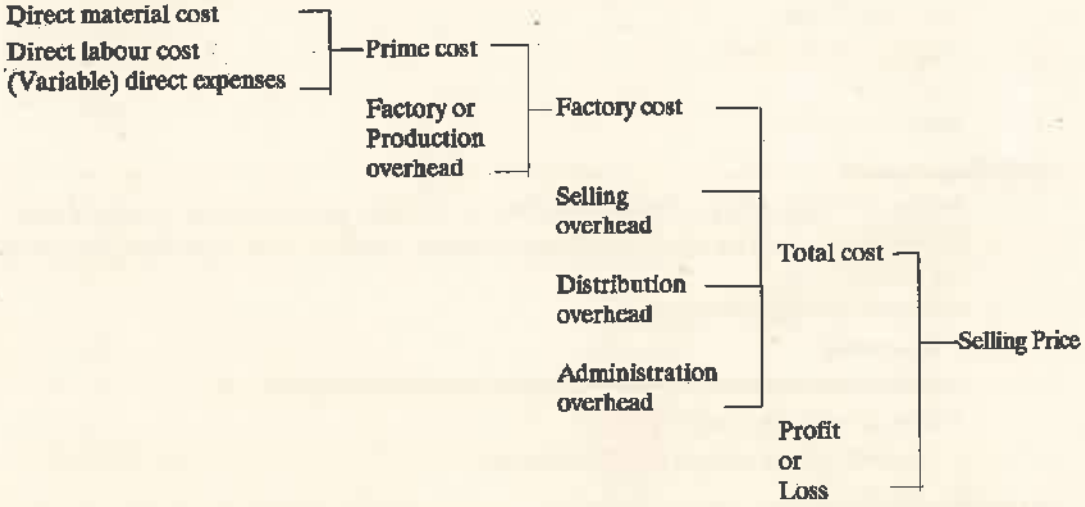


Fig. 27.1. Development of selling price of a product.

27.8. NATURE OF COST

(a) Fixed Costs

- *Fixed costs, policy costs* or *period costs* are those which tend to remain constant irrespective of the volume of output or sales.
- *Examples of fixed costs* :
  - * Staff salaries.
  - * Administration expenses.
  - * Rent and establishment charges.
  - * Depreciation, etc.

(b) Variable Cost

- *Variable costs* tend to vary directly with the volume of output.
- *Examples of variable costs*
  - * Direct productive labour.
  - * Direct materials.
  - * Direct expenses.

(c) Semivariable Costs

- These costs are partly fixed and partly variable.
- Semivariable costs vary with changes in output but the variation is irregular.
- *Examples of semivariable costs*
  - * Indirect hourly labour which varies more less with output but not in direct proportion to it, for example, wages of maintenance men.
  - * Grease and oil.
  - * Water and electricity, etc.

(d) Controllable Cost

– Controllable cost is one which can be influenced by the action of a specified member of an undertaking.

(e) Uncontrollable Cost

– Uncontrollable cost is one which cannot be influnced by the action of a specified member of an undertaking.

27.9. TYPES OF COST

(a) Predetermined Cost

– Predetermined cost is one which is computed in advance of production on the basis of a specification of all the factors affecting cost.

(b) Standard Cost

– Standard cost is a predetermined cost which is calculated from management's standards of efficient operation and the relevant necessary expenditure.

– Standard costs are built upon a theoretically desired standard that is capable of attainment under practical operation conditions.

Standard cost is estimated cost per unit of output for labour, materials and overheads, based on a prediction of material prices, labour rates and overhead expenses for a given future period.

Standard costs represent the best estimate that can be made of what cost should be for material, labour and overhead after eliminating inefficiencies and waste.

– Any deviation from the standard of materials used will tend to produce a deviation from the standard cost.

– Variations from predicted performance can be accurately determined and action taken to prevent their recurrence.

– *Advantages* of establishing standard cost :

1. Standard costs tend to bring about a more systematic and thorough analysis of costs and discourage reliance on separate job-by-job studies as a basis for cost estimation for new products.

2. Standard costs tend to reduce to a minimum the variations in price.

3. Standard costs represent management's best measure of efficient plant operation.

Standard costs may be used as a basis for price fixing and for cost control through variance analysis.

(c) Marginal Cost, Differential Cost, Incremental Cost

– *Differential costs*, also frequently described as *marginal costs* and *incremental* costs are the increase or decrease in total costs that result from producing and distributing an additional or fewer *unit of a product, a product, a sales territory, etc.*

– If it is assumed that fixed costs remain unchanged by increasing output by one more unit, the marginal cost of a product will consist of the variable cost only.

– These are anticipated costs and refer to future operations.

– These costs are not entered in general accounting records, but may be incorporated in budgets.

– *Uses of differential costs*

1. In determining selling price of the products.
2. In making decision regarding replacement of machinery.
3. In accepting an offer.
4. In submitting a bid.

27.10. PROCESS COST AND COST OF PRODUCTION

27.10.1. Process Cost

- It is the cost for each, of a number of distinct stages or processes which are performed to make a product.
- The total time spent and materials used on each process, as well as services such as power, light and heating, are all charged in calculating the process cost.

  For this purpose, a *process cost sheet* may be made use of.
- Process costs are usually applied in industries where the final product has passed through a number of distinct stages or processes; for example, in textile mills, gas, chemical and paper mills, breweries, etc.
- An important objective in process costing is the evaluation of wastage.

27.10.2. Cost of Production or Production Cost

- It is the cost of the sequence of operations which begins with supplying materials, labour and services and ends with primary packing of the product.

Examples 27.1. From the following data, find (*a*) material cost, (*b*) Prime cost, (*c*) Direct cost, (*d*) Factory cost, (*e*) Administrative overheads, (*f*) Cost of production, (*g*) Selling and distribution overheads, (*h*) Total cost or cost of sales, and (*i*) Selling price. Assume a net profit of Rs. 10,000.

		Rs.
1.	Material in hand (April 1, 1975), of	60,000
2.	New material purchased	2,50,000
3.	Director's fees	3,500
4.	Advertising, etc.	12,000
5.	Depreciation on sales department car	1,200
6.	Printing and stationery charges	300
7.	Plant depreciation	5,000
8.	Wages of direct workers	70,000
9.	Wages of indirect (factory) workers	10,000
10.	Rent of factory building	5,000
11.	Postage, telephone and telegraph	200
12.	Water and electricity for factory	1,000
13.	Office salaries	2,000
14.	Rent of the office	500
15.	Rent of the show room	1,500
16.	Commission of salesmen	2,500
17.	Sales department car expenses	1,500
18.	Material in hand (March 31, 1976)	50,000
19.	Variable direct expenses	750
20.	Plant repair and maintenance	3,000
21.	Heating, lighting and water for office use	2,500
22.	Cost of distributing goods	2,000

Soulution :

(a) Material Cost

=Cost of material in hand on April 1, 1975
−Cost of material in hand on March 31, 1976
+Cost of new material purchased
=60,000−50,000+2,50,000=**Rs. 2,60,000**

(b) Prime Cost

=Direct material cost
+Direct labour cost
+(Variable) direct expenses
=Rs. 2,60,000+70,000+750=**Rs. 3,30,750**

(c) Direct Cost

It is same as Prime Cost.

(d) Factory Cost

Factory cost = Prime cost+Factory or Production overhead,

Whereas Factory overheads include Serial Nos. 7, 9, 10, 12 and 20.

Factory cost = Rs. 3,30,750+5,000+10,000+5,000+1,000+3,000
= **Rs. 3,54,750.**

(e) Administrative Overheads

Administrative overheads include Serial No. 3, 6, 11, 13, 14 and 21 and are
=Rs.3,500+300+200+2,000+500+2,500
= **Rs. 9,000**

(f) Cost of Production

Cost of production = Factory cost+ Administrative overhead
= Rs. 3,54,750+9,000
= **Rs. 3,63,750.**

(g) Selling and Distribution Overheads

They include Serial Nos. 4, 5, 15, 16, 17 and 22 and are
=Rs. 12,000+1,200+1,500+2,500+1,500+2,000
= **Rs 20,700.**

(h) Total Cost or Cost of Sales

Cost of sales = Cost of production+Selling and Distribution overheads
=Rs 3,63,750+Rs 20,700
= **Rs. 3,84,450.**

(i) Selling Price

Selling price = Cost of sales+Profit
=Rs 3,84,450+10,000
=**Rs. 3,94,450.**

Example 27.2. A factory producing 150 electric bulbs a day, involves direct material cost of Rs. 250, direct labour cost of Rs. 200 and factory overheads of Rs. 225. Assuming a profit of 10% of the selling price and selling on cost (overhead) 30% of the factory cost, calculate the selling price of one electric bulb.

Solution :

Factory cost = Direct material cost + Direct labour cost + Factory overheads

= Rs. 250 + 200 + 225 = Rs. 675.

Total cost = Factory cost + Selling overhead (*i.e.*, on cost)

$$= \text{Rs. } 675 + \text{Rs } 675 \times \frac{30}{100}$$

$$= \text{Rs. } 877.50 \qquad \ldots(i)$$

Also, Total cost = Selling price − Profit

$$= \text{S.P.} - \text{S.P} \times \frac{10}{100} \qquad \ldots(ii)$$

Equating (*i*) and (*ii*) above

$$\text{S.P.} - \text{S.P.} \times \frac{10}{100} = \text{Rs. } 877.50$$

$\therefore$ Selling price, S.P. = Rs. 975

Hence the selling price of one electric bulb

$$= \text{Rs.} \frac{975}{150}$$

= Rs 6.50

Example 27.3. A cast iron foundry employs thirty persons. It consumes material worth Rs, 25,000, pays workers at the rate of Rs. 10 per hour and incurs total overhead of Rs. 10,000. In a particular month (25 days) workers had an overtime of 150 hours and were paid at double their normal rate. Find (*i*) the total cost; and (*ii*) the man hour rate of overheads. Assume an eight hour working day.

Solution :

Labour cost = (Number of working hours pre months) × (Rate of payment per hour)

= (25×8×30)×(10)

= Rs. 60,000.

Overtime expenses = Rs. 150×Rs. 20

= Rs. 3000

Thus, total labour cost = Rs. 60,000 + Rs. 3000 = Rs. 63000.

(*i*) Total cost = Total labour cost + Material cost + Overheads

= Rs. 63,000 + Rs. 25,000 + Rs. 10,000

= Rs 98,300

(*ii*) Man hour rate of overhead

$$= \frac{\text{Total overheads}}{\text{Number of total man hours put}}$$

$$= \frac{\text{Total overheads}}{\text{Regular man hours} + \text{overtime man hours}}$$

$$= \frac{10{,}000}{25 \times 8 \times 30 + 150}$$

= Rs. 1.627

Examples 27.4. Two molders can cast twenty-five gears in a day. Each gear weight 3 kg and the gear material costs Rs. 12.50 per kg. If the overhead expenses are 150% of direct labour cost and two molders are paid Rs. 70 per day, calculate the cost of producing one gear.

Solution :

$$\text{Total cost} = (\text{Material cost}) + (\text{Labour cost}) + (\text{Overheads})$$

$$= (25 \times 3 \times 12.5) + (\text{Rs.}70) + \left(70 \times \frac{150}{100}\right)$$

$$= \text{Rs. } 937.5 + 70 + 105 = \text{Rs. } 1112.5$$

$$\text{Cost per gear} = \frac{\text{Total cost}}{\text{No. of gears}} = \text{Rs. } \frac{1112.5}{25}$$

$$= \boxed{\text{Rs. } 44.50}$$

Problem 27.1 : Calculate the selling price of one fountain pen from data given below :

No. of fountain pens produced		135
Labour cost	Rs.	200
Material cost	Rs.	160
Factory overheads		35% of prime cost
Administration & Selling overheads		20 % of factory cost
Profit		10% of the total cost

[Ans. Rs. 4.75]

Problem 27.2 : A drill press costs Rs. 6,000. A discount of 25% of this price is given to the distributor. If labour cost, material cost and factory overheads are as 4:1:2; and selling expenses are 25% of the factory cost, calulate the profit of the factory for one drill press. Assume factory overheads of Rs. 800.

[Ans. Rs.1,000]

Problems 27.3 : A factory is making a pipe fitting by (*a*) Casting (*b*) Forging. The cost data is as follows

	Casting	*Forging*
Materials cost per piece	Rs. 2	Rs. 2
Labour rate	Re. 0.8 per hour	Rs. 0.8 per hour
Time required to make one fitting	3 hours	48 minutes
Overheads	25% of labour cost	150% of labour cost

Calculate and compare the total cost of each pipe fitting in the two cases. [Ans. Rs. 5; Rs. 3.60]

27.11. ALLOCATION OF OVERHEAD COST (*i.e.*, ON COST)

- Once the total overhead expenses have been found out, the next step is to apportion the overheads to each product, job or process.
- If an industry is making only one product, a uniform charge for overhead may be possible; but if a number of different products are being manufactured, an equitable base must be sought out to charge, each (product) with a fair and reasonable share of the overhead cost, so that the total cost (direct and indirect) of each product unit may be calculated.
- Generally, *fixed overhead costs* are charged on a basis of relative benefit and *variable overhead costs* are charged according to responsibility. Therefore, a method for allocating overheads should be such that it covers both cases. Responsibility and relative benefits are assigned by reference to the time spent on each unit of production.

– Among the many *methods* that have been adopted to apply overhead to production, the most common ones have been dealt below :

1. Percentage of direct labour cost.
2. Percentage of direct material cost.
3. Prime cost percentage rate.
4. Labour hour rate.
5. Machine hour rate.
6. Production unit method.

1. Percentage of direct labour cost

Introduction

– This method makes use of the cost of direct labour charged to a particular product as a basis for setting the overhead rate for the product.

– % of direct labour cost=% of overhead (on cost)

$$= \frac{\text{Factory overhead for budget period}}{\text{Direct labour cost for budget period}} \times 100 \qquad ...(1)$$

Advantages

– The method is economical and easy to apply. It reaches its highest degree of efficiency when there is uniformity in

Wage rates,

Skills of workers,

Equipment used, and

Work performed.

– The method is employed with advantage when standard costing is used.

– The method proves to be very useful where the products are manufactured using manual operations.

Disadvantages

(*a*) The method ignores variations in equipment used in different production operations. A highly skilled filing operation requiring only hand tools might involve a heavier overhead than a hydraulic forging process, an operation requiring expensive and large equipment.

(*b*) The method is inequitable because it applies a greater amount of overhead to jobs performed by workers receiving high wages.

Example 27.5 : A fabrication concern, for the year 1975-1976 had factory overheads of Rs. 4,000, and the direct labour cost of Rs. 12,000. Find the percentage overhead using percentage of direct labour cost method.

(*b*) If production order 'Z' had a direct labour cost of Rs. 60, find the overhead cost for the production order.

Solution :

(*a*) Using equation (1)

$$\% \text{ overhead} = \frac{4{,}000}{12{,}000} \times 100 = 33\frac{1}{3}\%$$

(*b*) Overhead cost for production order 'Z'

$$= 60 \times \frac{33\frac{1}{3}}{100} = \text{Rs. } 20$$

2. Percentage of direct material cost

- This method charges an overhead rate commensurate with either the *weight* or the *cost* of direct material going into the product.
- The method is *useful* where :

(*i*) the material and method of manufacture are common to all products,

(*ii*) the expenses on direct material constitute the main factor determining total cost (*e.g.* foundries).

- Percentage of direct material cost = % overhead

$$= \frac{\text{Factory overhead for budget period}}{\text{Direct material cost for budget period}} \times 100 \qquad ...(2)$$

- The method finds applications in the manufacture of cement, paint, sugar, etc.
- The method does not prove to be accurate when applied where different types of materials, (having wide variation in their prices) go into a product, *e.g.*, manufacture of industrial instruments using gold and platinum along with steel or aluminium. An instrument not having gold or platinum parts will obviously fare better than the other (having them) on the question of incurring overhead costs.

Example 27.6. (*a*) A sugar mill had its overheads of Rs. 60,000 while it purchased sugarcane worth Rs. 2,40,000. Find the percentage overhead using the percentage of direct material cost method.

(*b*) If a particular batch had a direct material cost of Rs. 30,000, determine it overheads.

Solution :

(*a*) Using equation (2) above

$$\% \text{ overhead} = \frac{60{,}000}{2{,}40{,}000} \times 100$$

$$= 25\% \text{ of direct material cost}$$

(*b*) $$\text{Overheads} = \frac{25}{100} \times 30{,}000 = \text{Rs. } 7{,}500.$$

3. Prime cost percentage rate

- Prime cost is sum of the direct labour cost and direct material cost.
- Thus, this method is similar to methods (1) and (2) explained earlier, except that the overhead instead being based on a percentage of either direct material or direct labour, relies upon the two taken together.
- Therefore, this method proves to be very useful where both material and labour costs are prominent factors in determining total cost, *e.g.* in fabrication shops.
- This method does not account for the differing rates of material and labour and different equipment sizes and capacities used in manufacturing various products
- Prime cost percentage rate = % overhead

$$= \frac{\text{Factory overhead for budget period}}{\text{Prime cost for budget period}} \times 100 \qquad ...(3)$$

- Prime cost method has same disadvantages as possessed by direct material cost and direct labour cost methods.

Example 27.7. (*a*) A fabrication and assembly shop had its total overheads of Rs. 10,000. It used direct material worth Rs. 10,000 and paid Rs. 15,000 as direct labour charges. Calculate the % overhead.

(*b*) If one product has its prime cost as Rs. 5,000, determine overheads or on cost related to it.

Solution :

(*a*) Using equation (3) above

$$\% \text{ overhead} = \frac{10{,}000}{10{,}000+15{,}000} \times 100 = 40\% \text{ of prime cost.}$$

(*b*) overhead (*i.e.*, on cost) $= \frac{40}{100} \times 5{,}000 =$ Rs. 2,000.

4. Labour hour rate

- Variations in pay that cause confusion in the direct labour cost basis method are eliminated in the labour hour rate method.
- In this method, *labour hours* instead of direct labour cost form the basis for finding percentage overhead.
- It is more accurate than direct labour cost method.
- The direct labour hour rate is calculated as follows :

  The rate per hour of direct labour

$$= \frac{\text{Factory overhead for budget period}}{\text{Direct labour hours for budget period}} \quad \text{...(4)}$$

- This method is useful where hand-labour methods exist and where uniformity of rates, workers and conditions is present.
- Since the majority of factory overhead costs accrue on the basis of time, this method provides the most equitable means of apportioning factory overhead to production.
- However, labour hour rate method
  - (*i*) does not recognize variations in type and size of equipment;
  - (*ii*) necessitates for additional clerical records to be maintained; and
  - (*iii*) proves to be inaccurate if the factory produces various products involving both manual and machine operations.

Example 27.8. (*a*) A fitting and assembly shop had its factory overheads of Rs. 1,20,000 and the production for the period in terms of direct labour was 24,000 hours. Find the rate per direct labour hour.

(*b*) If a particular job takes 20 labour hours, calculate the overhead applied.

Solution :

(*a*) Using equation (4) above,

$$\text{Rate per hour of direct labour} = \frac{1{,}20{,}000}{24{,}000} = \text{Rs. } 5.$$

(*b*) Overhead $= \text{Rs. } 20 \times 5 = \text{Rs. } 100.$

5. Machine hour rate

- In this method, factory overhead costs are applied to production orders on the basis of the number of *machine hours* required to complete the production.
- Machine hour rate

$$= \frac{\text{Factory overhead for budget period}}{\text{Machine hours for budget period}} \quad \text{...(5)}$$

- This is an accurate and very relevent method because in modern age of mechanisation and automation, the factory overhead resulting from the use of machinery are far in excess of costs from other sources.
- This method is based upon a study of the actual overhead expenses of the machines used. Factors such as capital investment, depreciation, insurance, repair and maintenance, floor space, power

and lighting costs are calculated.

- All these (factors) are added together and then divided by the machine hours to give machine rate per hour. Products made on the machine are then charged at this hourly rate on the basis of machining time involved.
- This method is very useful in concerns where machines constitute a more important and costly element than manual labour.
- However, machine hour rate method is not well adapted for industries which desire a single overhead rate for the entire plant and involve a variety of types of hand, bench and machine operations, performed by different grades of workers.
- Rather, this method is most satisfactorily employed when plants are departmentalized and a rate for each department and in some cases for each machine is required.

Examples 27.9. A machine shop has 10 lathes, 6 drill presses and 2 milling machines. Calculate the machine hour rate for lathes if the factory expenses for a particular period and other data are as follows:

1. Area occupied by lathes 10 m².
2. Area occupied by drill presses 3 m².
3. Area occupied by milling machines 2 m².
4. Cost of indirect material and labour Rs. 1,20,000.

5. Rent of building	Rs. 36,000.
6. Insurance	Rs. 15,000.
7. Depreciation	Rs. 20,000 for lathes
	Rs. 15,000 for drill presses
	Rs. 20,000 for milling machines.
8. Power consumed	Rs. 18,000 for lathes
	Rs. 6,000 for drill presses
	Rs. 900 for milling machines.
9. Repair and maintenance	Rs.10,000 for lathes
	Rs. 4,000 for drill presses
	Rs.4,000 for milling machines.
10. Machine hours	10,000 for lathe
	6,000 for drill presses
	2,000 for milling machines.

Solution. Divide cost of indirct material and labour, rent of building and insurance as per the floor area occuiped by different machine tools, for example for lathes :

(*a*) Cost of indirect material and labour

$$= \text{Rs. } \frac{120{,}000 \times 10}{10+3+2} = \text{Rs. } 80{,}000$$

(*b*) Rent of building $= \text{Rs. } \frac{36{,}000 \times 10}{10+3+2} = \text{Rs. } 24{,}000$

(*c*) Insuranace $= \text{Rs. } \frac{15000 \times 10}{10+3+2} = \text{Rs. } = 10{,}000$

(*d*) Depreciation = Rs. 20,000

(*e*) Power consumed = Rs. 18,000

(*f*) Repair and maintenance = Rs. 10,000

Total overhead Rs. 1,62,000

∴ Rate per machine hour (*Lathe*) = Rs. $\frac{1,62,000}{10,000}$

= **Rs. 16.2**

Problem 27.4. Using the data given in example 27.9, calculate rate per machine hour for

(*a*) drill presses

(*c*) milling machines.

6. Production unit method

- One of the simplest methods of applying factory overhead to production is on the basis of *number of production units* such as kgs, tons, thousand feet, hundred litres, etc.
- Overhead rate per unit

$$= \frac{\text{Factory overhead for budget period}}{\text{Production in terms of units for budget period}} \quad \text{...(6)}$$

- It is a simple method and easy to use.
- It is used in those industries or in one or more production departments of big industries, which employ job order cost methods.
- This method is preferred for industries manufacturing one type of product, *i.e.*, televisions, refrigerators, etc., of one size only.
- Since, mostly industries make diversified products, it is more desirable to use a common denominator such as direct labour hours rather than units of production as the basis of calculating overhead.

Example 27.10. If the estimated overhead costs of a factory making two band transistor radios is Rs. 8,000 in a particular period and if the number of transistor radios produced during that period is 400, calculate the overhead rate per transistor radio.

(*b*) If a production order 'Z' schedules making 100 such radios, determine the factory overhead to be applied to the production order 'Z'.

Solution. Using equation (6) above

Overhead rate per transistor radio

$$= \text{Rs. } \frac{8000}{400} = \text{Rs. } 20.$$

(*b*) Factory overhead for production order 'Z'

= Rs. 20×100 = Rs. 2000.

27.12. CONTROL AND ACCOUNTING OF MATERIAL, LABOUR AND OVERHEAD

27.12.1. Material (Refer chapeter No. 23 also)

- A system of material control and accounting,

(*a*) requires a number of subsidiary records which will contain detailed material costs. The subsidiary records include stock ledgers, production orders, material requisitions, returned material reports, etc.,

(*b*) needs to maintain controlling accounts in the general ledger. Since materials are consumed in

production and service functions (*e.g.* maintenance), the general ledger, will summerize periodically material costs.

The general ledger controlling accounts are materials control, Materials in Process, Factory overhead control etc.

(*i*) Store issues materials and supplies after receiving Material issue Requisition form duly signed by the office-in-charge of the section/department.

(*ii*) A copy of the requisition form is kept by the storekeeper and the other returns to the section.

(*iii*) At the end of each accounting period, the materials issued from the stores can be checked against those received by the section.

(*iv*) A summary report of quantities and value of materials issued to the section during the period provides the basis for a general journal entry debiting each section account and crediting the Material Control account.

27.12.2. Labour

- Labour control has received good attention from cost accountants because there is a direct transfer of cash between a business and its labourers.
- In accounting for labour the important cosideration is the indentification of each worker as to how his services are being utilised.
- The accounting system, beside recording the wages paid, should also provide information to control labour cost effectively.
- The main functions necessary for recording and accounting for labour are,

(*i*) Engagement of labourers.

(*ii*) Compiling hours spent by each person.

(*iii*) Ascertaining direct labour hours for each cost centre.

(*iv*) Ascertaining direct labour hours for each production order.

(*v*) Calculation of cost of labour of each Production or Standing order (*i.e.*, an account which represents indirect labour--an overhead account).

(*vi*) Calculation of the wage due to each employee.

– *Accounting for direct labour*

(*i*) *Time tickets* (showing the production order number and the time required), and *piece rate cards* (showing production order number and number of pieces completed for that production order, etc.) are the basis for the daily entries by the cost department in production orders. At the end of a week or a month, (daily) reports are summarized and they form the basis for entries to general ledger accounts.

(*ii*) The entries essential to record the distribution of the direct labour cost to a production order are as follows :

Entry in general ledger :

Labour in process.....

Payroll control.....

Entry in subsidiary records :

Number of hours and labour cost are recorded everday in the labour section of production orders from the information got from piece rate cards and daily time tickets.

(*iii*) Direct labour cost may be *controlled* by the following methods :

(*a*) Effective supervision.

(*b*) Use of Workstudy.

(*c*) Estimated times—comparing estimated with actual time.

(*d*) Introduction of an incentive scheme to reduce lost time.

(*e*) Permitting over-time only when it is a must.

(*f*) Standard costing.

– *Accounting for indirect labour :*

(*i*) Indirect workers such as foremen, engineers, clerks, etc. are paid by week or month.

(*ii*) Their time (of arrival and departure) is recorded on a *time sheet* or *time card.*

(*iii*) Time sheets are summarized weekly or so, to form the basis for the entry to distribute the portion of the payroll representing indirect labour for the period.

Entry in general ledger :

Factory overhead control.....

Payroll control.....

Entry in subsidiary records :

The indirect labour cost is entered as a charge to appropriate service and production departments in the standing order for indirect labour.

27.12.3. Overhead Costs

– The prime cost of an article does not differ much from one factory to another; the major difference in the cost of an article produced by two different concerns is actually the result of differing overhead charges. Thus, overhead expenses must be controlled and minimized for *cost reduction* and increase of profits.

– *Overhead cost accounting :*

(*i*) Costs such as rent, power, gas, light, water, telephone etc., are vouchered during the accounting period and are entered in the voucher register as a charge to the general controlling account, factory overhead control.

(*ii*) Depreciation, taxes and insurance are set up through the media of adjusting entries.

(*iii*) Some of factory overhead costs may be divided directly amongst the process accounts, while for other (overheads), proper basis of distribution should be determined, and the amount of each cost to be allocated to each process should be calculated. Next, an entry is made debiting each process and crediting the controlling account, factory overhead control.

– *Overhead cost control :*

(*i*) Divide overhead into fixed, semifixed and variable costs. Spread fixed and semifixed costs over a larger production in order to reduce overhead costs per piece of product.

(*ii*) Eliminate or decrease the expenditures which are not essential to efficient operation.

(*iii*) Supplies, light, power, telephone, travel, donations, etc. should not be used in wasteful quantities.

(*iv*) If rents are high, new leases may be secured.

(*v*) Depreciation of fixed assets (Building, equipment, etc.) should be reduced through efficient, purchasing and repair policies.

A Careful study of overheads department vice, made periodically will cut short unnecessary costs.

27.13. DEPRECIATION

27.13.1. Definition and Concept

– Buildings, equipments and machinery wear and tear with the amount of use and passage of time.

Their worth does not remain as much after a few years as it is today. This is a state of *depreciation;* equipments, etc., depreciate, *i.e.* their value falls, their worth gets lowered, they become less efficient and ultimately are replaced as they no longer function economically.

- *Depreciation* may be *defined* as the reduction in the value, or the effective economic life of a product arising from the passage of time, use or abuse, wear and tear, influence of the elements, or the cessation of demand for use.
- *Depreciation* may be *defined* as a method for spreading the cost of a long-term asset over the life, or expected years of usage, of the asset.
- Depreciation is a term applied to fixed assets such as buildings, plant, machinery and vehicles which suffer natural deterioration in the course of time. Such deterioration can rarely be wholly arrested by regular maintenance.
- From an accounting point of view, depreciation is an annual charge reflecting the decline in value of an asset due to such causes as wear and tear, action of the elements, obsolescence, and inadequacy.
- From the operating standpoint, depreciation can be thought of as the *rent* paid for use of the equipment during a period of time; depreciation in effect sets aside from each year's income enough money so that funds will be availabe to buy the new machine when the present one is worn out.
- Depreciation is an overhead expense.

27.13.2. Causes of Depreciation

They are :

(*a*) Physical causes.

(*b*) Custom or usage.

(*c*) Abnormal occurrences.

(*d*) Technological developments and changes.

- *(a) Physical causes :*

(*i*) Normal physical wear and tear, due to friction, pull, impact, fatigue, twisting, etc.

(*ii*) Lack of maintenance and timely repairs of fixed assests.

(*iii*) Action of chemical elements on the component parts.

(*iv*) Passage of time.

- *(b) Custom or usage :*

With some types of fixed assets, *e.g.*, cars and other vehicles, there are customs which have been established on the rate of wear and tear normally expected every year. There is definitely a correlation between the price of a second-hand car and the likely extent of depreciation.

- *(c) Abnormal occurrences,* such as

(*i*) Accidents

(*ii*) Defects in materials

(*iii*) Excessive wear and tear

(*iv*) Contingent occurrences *e.g.* appearance of hairline cracks in a pressure vessel adequately tested.

- *(d) Technological developments and changes :*

(*i*) New equipments which supersede the existing ones, start coming in the market *e.g.* calculators have superseded the slide-rules to a major extent.

(*ii*) Change in manufacturing methods which necessitates the use of another type of equipment.

(*iii*) Improved and automated machine tools which render the use of existing ones uneconomical (obsolescence).

(*iv*) Inadequacy of the existing equipment to perform the necessary functions such as increased output, more precision and better quality.

27.13 3. Methods of Calculating (or Providing For) Depreciation

27.13.3.1. Introduction

- A number of methods of calculating depreciation are being employed; some of them are used regularly whereas others are relatively uncommon.
- Most of the methods are concerned with charging of the original cost in the accounts over the useful life of the equipment, etc., usually after deducting the estimated scrap value of the asset concerned.
- The method used for calculating depreciation should be simple to operate and easy to understand.
- The method selected should be employed consistenly and not varied to suit particular financial years.
- Depreciation should be regarded as a legitimate cost and not simply an adjustment of profit.
- The method should be able to help replace the existing asset (*i.e.* equipment, etc.) conveniently when it needs be replaced.
- Depreciation charge should be according to the financial position of the business enterprise and the fall in the value of the fixed asset in different years.
- Legal requirements should be observed (*e.g.*, Companies Act, Income Tax Act, etc.) but requirements of management should also be kept in mind.
- The method to calculate depreciation should, preferably, be decided before purchasing the asset.

27.13.3.2. Methods

The following methods may be employed for calculating *depreciation :*

(*a*) Straight line method.

(*b*) Reducing balance method.

(*c*) Production based methods.

(*i*) Per unit; and

(*ii*) per hour.

(*d*) Repair provision method.

(*e*) Annuity method.

(*f*) Sinking fund method.

(*g*) Endowment policy method.

(*h*) Revaluation method.

(*i*) Sum of the digits method.

(*a*) Straight Line Method

- This method provides for depreciation by means of equal periodic charges over the assumed life of the asset.
- Thus, the method is also known as the *fixed instalment method* or *proportional method.*

- The method assumes that the fixed asset (*i.e.*, equipment) will wear out at precisely the same rate over its useful life.
- According to this method, annual depreciation charge,

$$A.D.C. = \text{Rs. } \frac{C-S}{N} \quad \text{..(7)}$$

where C is the original cost of the asset,

S is scrap value or residual value at the end of its useful life,

and N is seviceable life in years.

- *Advantages*

(*i*) The method is easy to understand and simple to operate.

(*ii*) It is frequently used in practice.

(*iii*) It recognises that the passing of time is a major factor in depreciation and the decline in value of an asset is directly proportionl to its age.

(*iv*) Uniform annual charge affords better comparative costs.

(*v*) The method requires little work for calculating depreciation amounts.

- *Disadvantages*

(*i*) Since fixed assets do not wear out at exactly the same rate during their life, the straight line method in many cases becomes unrealistic.

(*ii*) Usually, repair and maintenance costs tend to increase in the later years of the life of an asset, it may be better to charge a higher rate of depreciation in the earlier years.

Example 27.11. A melting unit for a steel foundry was purchased for Rs. 30,000. Rs. 5,000 more were spent on its erection and commissioning. The estimated residual value after ten years was Rs. 7,000. Calculate the annual rate of depreciation.

(*ii*) Determine the depreciation fund collected at the end of seven years after the purchase of the melting unit.

Solution :

Using equation (7),

C = Rs. 30,000+5.000=Rs.35,000

S=Rs. 7,000

N=10 years.

∴ A.D.C., Annual depreciation charge

$$= \text{Rs. } \frac{C-S}{N} = \text{Rs. } \frac{3,5000-7,000}{10} = \text{Rs. } 2,800.$$

(*ii*) Depreciation fund collected at the end of 7 years

= Rs. 2,800×7 = Rs.19,600.

(*b*) Reducing Balance Methods

- It is also known as *Diminishing balance method* or *Percentage on book value method.*
- In mamy cases, the cost of maintenance of an equipment *i.e.*, fixed asset increases towards the end of its life. Therefore, it is sometimes considered desirable to calculate depreciation so that the charge lessens towards the end of the asset's life, thus roughly equalising the combined charge of depreciation plus maintenance over the period.

– Reducing balance method involves non-linear change that is achieved by taking a fixed percentage, p, of the undepreciated balance every year.

Thus at any time t, the undepreciated portion, will be

$$= C.(1-p)^N \qquad ...(8)$$

– The method charges to the revenue account in the first year a percentage of the cost of the asset. In the following year, the same percentage will be calculated on the reduced value of the asset after the first years's depreciation has been deducted and so on year by year until the value of the asset has been virtually reduced to nil.

– Rewriting equation (8)

$$S=C(1-p)^N \text{ , or } \left(\frac{S}{C}\right)^{\frac{1}{N}} = 1-p$$

$$\therefore \quad p=1-\left(\frac{S}{C}\right)^{\frac{1}{N}} \qquad ....(9)$$

– *Advantages*

(*i*) It is simple to understand and calculate.

(*ii*) A mathematical relation can be employed to arrive at the appropriate percentage.

(*iii*) The method is more logical as largest annual amount of depreciation is charged in the first year when repair and maintenance charges are almost negligible.

– *Disadvantages*

(*i*) It is not simple to fix percentage, p, accurately.

(*ii*) A standard percentage (p) for all conditions may produce misleading results.

(*iii*) It is not possible to ever write off an amount (investment) completely by this method; it approaches the full write-off asymptotically, but never reaches it (refer Fig. 27.1).

Example 27.12. An old car was purchased for Rs. 32,000. Its life was estimated as ten years and the scrap value as Rs. 18,000. Using the reducing balances method, calculate the depreciation rate (%)

(*b*) Estimate the depreciation fund at the end of two years.

Solution :

Using eqation (9); S=Rs. 8,000 ; C=Rs. 32,000 and N=10.

$$p=1-\left(\frac{S}{C}\right)^{\frac{1}{N}} = 1-\left(\frac{8000}{32000}\right)^{\frac{1}{10}}$$

$$=0.1294$$

$$\therefore \quad \%\, p=12.94\%.$$

(*b*) The value of car at the end of one year

$$C_1=C(1-p)$$

$$C_1=\text{Rs. } 32{,}000\,(1-0.1294)=\text{Rs. } 27{,}859.20.$$

The depreciation fund at the end of one year

$$=\text{Rs. } 32{,}000-\text{Rs. } 27{,}859.20$$

$$=\text{Rs. } 4140.80 \qquad ...(i)$$

The value of car at the end of second year

$$C_2=C_1(1-p)=27{,}859.20\,(1-0.1294)$$

$\therefore$ C_2=Rs. 24,237.50.

The depreciation fund for second year

=Rs. 27,859.20–24,237.50

=Rs. 3,621.70. ...(*ii*)

The depreciation fund at the end of two years

=Rs. 32,000–Rs. 24,237.50

=Rs. 7,762.50.

The same can also be obtained by adding (*i*) and (*ii*) above, *i.e.*, Rs. 4,140.80+Rs. 3,621.70=Rs.7,762.50.

Comparison of Reducing Balance Method with Straight Line Method

– Fig. 27.2 shows a comparison of three alternative methods of calculating depreciation.

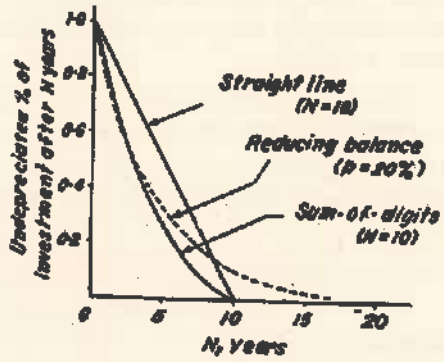


Fig. 27.2. Comparison of methods of calculating depreciation.

– Example 27.13 will further clarify the difference between the methods.

Example 27.13. Two machines are purchased, each for Rs. 12,000. The estimated useful life of the machines is 5 years. The estimated scrap value is Rs. 2,000. For machine *A*, the straight line method and for *B*, the reducing balance method with p=30% is used to calculate the depreciation every year. Compare the depreciation charged in each case.

Solution :

	Machine A (Straight line)	*Machine B (Reducing balance)*
Cost	Rs. 12,000	Rs. 12,000
Less :		
1st year's depreciation	Rs. 2,000	Rs. 12,000 × $\frac{30}{100}$ =Rs. 3,600
	Rs. 10,000	Rs. 8,400
2nd year's depreciation	Rs. 2,000	Rs. 2,500 (rounded)
	Rs. 8,000	Rs. 5,900

3rd year's depreciation	Rs. 2,000.....	Rs. 1,800
	Rs. 6,000	Rs. 4,100
4th year's depreciation	Rs. 2,000.....	Rs. 1,200
	Rs. 4,000	Rs. 2,900
5th year's depreciation	Rs. 2,000.....	Rs. 900
SCRAP VALUE	Rs. 2,000.....	Rs. 2,000

(c) Production Based Methods

- If the basis of calculation – units or hours – are to accrue at the same rate for each year, then equal instalments will be charged every year. On the other hand, if output, per annum varies from one year to another (and the charge is based on the actual hours), the total annual depreciation will not be same.
- *Production unit method* : The method provides for depreciation by means of a fixed rate per unit of production calculated by dividing the value of the asset by the estimated number of units to be produced during its life

$$\text{Rate of depreciation} = \frac{\text{Value of asset}}{\text{Number of units of production}} \quad \text{...(10)}$$

- *Production hour method* : The method provides for depreciation by means of a fixed rate per hour of production calculated by dividing the value of asset by the estimated number of working hours of its life.

$$\text{Rate of depreciation} = \frac{\text{Value of asset}}{\text{Number of production hours}} \quad \text{...(11)}$$

- *Advantages of production based methods*

(*i*) They attempt to base depreciation on service. Instead of assuming constant depreciation every year, the hours or units in each year are estimated and depreciation is calculated

(*ii*) This approach is more realistic where depreciation is determined primarily by reference to work done.

- *Disadvantages of production based methods*

(*i*) It may not be easy to forecast accurately the total annual production units or hours.

(*ii*) These methods do not consider the fact that repair and maintenance costs tend to increase with the age of fixed assets.

Example 27.14. A machine costing Rs. 2,00,000 has a residual value of Rs. 1,00,000 after 10 years of service. The estimated rate of production is 8 units per hour. Using the production unit method calculate the rate of depreciation. Assume a 50 week year and a 46 hours week.

Solution :

Using equation (10)

$$\text{Rate of depreciation} = \frac{2,00,000 - 1,00,000}{10 \times 50 \times 46 \times 8}$$

$$= \text{Re. } 0.5435 \text{ per unit.}$$

Example 27.15. A machine costing Rs. 15,000 has a scrap value of Rs. 5,000 at the end of 10 years of its serviceable life. If the machine runs for 2,100 hours per years, calculate the depreciation rate per hour of the machine and the total annual depreciation.

Solution :

Using equation (11)

Rate of depreciation per hour of machine

$$= \text{Rs. } \frac{15,000-5,000}{10\times2,100}$$

$$= \textbf{Rs. 0.476}$$

Annual depreciation = Rs. 0.476×No. of hours per year

= Rs. 0.476×2,100

= **Rs. 1,000.**

(*d*) Repair Provision Method

- This method is not strictly a separate method.
- It carries out in a more positive manner what the Reducing balance method is alleged to achieve, *i.e.*, the equalisation of the combined charges of depreciation and repair and maintenance cost over the life of asset. Repair and maintenance cost is added to the original cost to give a total capital outlay which is apportioned over the life of the asset.
- This method is oftenly used by public works contractors as a suitable method of charging the hire and use of their own plant to contracts.

Example 27.16. Cost of an air-conditioning units is Rs. 1,00,000. During an estimated life of 10 years, two major overhauls were carried out, each involving Rs, 20,000. If the scrap value of the plant is Rs. 15,000, calculate the depreciation rate on the basis of Repair provision method.

Solution :

	Rs.
Cost of air-conditioning unit	1,00,000
Cost of two major overhauls	40,000
Total cost	1,40,000
Scrap value of the plant	15,000
Remaining cost	1,25,000

Depreciation rate per year $= \frac{1,25,000}{10}$

= **12,500 per year.**

(*e*) Annuity Method

- It considers *original cost* and *interest* on the written down value of the fixed asset.
- It assumes that the purchase of a fixed asset is an investment on which interest is earned.
- Therefore, the *investment* for the purpose of the method is the written down value plus interest earned to date.
- The annuity method is generally used for the redemption of leases over a fairly long period, since money invested for a lengthy period in a capital asset should be deemed to be earning interest.
- The mathematical relation used to calculate rate of depreciation, R.O.D., is

$$\text{R.O.D.} = \frac{[C\,(1+I)^N - S]\,[1-(1+I)]}{[1-(1+I)^N]} \qquad \text{...(12)}$$

where *C*, *S* and *N* are same as in equation (7)

and I is fixed rate of interest (in fractions) determined before hand and charged throughout the life of the asset.

Advantages

– Money invested in fixed asset is not idle, rather it is earning a certain rate of interest.

Disadvantages

– In most cases the interest *as such* never materialises.

– With plant, machinery and similar fixed assets, changes which take place as sales, renewals and additions tend to make the annuity method difficult to apply.

Example 27.17. The cost of a machine is Rs. 6,000 and its scrap value after 4 years is Rs. 3,000. Assuming an interest rate of 4% per year find depreciation rate per year.

Solution :

Given C = Rs. 6,000

S = Rs. 3,000

N = 4 years

I = 4% = 0.04

Using equation (12)

$$\text{R.O.D.} = \frac{[C(1+I)^N - S][1-(1+I)]}{[1-(1+I)^N]}$$

$$= \frac{[6,000(1+0.04)^4 - 3,000][-0.04]}{[1-(1.04)^4]}$$

$$= \text{Rs. } 946.$$

(f) Sinking Fund Method

– The method bases on the assumption of setting up a *sinking fund* in which money accumulates to replace the existing asset at the proper time.

– The method charges annually to revenue account such sum as, with compound interest, will amount to the net cost of the asset at the end of its useful life.

– An identical sum is charged every year as depreciation. This is invested outside the business, so that from the end of second year and each subsequent year interest is added.

At the end of useful life of the asset, the total amount in depreciation plus compound interest should become equal to the original cost of the fixed asset.

– This is only method so far considered which provides cash for the replacement of the asset at the end of the useful life forecast for it.

– The method is frequently used to provide for the amortisation of leases.

– The mathematical relation used to calculate annual rate of depreciation, *i.e.*, R.O.D. is

$$\text{R.O.D.} = \frac{I(C-S)}{(1+I)^N - 1} \qquad \ldots(13)$$

where I, C, S and N have same meanings as in equation (12).

Example 27.18. Calculate the annual rate of depreciation from the following data, using the sinking fund method.

Cost of asset Rs. 6,000

Scrap value Rs. 3,000

Interest at the rate of 4% (compound)

Useful life period 3 years.

Solution :

Using equation (13)

$$\text{R.O.D.} = \frac{0.04\,(6{,}000-3{,}000)}{(1+0.04)^3-1}$$

$$= \text{Rs. } 961.$$

(g) Endowment (Insurance) Policy Method

- The method involves charging depreciation and then investing it in the form of an endowment policy. Each year the sum charged is paid as a premium to an insurance company. At the end of the life of the asset the sum payable should be equal to the original cost.
- The method is similar in effect to the sinking fund method. Cash is taken out of the business to pay the insurance premiums and is made available again at the end of the period for the purchase of another asset, when the policy matures.

(*h*) Revaluation Method

- Revaluation method provides for depreciation by means of periodic charges, each of which is equal to the difference between the values assigned to the assset at the beginning and end of each year, for example :

  "If the value of a machine on April 1, 1974 is Rs. 7,000 and on March 31, 1975 it is revalued as Rs. 6,000, then the depreciation for this period is Rs. 7,000–Rs. 6,000=Rs.1000".
- Usually the revaluation method is concerned with the recovery of original cost.
- The revaluation method is commonly used for loose tools, laboratory glassware, patterns, farmer's livestock, plant used on contract work, etc.

(*i*) Sum of the Digits Method

- The method provides for depreciation by means of differing periodic rates calulated as follows :

  "If *N* is the estimated life of a machine, the rate is calculated for each period as a fraction in which the denominator is always the sum of the series 1,2,3,4...*N* and the numerator for the first period is *N*, for second *N*-1, for the third *N*-2 and so on."
- The effect of this method is to charge depreciation at a decreasing rate each year.

Advantages

(*i*) It is a method of quick depreciation for motor vehicles.

(*ii*) It realistically takes account of the immediate drop in value of a new vehicle, even recently purchased.

(*iii*) It makes the decision to sell and repurchase before the estimated time, easier.

Example 27.19 will explain the sum of the digits method.

Example 27.19. The cost of a vehicle is Rs. 1,90,000. The residual (scrap) value after a period of 5 years is estimated as Rs. 40,000. Using the sum of the digits method, calculate the depreciation rate every year.

Solution :

As per the procedure of the method, the denominator will be 1+2+3+4+5=15, the numerators will be 5, (5–1), (5–2), (5–3) and (5–4).

Thus the depreciation charge for

– Year 1 will be $\frac{5}{15}$ of Rs. (1,90,000–40,000) = Rs. 50,000.

– Year 2 $\frac{4}{15} \times 1,50,000 = \text{Rs. } 40,000.$

– Year 3 $\frac{3}{15} \times 1,50,000 = \text{Rs. } 30,000.$

– Year 4 $\frac{2}{15} \times 1,50,000 = \text{Rs. } 20,000.$

– Year 5 $\frac{1}{15} \times 1,50,000 = \text{Rs. } 10,000.$

27.14. BREAKEVEN ANALYSIS

27.14.1. Concept of Breakeven Analysis

– Revenue and cost can be studied by directing attention to total revenue[1] and total cost. Breakeven analysis implies that at some point in the operations, total revenue equals total cost. Basically, breakeven analysis is concerned with finding the point at which revenues and costs agree exactly – hence the term *BREAKEVEN* (point).

– The breakeven point is, therefore, the volume of output at which neither a profit is made nor a loss is incurred (Fig. 27.3).

– The breakeven analysis can be carried out *algebraically* or *graphically.*

27.14.2. Importance and Scope of Breakeven Analysis

– Breakeven analysis helps solving the following types of problems :

(*a*) What volume of sales will be necessary to cover

(*i*) a reasonable return on capital employed;

(*ii*) preference and ordinary dividents; and

(*iii*) reserves.

(*b*) Computing costs and revenues for all possible volumes of output to fix budgeted sales.

(*c*) To find the price of an article to give the desired profit.

(*d*) To determine variable cost per unit.

(*e*) To compare a number of business enterprises by arranging their earnings in order of magnitude.

27.14.3. Calculation of Breakeven Point

– The breakeven point can be calculated by using the following relation :

$$\text{Breakeven point} = \frac{F}{1 - V/P} \qquad ...(14)$$

where F is fixed cost

V is variable cost per unit or total variable costs.

and P is selling price of each unit (or total sales value may be substituted, symbol S).

Example 27.20. The fixed costs for the year 1975-1976 are Rs. 8,00,000. Variable cost per unit is Rs. 40. The estimated sales for the period are valued at Rs. 20,00,000. Each unit sells at Rs. 200.

(*a*) Find the breakeven point.

(*b*) If Rs. 16,00,000 will be the likely sales turnover for the next budget period, calculate the estimated contribution and profit.

(*c*) If a profit target of Rs. 6,00,000 has been budgeted, compute the turnover required.

---

1. Revenue is determined by the demand factors that affect the quantity of products (items) that can be sold at various prices.

Solution :

Given : F = Rs. 8,00,000.

V = Rs. 40.

P = Rs. 200.

S = Rs. 20,00,000.

(*a*) Using equation (14)

$$\text{Breakeven point} = \frac{F}{1-V/P} = \frac{8,00,000}{1-\frac{40}{200}} = \text{Rs. } 10,00,000.$$

(*b*) Contribution, $C = S\left[1-\frac{V}{P}\right]$

$$= 16,00,000\left[1-\frac{40}{200}\right] = \text{Rs. } 12,80,000$$

Profit $= C-F$

$$= \text{Rs. } 12,80,000-8,00,000 = \text{Rs. } 4,80,000$$

(*c*) Turnover for the stated profit (P_S)

$$= \frac{F+P_S}{1-\frac{V}{P}} = \frac{8,00,000+6,00,000}{1-\frac{40}{200}}$$

$$= \text{Rs. } 17,50,000.$$

27.15. BREAKEVEN CHART

Introduction

- In 1930's Walter Rautenstrauch, an industrial engineer and professor of Columbia University, invented the planning device known as a *Breakeven chart.*
- It was one of the first synthetic tools that became available to Production Management and Management Accountancy.
- Modifications of the breakeven chart that introduce risk make it an even more useful tool for the synthesis of the production management field.

Functions (scope) of

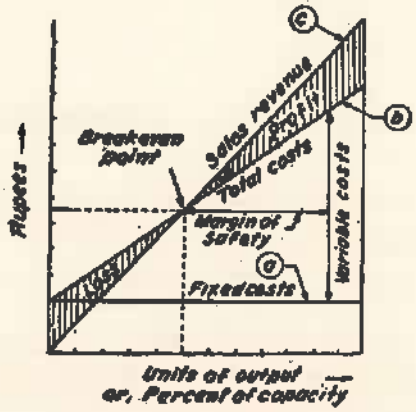
1. A breakeven chart is an aid to management and it depicts a clearer view of the position of a business.
2. It is one of the most useful graphic presentation of accounting data.
3. It is a graphic presentation of an economic rather than an accounting concept.
4. It portrays likely profits or losses at various output levels.
5. It depicts relationship between marginal costs and fixed costs.
6. It marks no profit no loss situation.
7. It portrays margin of safety.
8. It can help make specific plans to effect profits through the control of expenses.
9. It can nicely sum up the impact of alternative decisions on costs and profits.
10. It is a decision making tool in the hands of management.

Definition

- A *breakeven chart* is a graphical representation of the relationship between *costs* and *revenue* at a given time.
- It is a graphic device to determine the breakeven point and profit potential under varying conditions of output and costs.

Construction

- Fig. 27.3 portrays a Breakeven chart.



θ : Angle of incidence.

Fig. 27.3. A Breakeven chart.

- The breakeven chart consists of an ordinate (y-axis) and an abscissa (x-axis). The ordinate presents a scale of rupees against which fixed costs, variable costs, and rupees of revenue can be measured. The abscissa can be dimensioned in terms of the production volume, *i.e.,* number of units produced.
- Three lines marked as a, b and c can be noticed on the breakeven chart.
- Line 'a' is a fixed cost function. Fixed charges do not change as a function of increased volume of production.
- Line 'b' is an increasing linear, monotonic function that increases with increasing volume of production. It represents total costs which result from the summation of fixed and variable costs. The variable costs assigned to the production system are shown by the triangular area between the fixed cost line and total costs line, *i.e.,* 'a' and line 'b'.
- Line 'c' is the sales revenue line. A linear relationship is utilized to describe revenue; which indicates that the price at which any quantity of the output can be sold is fixed and does not change with volume of production.

This line indicates income at varying levels of output or production volume.

Interpretations and analysis of a Breakeven Chart

1. The breakeven point marking no profit no loss situation occurs for a given volume of production.

2. The cross-hatched area between the total cost line and revenue line on the left-hand side of the breakeven point marks loss to the concern whereas the area between the same lines on the right-hand side of the breakeven point represents profit to the enterprise or concern.

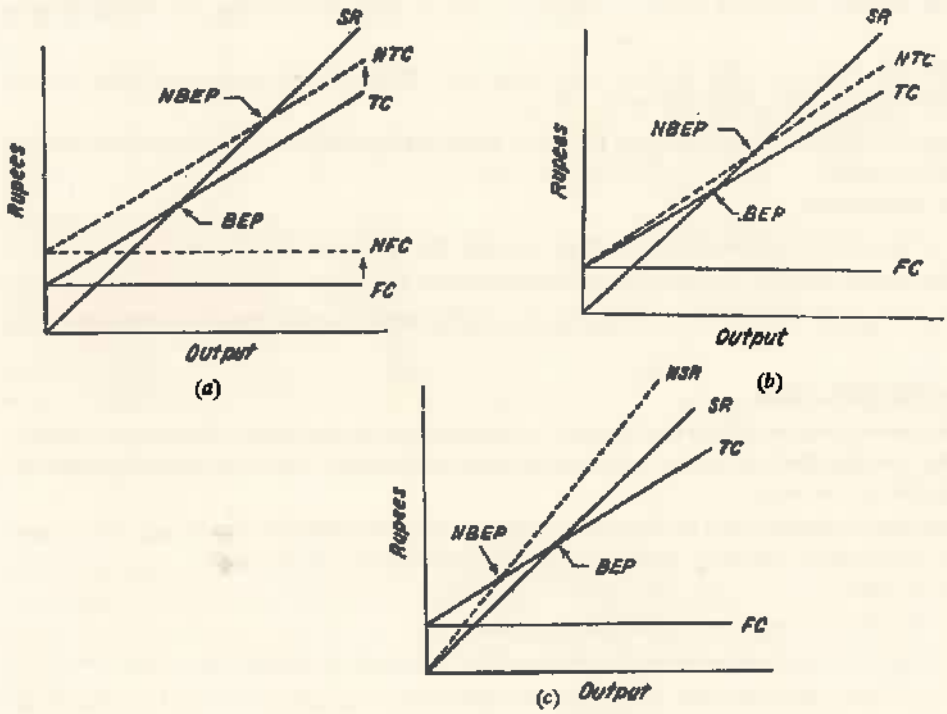
3. Profit appears only when more than a minimum volume of output is reached. Profit increases at a faster rate than do total costs.

4. *Profit margin as %*

$$= 1 - \frac{\text{Variable cost}}{\text{Sales}}$$

Where, sales = Fixed costs + (Variable costs as a % sales) sales.

5. *Effect of an increase in fixed costs* [*Fig.* 27.4 (*a*)]. An increase in fixed costs, possibly owing to the purchase of a new machine, increases the total costs and thus shifts *BEP* (Breakeven Point) towards the right-hand side. This shows that the company's profit position will be impaired if all other conditions remain the same. Therefore, one should study the market conditions carefully before purchasing the new equipments.



BEP - Breakeven point
NBEP - New breakeven point
FC - Fixed cost
NFC - New fixed cost
TC - Total costs
NTC - New total costs
SR - Sales revenue
NSR - New sales revenue

Fig. 27.4. Effect of changing different parameters on breakeven chart.

6. *Effect of an increase in variable cost* [*Fig.* 27.4 (*b*)].

– An increase in variable cost and therefore in total costs, possibly owing to an increase in labour cost, would shift the *BEP* towards the right-hand side. This involves a decrease in profit for the same units of output. Therefore the management may think of going for some new labour saving equipment to maintain its profits as before.

7. *Effect of an increase in sales price* [*Fig.* 27.4 (*c*)]. If the price of an article rises, a new sales revenue will be drawn with a greater slope. This shifts the *BEP* towards the left-hand side and thus increases the company profits for the same volume of output.

8. Effects of a decrease, in fixed cost, variable cost and sales price can be visualised in the same manner as above by drawing separate breakeven charts as in Fig. 27.4.

– ***Margin of safety***

(*i*) Margin of safety can be presented on the breakeven chart as the distance between BEP and the output being produced (Fig. 27.3).

(*ii*) If this distance is large, it indicates that profits will be there even if there is a serious drop in production.

(*iii*) If this distance is relatively small, it hints that profits will be reduced considerably even if there is a small drop in productive capacity or sales.

(*iv*) Margin of safety may be expressed in monetary terms or as a percentage – – the margin of safety in relation to total sales.

– ***Angle of incidence***

(*i*) This is the angle (θ) at which sales revenue line cuts the total costs line (refer Fig. 27.3).

(*ii*) A large angle indicates that profits are being made at a high rate.

(*iii*) A large angle of incidence with a high margin of safety, mark the extremely favourable business position.

Limitations of breakeven chart

1. The breakeven point is difficult to determine in many instances because of the difficulty in properly classifying costs as either fixed or variable and because market conditions may not remain constant over the range of projected capacity.

2. The breakeven chart is a tool for short run analysis; it cannot be used for 8 or 10 year projections because of the difficulty of indicating variables in each of the costs line on the chart.

3. The total cost line, representing the variable costs added to fixed costs, need not be straight line, in actual fact, costs do not usually vary in direct proportion.

4. The straight line which represents sales revenue may also misrepresent the true facts.

5. The breakeven chart represents a static picture whereas business operations are far from static.

6. Analysis of breakeven chart presents additional difficulties. (*e.g.*, in product mix) when a company produces a variety of products.

Example 27.21. The fixed costs for the year 1975-76 are Rs. 80,000. The estimated sales for the period are valued at Rs. 200,000. The variable cost per unit for the single product made is Rs. 4. If each unit sells at Rs. 20, and the number of units involved coincides with the expected volume of output, construct the Breakeven Chart.

(*i*) Determine the breakeven point.

(*ii*) Above how many units, the company should produce in order to seek profit.

(*iii*) Determine the profit earned at a turnover of Rs. 160,000.

(*iv*) Find the margin of safety.

(*v*) Measure the angle of incidence.

Solution :

Given : F = Rs. 80,000 (fixed cost)

V = Rs. 4 (variable cost per unit).

P = Rs. 20 (selling price of each unit).

Estimated sales, S = Rs. 200,000.

$$\therefore \text{No. of units sold} = \frac{200{,}000\ (S)}{20\ (P)} = 10{,}000.$$

Procedure to draw breakeven chart :

1. Draw the fixed cost line (AB) at Rs. 80,000 on the graph paper.

2. Variable cost = No. of units × Variable cost per unit

= 10,000 × 4 = Rs. 40,000.

Variable cost varies from 0 at 0 units to Rs. 40,000 at 10,000 units.

3. Draw variable cost line (AC) above the fixed cost line. The variable cost when added to fixed cost gives the total cost.

4. Sales revenue is zero at 0 units and it is 200,000 at 10,000 units. Therefore draw the sales revenue line OD.

Breakeven chart has been drawn in Fig. 27.5.

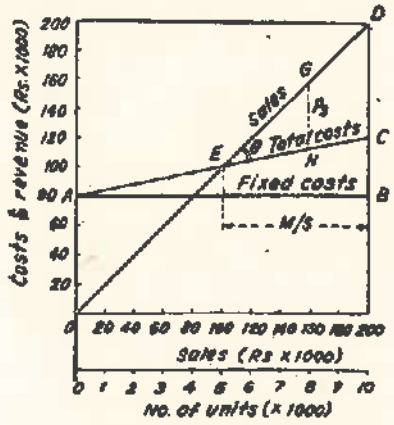


Fig. 27.5. Breakeven Chart.

(*i*) In the breakeven chart, point E represents the breakeven point. It is at 5,000 units or Rs. 100,000, *i.e.,* where production when sold will return Rs. 100,000 in revenue to the company.

(*ii*) The company should produce and sell more than 5,000 units to seek profit.

(*iii*) The profit earned at a turnover of Rs. 160,000 is marked by P_2 in Fig. 27.5 and it is equal to Rs. 48,000.

(*iv*) The margin of safety at 10,000 units has been marked by M/S in Fig. 27.5 and it is

= Total sales − Sales figure at B.E.P.

= Rs. 200,000 − 100,000 = Rs. 100,000

Also, margin of safety when represented as a percentage is

$$= \frac{\text{Margin of safety}}{\text{Total sales}} \times 100$$

$$= \frac{100{,}000}{200{,}000} \times 100 = 50\%$$

(*v*) The angle of incidence θ has been marked in Fig. 27.5 and is 34.3°.

28

Budget and Budgetary Control

28.1. BUDGET, DEFINITION AND CONCEPT

- A budget is an instrument of management used as an aid in the planning, programming and control of business activity.
- A budget may be defined as a financial and/or quantitative statement, prepared and approved prior to a defined period of time, of the policy to be pursued during that period for the purpose of attaining a given objective. It may include income, expenditure and employment of capital.

Based upon this definition, a *recreation budget* of a person for one fine evening may look as :

Taxi charges to cinema hall	=	Rs. 20.00
Cinema ticket	=	Rs. 6.50
Dinner in a restaurant	=	Rs. 75.00
Taxi charges back to home	=	Rs. 20.00
Total		Rs. 121.50

The budget is a statement showing the way the person plans to spend Rs. 121.50.

- Thus budget is a written plan of action.
- A budget is used for cost control purposes and it is one of the most important overall control devices employed by management.
- A budget represents the financial requirements of different sections of the business during a given period to achieve an estimated profit based upon a given volume of sales.
- A budget is based upon past statistical data and it predicts the estimated labour, sales, production and other management requirements for future, *i.e.*, for a definite budgetary period (of time).
- A budget can be thought of as an overall plan for the operation of the business in terms of sales, production and expenditures.

  Thus budget acts as a coordinating device among the various functions of the business.

28.2. BUDGETING

Budgeting is an art of budget making. Budget plays an important role in the development and use of modern cost accounting systems in all types of business enterprises.

- A good budgeting shows the manager what he may expect in sales over the next few months; it permits the formulation of a production quota including the types and quantities of material, the number and kind of labourers, the amount of overhead and the fixed assest requirements; and it points out financial requirements needed to accomplish the budget plans.
- Thus, budgeting implies forecasting and preplanning for the budget period, basing upon past (experience) statistical data, and present conditions.
- *Requirements for an effective budgeting*

(*i*) There should be a proper and recognised organisation (for budgeting) with all lines of authority and responsibility definitely allocated and defined.

(*ii*) The budget should distinctly mark the responsibilities of each section of the business.

(*iii*) Since a budget is based on estimates of sales, costs, etc., good care should be taken to make estimates.

(*iv*) Cost accounting data should be used for (estimating) forecasting purposes.

(*v*) A budget should be made flexible so that unavoidable changes may be incorporated if and when necessary.

28.3. BUDGETARY CONTROL, DEFINITION AND CONCEPT

- Budgetary control makes use of *budgets* for *planning* and *controlling* all aspects of *producing* and/or *selling* products or services.
- Budgetary control attempts to show the plans in financial terms.
- Budgetary control is the planning in advance of the various functions of a business so that the businees can be controlled.
- Budgetary control relates expenditure to a section or department who incurs the expenditure, so that the actual expenses can be compared with the budgeted ones, thus providing a convenient method of control.
- Budgetary control includes forecasts of income and expenditures (for the budgetry period) on equipment, machinery, manpower, materials, etc., necessary for the efficient production and distribution of estimated volume of sale.
- The budgetary control when applied to a business as a whole or to different sections within the business—compares actual performance and the predicted performance and thus enables all levels of management and supervision to know how their sections (of business) are moving towards the achievements of budgeted targets. Is corrective action needed; should it be applied?

Thus, budgetary control attempts to bring actual performance at par with the predicted performance by keeping a strict supervisory eye on the actual performance and by exercising a control, if necessary.

Control follows the planning and co-ordination. Deviations from predicted plan or performance are noticed by comparing actual and budgeted performances and costs. The differences between the two (*i.e.,* predetermined and actual) figures—the variances—are analysed and an action is taken quickly, at the right time and in the correct place to correct the actual performance—as per the predicted or predetermined plan or performance.

28.4. THE OBJECTIVES (FUNCTIONS) OF BUDGETS, BUDGETING AND BUDGETARY CONTROL

1. Budget should specify units to be produced, broken down into sizes and styles, as well as cost of production.

2. Budget should analyze all the factors affecting the sections/departments and the business as a whole.

3. Budget should facilitate planning within the company. It should help planning future income and expenses.

4. Budget should harmonise departmental programmes.

5. Budget should serve as a medium of propagating policies throughout the business enterprise.

6. Budget should hold back or control unwise expenditure.

7. Budget should help stabilizing production and harmonise production and sale programmes.

8. Budgeting should decide basis for expenditure of funds.

9. Besides planning, budgetry control should provide a basis for, measuring performance and exercising control—control means noting when expenditures fall outside the budget estimates, tracing

down the cause of such variation and taking necessary corrective action.

10. Budgetary control should watch the progress of achievements of the business enterprise and evaluate policies of the management.

11. Budgetary control should pin-point those areas which are not working efficiently and according to the predetermined targets.

12. Budgetary control, after planning, should coordinate the activities of a business so that each is a part of an integral total.

13. Budgetary control should facilitate financial control; and control each function so that the best possible results may be obtained.

14. A budget should be flexible.

28.5. ADVANTAGES OF BUDGET, BUDGETING AND BUDGETARY CONTROL

1. Policy, plans and actions taken are all reflected in the budgetary control system. There is a formal recognition of the targets which the business hopes to achieve.

2. Not only departmental programmes are developed, over expenditures in departments are also curtailed and controlled.

3. Budgeting makes for better understanding, coordination and harmony of action in a business enterprise, because all departments take part in budget preparation.

4. The targets, goals and policies of a business enterprise are clearly defined.

5. Deviations from predetermined plans are brought to notice through variance analysis and corrective action is stimulated by reports, statements and personal contacts.

6. It provides management with a guide of daily activities; thus helps determining performance and efficiency of each department, thereby leading to improvement.

7. It informs management the progress made towards achieving the predetermined objectives.

8. It facilitates financial control.

9. Total capital required and price of an item (product) can be estimated in advance.

10. Budgetary control builds morale when operated in a truly managerial spirit, *i.e.,* it should not acquire merely a clerical outlook (or approach).

28.6. LIMITATIONS OF BUDGET

(*i*) Since budget is based on estimates, *i.e.,* estimated sales, estimated costs, estimated business conditions, etc. it may need periodic revisions because estimates may not come out to be cent per cent true.

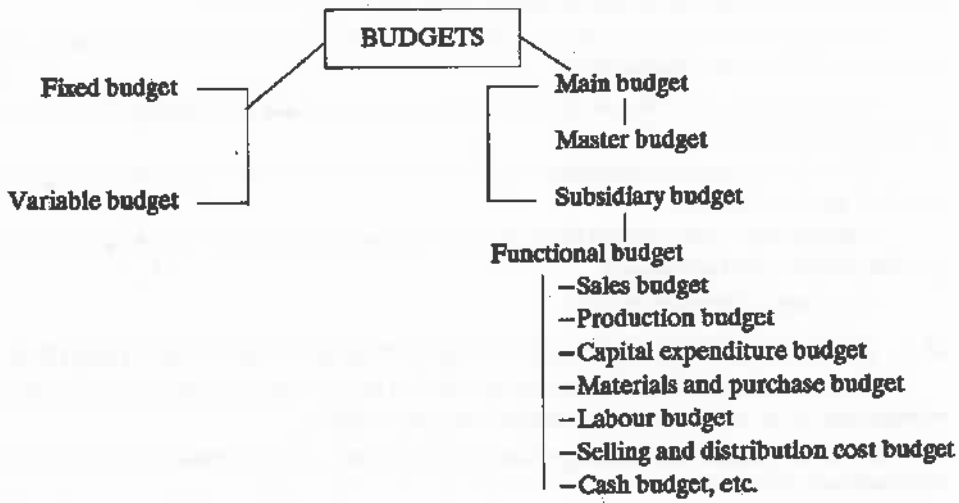
(*ii*) A budget may not work if the idea of budgeting is not sold properly to different sections of the business. Only the persons working in different sections can make an established budget, a success. Thus it should be a cooperative budgeting.

A budget cannot work until the desire to make it work is established in the minds of persons working in the different sections of a business concern.

28.7. TYPES OF BUDGETS

Fixed Budget

- A fixed or static budget shows one plan, one volume of output or sales and the related fixed costs.
- The fixed budget depends upon the ability to predict income, sales or shipments with atleast a reasonable degree of accuracy. It assumes that this prediction or forecast will prove correct. Thus no provision is made for any changes that may occur during the budget period.
- Fixed budget serves a valuable purpose in the planning and control of certain fixed types of expenditures, *e.g.,* a research project, hospitals, schools and colleges, etc.



– Fig. 28.1 shows a fixed budget.

Variable Budget

– A variable or flexible budget recognises the unreliability of income or sales predictions and makes provision in advance for variations in production and expenditures in accordance with variations in sales.

– A variable budget shows a range of volumes of output or sales or costs for each.

FIXED BUDGET

For year ending.....

	Hours		*Budget to capacity %*	*Total cost*	*Details schedule No.*
	Capacity	*Budgeted*			
1. Factory					
2. Selling and Distribution					
3. Administration					
4. R & D.					
				Rs....	

Fig. 28.1. A fixed cost budget.

– Variable budget takes in account only those costs, *e.g.,* direct labour and materials, which vary with output and over which the department has control.

– Flexible budgets are used by those concerns whose activities and levels of operation, etc., are uncertain. This may be due to an uncertainty in customer demand, shortage of materials, labour disputes, priorities etc., which make business forecasting and preparation of accurate budget a difficult matter. For example, for a large bottler of soft drinks, it is difficult to forecast production and sales accurately because of weather changes, conventions, military demand etc.

VARIABLE BUDGET

For year ending.....

Labour	*Volume of output*		
	5,000	*10,000*	*20,000*
	Rs.	Rs.	Rs.
1. Turner	10,000	17,000	30,000
2. Fitter	8,000	12,000	20,000
3. Welder	10,000	16,000	28,000
4. Molder	6,000	9,000	13,000
5. Painter	2,000	4,000	6,000
	36,000	58,000	97,000

Fig. 28.2. Example of a variable budget.

- Flexible budgeting has a major advantage that the element of control is maintained and (the next lower or higher level) budget is still effective even though a decrease or increase in business activity occurs.

Functional Budgets

- A functional budget is one which relates to any of the functions of an undertaking, *e.g.*, sales, production, cash, etc.
- Functional budgets are subsidiary to the master budget.
- The frequently used functional budgets are :
  1. Sales budget.
  2. Production and manufacturing budget.
  3. Capital expenditure budget.
  4. Material and purchase budget.
  5. Direct labour budget.
  6. Selling and distribution budget.
  7. Cash budget.

1. Sales Budget

- This is the budget to which all other budgets must be geared.
- The estimated sales volume must be a realistic assessment of what can be sold. If sales figure is wrong, then practically all other budgets and especially the master budget will be affected.
- It is very difficult to prepare a sales budget because it is not simple to estimate consumer's future demands especially when the company is introducing a new product in the market.
- A sales budget is an estimate of the quantity of products that will be sold and the rupee revenue that will be received during the budgeted period (1, 2, 3 or 5 years).
- Sales budget may be prepared by
  (*i*) Head office personnel.
  (*ii*) Top executives on the basis of their past experience, judgement and opinions, and
  (*iii*) The information collected from salesmen in the market, regional sales supervisors, sales executives, etc.

- The following data should be considered in estimating sales :
  - (*i*) Information concerning past performance.
  - (*ii*) Statistics in regard to present conditions within the company and in each sales territory.
  - (*iii*) Data concerning the industry and general business conditions, *e.g.*, unemployment conditions, steel, coal, and oil production, wholesale price indices, interest rate, etc.
- Fig. 28.3 shows a sales budget.

A. B. C. Co.

SALES BUDGET

Sales area..... Salesman.....For year ending.....

Product	*Rate*	*Estimate for year (Units)*	*Total amount (Rs.)*	*Units sold*	
				Last year	*Average for last 3 years*
X	Rs.....			3,000	27,000
Y	Rs.....			10,000	11,000
Z	Rs.....			7,000	6,000

Fig. 28.3. A sales budget.

2. Production and Manufacturing Budgets

- A production Budget may be prepared by production manager in consultation with his assistants after receiving the sales budget.
- A production budget shows the quantity of products to be manufactured. It is based upon :
  - (*i*) Sales budget,
  - (*ii*) Factory capacity (production and storage),
  - (*iii*) Budgeted stock requirements,
  - (*iv*) Economic lot size, and
  - (*v*) Availability of raw material and labour, etc.
- A production budget finds the cost of producing the estimated volume of salable products.
- A production plan is calculated in terms of the number of units to be produced in each period, say a month.
- As far as possible, the production should be planned at a relatively even rate, even though the sales budget indicates a high seasonal sales forecast.
- Manufacturing budget needs the following basis budgets or estimates to meet the plans.
  - (*i*) Production budget outlining the schedule of product units to be manufactured.
  - (*ii*) Direct material budget.
  - (*iii*) Plant (space) and equipment budget.
  - (*iv*) Maintenance budget.
  - (*v*) Manufacturing expense budget (overhead).
  - (*vi*) Labour budget.
- Production budget is a part of Manufacturing budget. Manufacturing budget helps management in keeping production at an even level and in controlling the use of labour, material, equipment, etc.

A. B. C. Co.

PRODUCTION BUDGET

For the year ending.....

	Units of Output					
	Jan.	*Feb.*	*Mar.*	*2nd Quarter*	*3rd Quarter*	*4th Quarter*
1. Department-*X* –product-*x*	4,000	4,000	4,000	13,000	14,000	15,000
2. Department-*Y* –product-*y*	2,500	2,500	3,000	9,000	9,500	10,000
Total *x*+*y*	6,500	6,500	7,000	22,000	23,500	25,000

Fig. 28.4. Production Budget.

- Production budget may be compiled on departmental basis.
- Figure 28.4 gives a production budget showing the total estimated volume of production, division of estimated output into types of products, scheduling of operations by months and quarters, etc.

3. Capital Expenditure Budget

- Capital expenditure budget represents the estimated expenditure on fixed assets during the budget period.
- The capital expenditure budget is prepared based upon the following information :
  - (*i*) Requirements of new production machinery submitted by production manager.
  - (*ii*) Overloading (in time for any corrective action, *e.g.*, overtime working, etc.) shown in the plant utilization budget.
  - (*iii*) Requirements of new service machinery submitted by Works engineer.
  - (*iv*) Requirement of a new transport by the distribution manager.
  - (*v*) Board's decision to extend building, etc.
- Since usually there is insufficient money available to indulge in all the capital expenditures which appear justified, capital expenditure therefore should be related to the cash position of the business and pruned accordingly.

4. Materials and Purchases Budget

(a) A material budget shows the quantities of each major type of raw material required by months or quarters to produce the goods as per the manufacturing budget.

- When determining the standard quantities, it is usual to allow for normal wastage and for parting off.
- Material quantities may be assessed from past-records, test runs, or technical estimates based on weight content or other factors.
- Fig. 28.5 shows a Materials budget.

(b) Purchases Budget

- Purchases budget is prepared using the information available from materials budget.
- Purchases budget represents the total purchases to be made in the budget period.

- Purchases budget details the quantity of raw material (which should be available at the right time) and the estimated cost of the material.
- Purchases budget helps constructing purchase plans in accordance with established inventory procedures.

A. B. C. Co.

MATERIALS BUDGET

Period : From.....

To.....

	Total units required	*Jan.*	*Feb.*	*Mar.*	*2nd quarter*	*3rd quarter*	*4th quarter*
1. Material-*X*							
–product-z_1	16,200	1,000	1,000	1,000	4,000	4,500	4,700
–product-z_2	43,500	3,000	3,000	3,500	11,000	11,000	12,000
Total	59,700	4,000	4,000	4,500	15,000	15,500	16,700
2. Material-*Y*							
–product-z_1	32,500	2,000	2,000	2,000	8,000	9,000	9,500
–product-z_2	80,000	6,000	6,500	6,500	20,000	20,000	21,000
Total	112,500	8,000	8,500	8,500	28,000	29,000	30,500

Fig. 28.5. A Material's Budget.

- Fig. 28.6 shows a purchases budget.

A. B. C. Co.

PURCHASES BUDGET

Period : From.....

To.....

	MATERIAL-X		*MATERIAL-Y*	
	Production requirements (Units)	*Estimated cost (Rs.)*	*Production requirements (Units)*	*Estimated cost (Rs.)*
Jan.	3,000	300	8,000	800
Feb.	3,250	320	8,000	850
March	3,250	340	8,500	850
2nd quarter	12,000	1,200	25,000	2,500
3rd quarter	13,000	1,300	25,500	2,600
4th quarter	14,000	1,440	26,000	2,600
Total	48,500	4,900	101,000	10,200

Fig. 28.6. Purchases Budget.

5. Direct Labour Budget

- It contains an estimate of direct labour required to manufacture the products shown on the production budget.
- Labour requirements are determined as follows :
  - (*i*) Split the product into operations.
  - (*ii*) Using work study calculate the standard time for each operation.
  - (*iii*) From step (*ii*) above, calculate total number of hours required for production.
  - (*iv*) Convert the hours into labour requirements.
- Direct labour budget is prepared as follows:
  - (*i*) Calculate man power requirements for the department. Ascertain the grade (*i.e.*, male and female) and the number of workmen.
  - (*ii*) Set standard wage rates for the workmen.
  - (*iii*) Fill up the above information on the direct labour budget as shown in Fig. 28.7.

A. B. C. Co.

DIRECT LABOUR BUDGET

Period : From.....

Department.....A.....

To.....

Output : 2000 Units-*X*
3000 Units-*Y*
1000 Units-*Z*

Total standard hours = 24000

Workers	*Number*	*Hours*	*Standard rate (Rs.)*	*Direct Labour cost (Rs.)*	*Total (Rs.)*
Skilled					
–male					
–female					
Semiskilled					
–male					
–female					
Unskilled					
–male					
–female					

Fig. 28.7 Direct labour budget.

6. Selling and Distribution Budget

- Selling and distribution are essential aspects of the profit earning functions.
- Selling and distribution budget represents the cost of selling and distributing the quantities shown in the Sales budget.
- Fig. 28.8 shows a selling and distribution budget.

A. B. C. Co.

SELLING AND DISTRIBUTION BUDGET

Period : From.....

To.....

Elements of Cost	*Territory No.*			*Total (Rs.)*
	1	*2*	*3*	
1. Direct Selling Expenses	Rs.	Rs.	Rs.	
–Salesmen's salaries	1,500	800	1,000	3,300
–Salesmen's expenses	300	200	250	750
–Car expenses	1,000	600	800	2,400
Total	2,800	1,600	2,050	6,450
2. Distribution Expenses				
–Warehouse rent	200	150	220	570
–Warehouse men wages	1,800	1,200	1,500	4,500
–Lorry expenses	2,500	1,800	2,000	6,300
Total	4,500	3,150	3,720	11,370
3. Advertising				
–Press	1,200	1,200	1,200	3,600
–Displays	500	200	400	1,100
Total	1,700	1,400	1,600	4,700
4. Sales Office				
–Salaries	2,500	2,000	2,800	7,300
–Rent	500	400	400	1,300
Total	3,000	2,400	3,200	8,600
Grand Total Rs.	12,000	8,550	10,570	31,120

Fig. 28.8. Selling and Distribution Budget.

7. Cash Budget

- The direct labour budget helps establishment of a *cash budget* because each cash requirements for payments to workers have been estimated accurately.
- It is very necessary to procure cash to meet the company's needs. *Cash budget* represents the cash receipts and payments and the estimated cash balance for each month of the budget period.
- *Functions of Cash budget*

(*i*) To ensure that sufficient cash is available when required to meet daily cash expenditures.

An insufficient amount of cash in hand may result in loss of purchase discounts, inability to meet payrolls, etc., whereas cash in excess of needs, results in loss in income from investments and interest payments.

(*ii*) To reveal any expected shortage of cash so that it may be arranged by taking loan or through a bank overdraft.

(*iii*) To reveal any expected surplus of cash so that it may be loaned or invested.

A. B. C. Co.

CASH BUDGET

Period : From.....

To.....

	Jan.	*Feb.*	*March*	*April*.....
	Rs.	Rs.	Rs.	Rs.
– Cash balance (beginning)	10,000	2,000	3,000	6,000.....
– Receipts from sales and receivables	7,000	12,000	15,000	.....
– Less disbursements	15,000	16,000	12,000	.....
Shortage	–	2,000	–	.....
Bank loans required	–	5,000	–	.....
– Cash Balance (ending)	2,000	3,000	6,000	.....

Fig. 28.9. Cash Budget.

- Cash budget should include two distinct parts, one including a detailed estimate of cash receipts and the other presenting a detailed estimate of cash disbursements.
- The estimates contained in the cash budget are projections of the cash requirements, assuming that the estimates of sales, production and costs included in all other budgets are correctly prepared.
- Fig. 28.9 shows a cash budget.

Master Budget

- Once the functional budgets have been completed, the next step is the preparation of the master budget.
- In brief, master budget includes the information from all functional budgets. It may be regarded as a summary budget. It portrays the overall plan for the budget period.
- Master budget is, in effect, a planned profit and loss account and balance sheet together with a certain statistical information such as return on capital employed, current ratio[1] and quick or liquid ratio[2], (Fig. 28.10).

28.8. PREPARATION OF BUDGET

Steps involved

- Formulate a budget committee which will take up the job of budget preparation.

1. Current ratio = $\frac{\text{Current assets}}{\text{Current liabilities}}$

2. Quick or liquid ratio = $\frac{\text{Liquid assets}}{\text{Current liabilities}}$

- The committee consists of chief executive as the chairman of the committee, a budget officer (who is a senior member of the accounting staff) and representatives of Sales, Production, Purchases and works engineering (maintenance, etc.) departments.

  Consulting those who are responsible for operating the budget is good psychology; if employees participate in budget preparation they will automatically work hard to make budget a success.
- The budget committee will create standard budget forms on which production plans, estimated income and costs may be inserted for each section or department of the business concern.
- Committee asks accounting department to submit reports for the past years, showing a comparison of production costs, income and expenses by subdivisions and departments.
- Each functional executive is asked to prepare and submit the forecast for his department.

MASTER BUDGET

For the year ending.....

Normal capacity.....Standard hours (100%)

Capacity budgeted.....Standard hours.

	Budgeted figures			*Total (Rs.)*
	P-1	*P-2*	*P-3*	
1. Sales				
Manufacturing Costs				
Direct Labour				
Direct Material				
Factory Overhead				
Add Opening Stock				
Less Closing Stock				
2. Cost of Goods Sold				
3. Gross Profit (1-2)				
4. Selling & Distribution costs				
5. Administration Costs				
6. NET PROFIT (3-4-5)				
7. Fixed & Current Assets				
8. CAPITAL EMPLOYED				
9. Ratio of Profit to Capital Employed				
10. Ratio of Sales to Capital Employed				
11. Current Ratio				
12. Quick Ratio				
13. PROFIT APPROPRIATIONS				
14. Net Profit (6 above)				
Less				
Dividends				
Transfer to General Reserve				
Transfer to Asset Replacement Reserve				
Taxation				
15. TOTAL APPROPRIATIONS				
16. PROFIT & LOSS BALANCE				

P-1 : Product 1.

Fig. 28.10. Master Budget.

The Production Manager prepares the production forecast, the Sales Manager, the sales forecast and so on.

Functional executives may take the opinions of Workers, Foreman, Salesman, etc., who remain in direct contact with the job.

The budget officer makes rule that all departments forecasts or estimates are accompanying with sufficient supporting data to provide basis for effective consideration by the budget committee.

- An analysis of general business and market conditions is made with the help of the statistical department or from data supplied by commercial statistical forecasting agencies and government and trade reports.
- The budget officer presents departmental budgets before the committee and transmits back to the departments the recommendations of acceptance or revision.
- Forecasts submitted by functional (*i.e.*, production, sales, etc.) executives, current market and trade data and estimates of future sales in the territories enable the budget committee to formulate general policies and plans for the budget period.
- In consultation with functional or departmental executives, the budget committee reduces general policies of the concern to department plans.

Actual departmental budgets are prepared and revised and they form the standards of performance for the budget period.

28.9. BUDGET AS A MEANS OF PLANNING, CONTROL AND COORDINATION

(a) Planning. Planning implies looking ahead and anticipating probable difficulties.

The budget plans production in accordance with sales estimates and at minimum cost.

In addition, budget plans and forecasts the expenditures as regards production cost, plant utilisation, selling and distribution, purchases, etc.

(b) Coordination. Coordination means weaving together the segments of a business into a coherent whole in such a way that all parts operate at the most efficient level and produce maximum profit.

- Budget coordinates the efforts of all the sections, (*e.g.*, sales, production, etc.) of the business to achieve the common goals.
- A properly constructed and operated budget may have a constructive influence in bringing about a better understanding and team spirit among different persons working in a business enterprise. A proper budget may make them feel about the common goals which must be achieved unitedly for bringing profits to the concern and prosperity to them.

(c) Control. Controlling means the systematic appraisal of results to ensure that actual and planned operations coincide or, if there are any deviations, the carrying out of corrective action.

A budget becomes a means of control when the actual business performance is compared with the predetermined performance. Every functional executive knows what was expected of his department and presently where his department stands. If he feels that his department is falling behind than what was expected of, he prepares a report and reveals the points of difficulty so that the unfavourable situation may be analyzed and improved by taking suitable corrective actions.

28.10. OPERATION (WORKING) OF BUDGETARY CONTROL

- Good budgetary control necessitates establishment of accounting procedures to record actual operations in terms of sales, income, production, etc. within a department.
- The head of each department will receive a copy of the budget appropriate to his activity. Each month, he will get a copy of the departmental budget report.

- From the report, head of the department can visualise at once where he has over- or under-spent his budgeted allowance. This enables head of the department to have a constant check on the operation. Unusual variations come immediately to his attention.
- The variations between actual and budgeted performance and the reasons for variation require a thorough analysis. It may appear that the department has been operating below strength and this caused increased over-time costs.
- Monthly budget reports should be promptly issued to departments soon after the monthly period in question, otherwise adverse costs may go unnoticed for a longer time, and cause problem later on.
- Various department reports are summarized and consolidated by the chief budget executive or budget director in his regular report to the budget committee. On the basis of regular reports the budget committee may recommend revisions or changes in the budget.

29

Job Evaluation and Merit Rating

29.1. JOB EVALUATION

29.1.1 Introduction

It is essential that there should not be any inequity in the salaries of the persons working on the same job in same or in different organisations. Differences in pay lead to resentment (amongst the workers) which in turn increases labour turnover; therefore a planned comparison of jobs is necessary to restrict the occurrence of such situations. At this stage *Job Evaluation* technique comes to help the management.

29.1.2 Definition and Concept

Job evaluation is a systematic process of evaluating different jobs of an organisation. Depending upon the characteristics and requirements of a job, job evaluation determines its relative worth and attaches a value to it. These relative values of jobs assist in deciding wage rates and salaries for different jobs.

Job evaluation deals with jobs only and is in no way concerned with the persons doing these jobs. For evaluating the merit of the person (say a worker), there is another method known as *Merit Rating.*

29.1.3. Objectives

Job evaluation,

(*a*) decides the relative values of different jobs in an organisation;

(*b*) helps to formulate an appropriate and uniform wage structure. The aim is to provide equal pay for all jobs of equal value. The salary should be proportional to the job difficulty and the responsibility associated with it;

(*c*) clarifies the responsibility and authority connected with each job;

(*d*) provides a basis for recruitment, selection, training, promotion and transfer of the emplyees;

(*e*) improves employer-employee relationships;

(*f*) adds to job satisfaction;

(*g*) minimises labour turnover; and

(*h*) describes and evaluates new jobs.

29.1.4 Procedure

(1) Identify the job to be evaluated.

(2) Describe and analyse the requirements of the job. Write down the skill statement and the responsibilities involved.

(3) Compare the job with the pre-identified key jobs and decide its level or value (with respect to key jobs).

(4) Use the information supplied by (3) above to arrive at a suitable wage structure for the job.

29.1.5. Methods

The various commonly used methods or systems of Job Evaluation are ;

(*i*) Ranking method,

(*ii*) Classification method,

(*iii*) Factor comparison method, and

(*iv*) Point method.

(i) Ranking method. The different jobs, depending upon their requirements, responsibilities involved and their importance to the organisation, are ranked, graded or placed from top to bottom.

Advantages

(*a*) The method is simple and fast.

(*b*) It can be easily mastered and administered.

(*c*) The method is suitable for small organisations involving lesser number of jobs to be evaluated.

(*d*) The method does not involve expenses.

Disadvantages

(*a*) There is no commonly accepted base for deciding the ranks.

(*b*) The method is not very accurate.

(*c*) It is not useful for large organisations.

It is the least used method.

(ii) Classification or Grading Method. Jobs are classified or graded in groups or levels of equal skill, difficulty, responsibility, importance and other requirements. It may be a production job, a sales job or an office job; each job family can be broken into a number of grades. For example, office jobs may be classified into six grades, namely grade *A* to grade *F*. Grade *A* involves simple tasks like sorting whereas grade *F* deals with those tasks which require high responsibility and judgement. Each grade carries an appropriate monetary scale.

Advantages

(1) The method resembles Ranking method, is simple and can be easily mastered and administered.

(2) It is more accurate as compared to Ranking method.

Disadvantages

(1) It is not useful for large organisations.

(2) Job classification process is cumbersome and time consuming.

(3) The method does not involve detailed Job Analysis.

(4) Sometimes it is difficult to correlate the (classified) grade of the job with the present salary of the worker; he may be getting a wage higher than the one specified in the recently determined grade for him.

(iii) Factor Comparison Method. The method employs a five factor scale for analysis, comparing and evaluating different jobs. The five factors are *Skill, Mental Effort, Physical Effort, Responsibility* and *Working Conditions*. The various steps involved in the factor comparison method are as follows :

(1) Identify a few *Key Jobs* in the organisation and record their wages. Key jobs are those representative jobs which are assumed to be correctly or fairly paid.

(2) Analyse the key jobs for each of the five factors mentioned above.

(3) Allocate the salary (paid for each key job) amongst the five factors in proportion to their requirements, necessity or importance in the job, (refer Table 29.1).

(4) This formulates a money rating scale for each of the five factors.

Table 29.1 shows that key job-3 requires more skill on the part of the worker as compared to key job-2, whereas key job-2 needs more mental effort as compared to key job-1 and so on.

(5) From Table 29.1 construct a Job Comparison scale (*i.e.*, Table 29.2).

TABLE 29.1.

		Key job (J)				Job to be evaluated
	Salary Rs.	1	2	3	4	(Je)
		780	660	620	940	
Factors						
1.	Skill	180	120	280	80	100
2.	Mental effort	40	160	80	240	60
3.	Physical effort	220	100	20	200	60
4.	Responsibility	300	60	160	260	220
5.	Physical conditions	40	220	80	160	120
						Rs. 560

TABLE 29.2

Rs. (per month)	Skill	Mental effort	Physical effort	Responsibility	Physical conditions
20			J_3		
40		J_1			J_1
60		J_e	J_e	J_2	
80	J_4	J_3			J_3
100	J_e		J_2		
120	J_2				J_e
140					
160		J_2		J_3	J_4
180	J_1				
200			J_4		
220			J_1	J_e	J_2
240		J_4			
260				J_4	
280	J_3				
300				J_1	

(6) Analyse the job to be evaluated into the five factors.

(7) As per the job requirements, determine the importance of each factor in the job, fit the same in the job comparison scale and total the monetary values attached to each. This value for jobs (to be evaluated) J_e comes out to be 100 + 60 + 60 + 220 + 120 = Rs. 560.

Advantages

1. Factor comparison method finds the wages for a job from existing wage rates.
2. It finds wages by direct comparison.

3. For fixing wages for a new job, this method uses a ready made Job Comparison (monetary) scale and thus the wages can be calculated speedily.

Disadvantages

1. It is a complicated method; is not easily understood and hence it is less popular as compared to Point method.

2. Selection of unfairly paid jobs as key jobs can introduce considerable error in the wages calculated by this method.

3. It is difficult to divide each factor into a large number of sub-factors and unless done so, accurate results may not be achieved.

4. The method depends upon subjective judgement; different persons may attach different monetary values with each factor for the same importance.

(iv) Point Method. The point method bases itself on dividing the jobs into a number of factors which in turn are further subdivided into grades or degrees. Each degree is awarded certain points and when such points for all the degrees are totalled they indicate the importance of the job in the organisation; consequently a suitable wage rate proportional to the total points is determined. The steps involved in point method are given below :

(*a*) Select a few key jobs which can be taken as representatives of the jobs to be evaluated in the organisation. Key jobs are those which can be clearly defined and are fairly paid.

(*b*) Establish and define job factors whose number may vary between five to ten. Both, key jobs and the jobs to be evaluated should have common job factors. A few job factors are listed below :

1. Skill
   - Education and Training
   - Experience
   - Judgement and Initiative
2. Effort
   - Physical
   - Mental
3. Responsibility towards material, equipment, machinery, tools and fellow workers.
4. Working conditions
   - Exposure to hazards,
   - Dust, smoke, fumes and noise,
   - High temperature,
   - Glare and harmful radiations, etc.

For the range of jobs to be evaluated, establish the importance of each factor and decide its weighting (*i.e.*, points). Table 29.3 shows weighting for different factors for an arbitrary job.

(*c*) Select and define grades or degrees for each factor mentioned under (*b*) above. For example, the factor *Education and Training* may have the following degrees or grades.

(*i*) Degree in science with no training.

(*ii*) Degree in science with 2 years of training in the material testing lab.

(*iii*) Diploma in engineering with no training.

(*iv*) Diploma in engineering with 2 years of training in the material testing lab.

(*v*) Fresh graduate in engineering.

(*vi*) Degree in engineering with one year's experience in the material testing lab.

Each grade is allotted certain points. The first and the last grades possess minimum and maximum points respectively. The total number of grades may vary from four to eight. An even number of grades is preferred as it avoids the natural tendency to select the middle grade.

(*d*) Allocate points to each grade. Table 29.3 shows the weighting given to each factor and the points allocated to each grade. Four grades have been assumed for each factor.

(*e*) Break the (already selected) key jobs into factors and the factors into grades. Total up all the grade points for each key job.

TABLE 29.3

Grade Table

Factors		Weighting	Grade Points			
			G-1	G-2	G-3	G-4
SKILL	Education and training	20	20x1 = 20	20x2 = 40	20x3 = 60	20x4 = 80
	Experience	12	12	24	36	48
	Judgement and initiative	25	25	50	75	100
EFFORT	Physical	8	8	16	24	32
	Mental	12	12	24	36	48
RESPONSIBILITY		15	15	30	45	60
WORK-ING CON-DITIONS	Exposure to Hazards	3	3	6	9	12
	Other factors	5	5	10	15	20

Since the wage rate for each key job is fair and is known, plot the Figure 29.1.

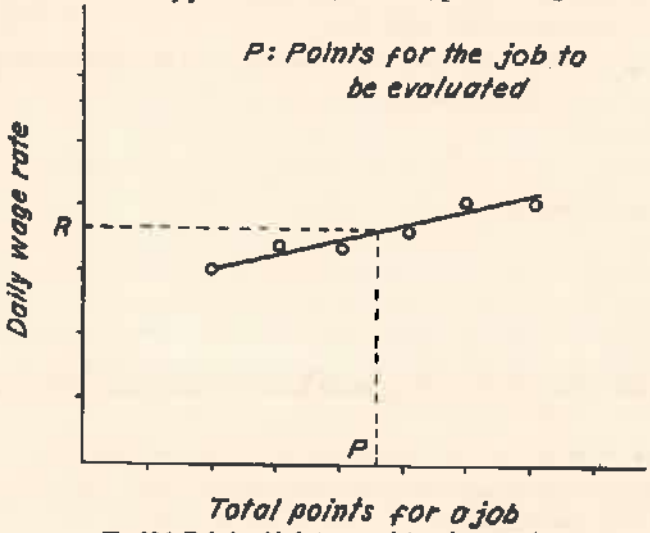


Fig. 29.1. Relationship between points and wages rate.

(*f*) Establish the factors and grades for the job to be evaluated. Add all the grade points (as taken from Table 29.3). Suppose the job gets total grade point '*P*'; then as per Fig. 29.1, the daily wage rate for this job is Rs. '*R*'.

Advantages

(1) Since the method involves points (*i.e.,* numerical figures), it is considered to be more accurate and reliable.

(2) It is more precise than any other method of job evaluations.

(3) Once Grade-Table has been constructed, the chances of subjective discretion decrease.

(4) The method can be understood without much difficulty.

(5) It is the most widely (about 80%) used method of job evaluation.

Limitations

(1) Analysis of factors and grades involves a large amount of work and experience.

(2) Points allocated to each factor base on more or less arbitrary grounds.

29.2. MERIT RATING

29.2.1. Introduction

Whereas Job Evaluation evaluates the job, Merit Rating assesses the merit of the person doing the job. Merit rating determines the extent to which an employee meets job requirements. Job evaluation and Merit Rating are two complementary aspects of a sound personnel policy. The first, determines a suitable wage structure for the job and the second (*i.e.,* merit rating), decides the rewards an emplyee should get in addition to his wages, depending upon his merits.

29.2.2. Definition

Merit Rating is a systematic and orderly approach to assess the relative worth of an employee working in an organisation in terms of his job performance, integrity, leadership, intelligence, behaviour, etc.

Merit rating is commonly referred to as Employee Rating, Employee Appraisal or Staff Reporting.

29.2.3. Objectives

(1) Merit rating provides a record of the worth of employees; they, therefore, can be put on the most appropriate jobs depending upon their capabilities.

(2) Merit rating unfolds the limitations of an employee and thus helps in employee improvement.

(3) Merit rating records form a basis for :

(*a*) Wage-increase,

(*b*) Promotion,

(*c*) Special assignments,

(*d*) Training,

(*e*) Transfer, and

(*f*) Discharge.

29.2.4. Methods

The different methods of merit rating, merit rating plans or merit rating systems are discussed below.

(1) Rating scale method. The steps involved in Rating Scale method are,

(*a*) Define the merit factors (*i.e.,* standards) to rate the employees. The different factors, according to the nature of job may be as follows :

(*i*)	Standard of output	(*ii*)	Quantity of output
(*iii*)	Intelligence	(*iv*)	Job knowledge
(*v*)	Leadership	(*vi*)	Integrity
(*vii*)	Dependability	(*viii*)	Education and experience
(*ix*)	Efforts and initiative	(*x*)	Adaptability
(*xi*)	Co-operation	(*xii*)	Judgement
(*xiii*)	Character	(*xiv*)	Loyalty
(*xv*)	Health and appearence.		

The number of factors employed for rating an employee may vary from six to ten.

(*b*) Divide each factor into three to five different grades or degrees like Excellent, Very good, Good, Fair and Unsatisfactory.

(*c*) Impart certain points (marks) to each grade.

(*d*) The worth of an employee can be determined from the total points he gets for all his merit factors. On the basis of these points different workers can also be compared.

(2) Check list method. The method employs a list of questions and several statements which are concerned with the employee performance on various aspects of the job and which are considered important for evaluating the merit of an employee for that job. The questions are of *Yes* or *No* type. Each question or statement possesses certain points which when totalled together for all the relevant questions indicate the rating of an employee.

Advantages

(*i*) It is a good method of merit rating.

(*ii*) It reduces *Halo-Effect* (explained later).

Disadvantages : It is time consuming and very difficult to construct statements and prepare appropriate questions.

(3) Employee comparison method. The method compares a worker on a job with all other workers on the same job, in pairs. Suppose there are four workers namely W, X, Y and Z. Then

W is compared with X *and suppose* W is better
W is compared with Y *and suppose* Y is better
W is compared with Z *and suppose* W is better
Next,
X is compared with Y *and suppose* Y is better
X is compared with Z *and suppose* Z is better
Y is compared with Z *and suppose* Y is better
The summary of the results shows that
W turned out to be better – 2 times
X turned out to be better – Nil.
Y turned out to be better – 3 times (maximum)
and Z turned out to be better – 1 time.

Therefore, the worker Y is taken to be the best worker.

This method consumes much time especially when the number of employees to be compared is large.

29.2.5. Advantages of Merit Rating.

Besides a few mentioned under objectives, other advantages of Merit Rating are as listed below :

(1) Merit rating developes the ability of a rater,

(2) Meritorious employees are encouraged,

(3) Employee-employer relations improve.

(4) It is easy to deal with the unions as merit rating is a systematic method to rate the employees.

(5) It involves lesser calculations as compared to other incentive schemes.

29.2.6. Disadvantages

(*i*) It entails *Halo Effect*. Halo effect means the tendency of the rater to rate an employee consistently low, average or high in all jobs, simply basing upon the general impression formed by him about the employee.

(*ii*) Correct results will not be obtained, if merit factors relevant to a particular job are, somehow or other omitted or points allocated to them are not fair.

(*iii*) A rater may play safe and tend to impart average grade to an employee who otherwise deserves unsatisfactory rating.

(*iv*) A rater, if he does not make enough personal contacts with each employee cannot rate them correctly.

(*v*) A rater (*i.e.*, supervisor) may not like to degrade his subordinates who may be excellent otherwise but not good at work.

(*vi*) Merit rating does not reward employees immediately for their performance.

30

Wage Payment Plans

30.1. INTRODUCTION

- In all societies taking from the most primitive, people have been selling their services for wages. Wage labour existed from the ancient, through the middle ages and till the time, the factory system developed and gave birth to the modern wage system. *Wage* may be defined as payment for the use of labour. Wages include both money and non-money payments. Non-money payments may also be called as Fringe benefits, etc. *Fair wage* is a wage paid to a worker which is fair as regards the work accomplished by him and which is sufficient to fulfil his basic necessities of life.
- Although the term *wages* is often used to include *salaries*, some experts differentiate between the two. The word, *wages* means compensation paid on an hourly basis; and *salaries* is used to mean compensation of executives, supervisors, salesmen and other employees paid on a basis other than an hourly rate.

Time Wages

The payment of wages on the basis of a year, a month, a week, a day or an hour is probably the most common method. Wages paid under this method are often spoken of as *time wages*. The most common kind of time wage is the *hourly wage*, but *straight salary* (a flat rate per week or month) is also frequently used.

Real Wages

- Real wages represent the *amount of goods and services* that the money wages will buy.
- Assume that the monthly cost of living for Mr.'X' and his family in 1985 was Rs.5000. If the same things which made up this Rs.5000 in 1985 now cost Rs.6000, Mr.'X' would have to be earning Rs.1000 more per month in order to have the same standard of living as he had in 1985. From this example, it is easy to see that the amount of money that one earns is important only in relation to the cost of living. There is no real increase in wages if the cost of living rises at the same rate as wages.

30.2. WAGE PAYMENT PLANS, CLASSIFICATION

Wages are and have been the single most important factor influencing the employee-employer relations. A good wage payment plan is one which satisfies the workers and at the same time brings profits to management (N.B. management is benefited because a satisfied employee will produce more and better).

Wage payment plans can be classified under two groups :

(a) Non-incentive plans like Time or Day rate system, and

(b) Incentive wage plans like piece rate and other schemes (explained later).

30.3. INCENTIVE

Incentive is an *Inducement* or a *Reward* which is given to a worker for his efficiency and hard work. Incentives motivate and encourage a worker to produce more and better. Incentives are in addition to the job hourly rate and are in (some) proportion to the worker's contribution towards production.

Incentives may be classified as *Direct* and *Indirect* incentives and *Financial, Non-Financial* and *Semi-*

Financial incentives. *Direct* incentives are those which are given to an individual worker for his own contribution whereas *Indirect* incentives are paid to a group of workers. *Financial* incentives involve direct monetary payment or benefits whereas *Non-Financial* ones include good working conditions, amenities and social benefits in the organisation.

Financial Incentives. Besides incentives for the immediate work contribution, workers may receive additional financial benefits in the form of

(*i*) Bonus, and

(*ii*) Profit sharing.

Non-Financial Incentives. Non-financial incentives include :

(*i*) Job satisfaction,

(*ii*) Better and healthy working conditions and surroundings,

(*iii*) Chances of promotion,

(*iv*) Job security,

(*v*) Helpful and co-operative management,

(*vi*) Respect and recognition in the organisation,

(*vii*) Training and other employee-improvement programmes, and

(*viii*) Housing, medical, recreational and educational facilities to workers and their families.

Semi-Financial Incentives. Semi-financial incentives include :

1. Provision of subsidised lunch, recreational and medical facilities to the workers and subsidised educational facilities for their children.

2. Pension and other benefits.

30.4. WAGE INCENTIVE PLANS

30.4.1 Introduction. Wage incentive plans reward an employee for his good job-performance. The various aspects of job-performance are

(*i*) Product Quantity;

(*ii*) Product quality;

(*iii*) Utilisation of materials, plant, tools and services; and

(*iv*) Efficiency.

Almost all commonly employed Wage Incentive Schemes guarantee a minimum (base) wage plus incentive based upon operator's performance, if it exceeds a plant-wide standard. Normally the wage incentive plans should depend on the standards set by Work Measurement. The *Wage Rate* may be the result of mutual agreement between employer and employee or formal/informal evaluation of the employee.

Upti! now, about twenty-five major *Wage Incentive Plans* have been analyzed. A few of them which are considerd to be the basic and representative, will be discussed in this chapter.

30.4.2 Requirements of. The requirements of a sound wage incentive plan are :

(*a*) It should be simple, easy to understand and to operate. It should involve least clerical work.

(*b*) It would be well planned and guarantee a minimum wage.

(*c*) A worker should be rewarded in proportion to his efforts and achievements. Reward should be promptly paid.

(*d*) A worker should get enough and adequate incentive for his contributions.

(*e*) The scheme should preferably be based on Time-study data.

(*f*) It should give incentive both for quantity and quality of production.

(*g*) Standards should be fairly set.

(*h*) The scheme should be *Just* for workers as well as for the management.

(*i*) Standards and hence the allowed time (to the worker) should be altered only when there is a change in the work method.

(*j*) Standardization should preferably be the basis for all incentive scheme. Work methods, materials, work place, working conditions, etc., all should be standardized.

(*k*) Worker should not suffer in his incentive (*i.e.*, earnings) for reasons (like faulty material, improper tools, etc.) beyond his control.

(*l*) No limit should be put on a worker's incentive earnings.

(*m*) The plan should be installed with the consent of the employees.

(*n*) Once installed, the incentive scheme should be rigidly maintained.

30.4.3. Objectives of

(1) The incentive scheme should be profitable to both workers and management.

(2) It should help increasing production and thereby lower the related costs.

(3) It should reward workers in proportion to their output, and thus high up their morale.

(4) The characteristics of an incentive scheme should be such that an able worker is in a position to earn sufficient amount of money to raise his standard of living.

(5) An incentive scheme should provide recognition to a worker for his good contribution.

(6) An incentive scheme should aid improvement in the utilization of equipment, materials and services.

(7) An incentive scheme should furnish a basis for cost control and labour control.

(8) An incentive scheme should help in reducing labour turnover and absentee rate.

(9) An incentive scheme should aim at improving relations between workers and management.

30.4.4. Drawbacks of

(*i*) An incentive scheme involves extra cost of :

(*a*) Standardizing methods, allowed time, materials, product design, etc.,

(*b*) installing and maintaining (the incentive plan), and

(*c*) keeping the records of worker's performance.

(*ii*) An improperly structured and planned incentive scheme can be a root of all troubles and disputes between the labour and management.

(*iii*) Observations* showed that groups of workers may have different opinions on an incentive plan and this may give rise to conflicts among workmen, between workers and inspectors and between workers and personnels who developed the incentive scheme.

30.4.5. Types of. The following different Wage Incentive Plans for *Direct Workers* will be discussed here.

(*a*) Straight piece rate,

(*b*) Straight piece rate with a guaranteed minimum wage,

(*c*) Differential piece rate system,

(*d*) Halsey Plan,

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* M. Dalton, 'Economic Incentives and Human Relations', Industrial Productivity, Monograph No. 7, IRRA, 1951.

(*e*) Rowan Plan,

(*f*) Gantt Plan,

(*g*) Bedaux Plan,

(*h*) Emerson's efficiency Plan, and

(*i*) Group Plan.

(*a*) **Straight Piece Rate System.** In the straight piece rate system, a worker is paid straight for the number of pieces which he produces per day.

Earning of a worker = No. of pieces (*i.e.*, units) produced×Rate per piece.

In other words, if a worker brazes 16 heat exchangers per day and for each heat exchanger the wage rate is Rs. 5 then he earns at the rate of Rs. 80 per day (8 hours).

The wage rate per piece to be paid to worker is decided as follows :

(*i*) Through any appropriate work measurement technique determine the standard time required to braze one heat exchanger. Suppose it comes out to be 30 minutes. It means in a working day (*i.e.*, 8 hours) a worker should be able to braze 16 heat exchangers.

(*ii*) Find from the local or national market the wages for such type of job. Suppose it is Rs. 2000 p.m. ; which means 2000/25×16 = Rs. 5 per piece (for a 25 days month).

Advantages

(1) The method is very simple, easy to understand and to operate.

(2) A worker's earnings are solely based upon his contribution towards production and it appears to be a good incentive for him.

(3) This method of payment helps boosting production fast.

(4) it is easy to estimate labour cost.

Disadvantages

(1) With a motive to produce more (and thus to earn more) the workers may not pay proper attention towards:

(*a*) maintaining the required product quality,

(*b*) effective utilization of materials, equipment and tools, etc.

(2) The method does not assure job security.

(3) A worker may suffer badly as regards his earnings owing to the enforced idleness if any, (*e.g.*, lack of material, instructions, power or proper tools, etc.)

(4) A worker is not guaranteed minimum wage.

(5) With a desire to earn more and excel others, a worker may spoil his relations with his co-workers.

Because of these disadvantages the method is not much used in industries today.

Applications. This type of wage incentive scheme is very suitable where

(*i*) industries involve repetitive nature of jobs;

(*ii*) a job can be distinctly identified and the output can be measured; and

(*iii*) management desires to increase total production.

(*b*) **Straight Piece Rate with a Guaranteed Base Wage.** This method is an improvement over the straight piece rate system as it guarantees a minimum (hourly or daily) base wage. Suppose the standard of output set by the management is 16 pieces per day. If a worker produces less than this amount he still gets the minimum guaranteed wage and if another worker exceeds this standard, he is given a wage in direct proportion to the number of pieces produced by him at the straight piece rate.

The following illustration will explain this method :

Assume

1. An output standard of 16 pieces per day.

2. A wage rate of Rs. 10 per hour.

3. 8 working hours in a day.

Therefore per piece wage is $10 \times 8/16$ = Rs. 5

The guaranteed wage rate will be 8×10 = Rs. 80 per day.

(*a*) If a worker produces less than the output standard set (*i.e.*, 16 pieces per day) he still gets Rs. 80 per day.

(*b*) On the other hand if a worker excels the output standard and makes 20 pieces per day, his earnings will be 20×5 = Rs. 100 per day.

Advantages

(1) The system provides a guaranteed minimum wage.

(2) By guaranteeing a minimum wage, this system automatically takes some care of the enforced idleness beyond the control of the workers.

Disadvantages : A worker who produces say 14 pieces per day, still gets Rs. 80 for that day—that means he earns @ Rs. 80/14, *i.e.*, Rs. 5.71 per piece whereas a worker producing 20 pieces per day, gets Rs. 100 only, *i.e.*, he earns @ Rs.5 per piece. This shows that the system does not offer sufficient incentive for a worker who exceeds the set output standard.

Like the straight piece rate system, this system is also becoming obsolete.

(*c*) **Differential Piece Rate System.** A differential piece rate system tends to overcome the disadvantages of the piece rate system by providing a guaranteed base. It bases itself on differential wage rates ; a worker who exceeds the output standard is paid a higher wage rate per piece and another who fails to do so gets his earnings at a low piece rate [refer to curve (*c*) of Fig. 30.1]. This system as suggested by F. W. Taylor had the disadvantage that the inferior or fresh workers, who were unable to reach output standard, could earn very little and hardly survive.

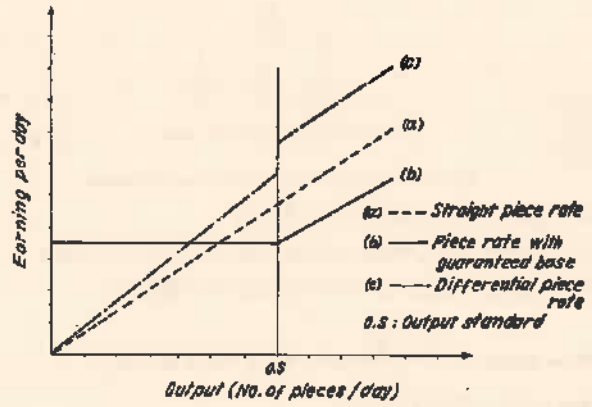


Fig. 30.1. Comparison of various piece rate plans.

Merrick modified the Taylor's plan and introduced *Merrick Differential Piece Rate System*. This plan assured a minimum wage to the workers and suggested separate differential piece rates (in an increasing

order) for workers reaching up to 70%, 100%, 120% of the output standards and above (refer Fig. 30.2). This system, though improved Taylor's plan could not become popular because of its complex nature of wage calculations.

(*d*) **Halsey Plan.** In Halsey Plan

(*i*) a minimum base wage is guaranteed.

(*ii*) an additional bonus is given to a worker who exceeds output standard (in a given time). He normally gets a percentage of the total bonus for the saved time. A very common percentage is 50-50, *i.e.*, 50% of the bonus (on the saved time) is given to the worker and the rest (50%) is enjoyed by management.

(*iii*) Output standards are based upon previous production records available.

Wage of a worker is given by

$$W = R.T + (P/100)\,(S - T)\,R.$$

for 50-50 Halsey plan

$$W = R.T + (50/100)\,(S - T)\,R = R.T. + \frac{(S-T)R}{2}$$

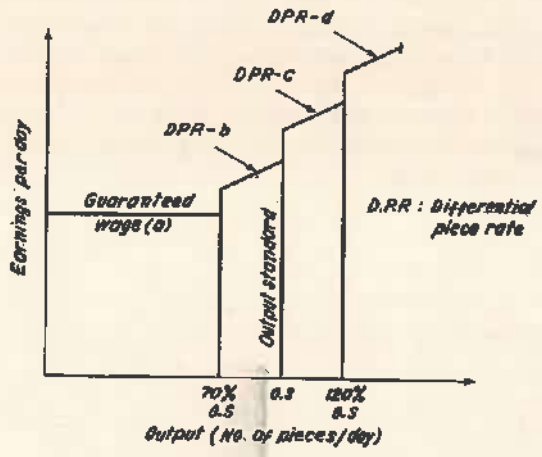


Fig. 30.2. Merrick differential piece rate system.

Assume R – the hourly wage rate = Rs. 10.

T – Actual time taken to complete the job = 4 hours

S – Standard time or allowed time = 6 hours.

Then

$$W = 10\times4 + \frac{(6-4)}{2}\,10 = 40 + 10 = \text{Rs } 50.$$

Therefore wage rate per hour = 50 / 4 = 12.5.

Whereas a worker who finishes the job in 6 hours gets only

R. T., *i.e.*, 10×6 = Rs. 60. In this case wage rate per hour is only Rs. 10.

Advantages

(*i*) It guarantees minimum wage.

(*ii*) It is simple to understand and to operate.

(*iii*) It does not consume time on expensive time studies.

(*iv*) Management also shares a percentage of bonus.

Disadvantages

(*i*) Workers do not like that management should share the bonus on the time saved solely because of their efforts.

(*ii*) Output standards being based upon past production records (and not on time study) may not be accurate and fair or just to all workers.

(*e*) **Rowan Plan.** Rowen Plan

(*i*) like Halsey plan provides a minimum guaranteed base wage;

(*ii*) like Halsey plan relies upon output standards based upon past production records; and

(*iii*) unlike Halsey plan gives a bonus on

$\left(\frac{S-T}{S}\right)$ rather on $(S-T)$ *i.e.,* time saved.

In Rowan plan

$$W = RT + \left(\frac{S-T}{S}\right) RT$$

Assume R–Hourly wage rate = Rs. 10

T–Actual time taken to complete the job = 4 hours

S–Standard time or allowed time = 6 hours.

Then

$$W = 10 \times 4 + \left(\frac{6-4}{6}\right) \times 10 \times 4 = 40 + 13.3 = \text{Rs. } 53.3$$

Advantages

(*a*) Since Rowan plan gives a bonus on $(S-T)/S$ value, it can be employed even if the output standard (as based upon the past production records) is not very accurate.

(*b*) It provides a guarantee of minimum wage.

(*c*) Inferior and fresh workers are not penalised.

(*d*) Management shares a percentage of bonus.

Disadvantages

(*a*) It is not easy to understand and to operate.

(*b*) Workers do not like management to share their bonus.

(*c*) Incentive for high productive workers is insufficient.

(*f*) **Gantt Plan.** In Gantt Plan

(*i*) a guaranteed wage is provided;

(*ii*) workers reaching output standard get a wage rate increase, and

(*iii*) workers exceeding output standard, are paid at a higher wage rate.

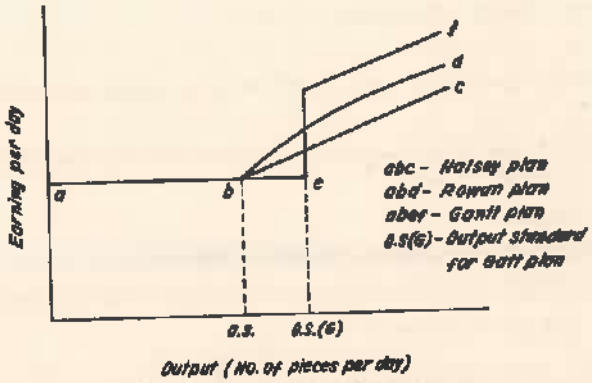


Fig. 30.3. Halsey, Rowan and Gantt Plans.

Curve *abef* of Fig. 30.3 explains Gantt Plan.

Gantt plan is an improvement over the Taylor's differential piece rate system.

(*g*) **Bedaux Plan.** In Bedaux plan

(*i*) Like other incentive wage schemes a minimum base wage is guaranteed.

(*ii*) '*B*' represents unit of work. 1 *B* stands for 1 standard work minute and it includes working time as well as time for rest. A worker earning "60*B*'s" per hour reaches 100% of the standard output or 100% efficiency.

(*iii*) A bonus is paid to a worker who earns more than 60 *B*'s in one hour. The bonus as in the original plan is 75% of the number of *B*'s above 60, in one hour.

Assume R – the hourly wage rate = Rs. 10

T – actual time taken to complete the job = 4 hours.

N_T – number of B's earned = 60×4 = 240

S – Standard or allowed time – 6 hours.

N_s – standard numbr of points for that job = 6×60 = 360

Then

$$W = RT + \left[\frac{N_s - N_T}{60}\right] \times \frac{75}{100} \times R$$

$$= 10 \times 4 + \left[\frac{360 - 240}{60}\right] \times \frac{3}{4} \times 10 = 40 + 15$$

$$W = \text{Rs. } 55.$$

(*h*) **Emerson's Efficiency Plan.** In Emerson's efficiency plan

(*i*) a base wage is guaranteed,

(*ii*) a worker having efficiency from 67-100%, earns an incentive from 0 to 20% (refer Fig. 30.4).

$$\text{Efficiency of a worker} = \frac{\text{standard or allowed time } (S)}{\text{actual time taken by the worker to complete the job } (T)}$$

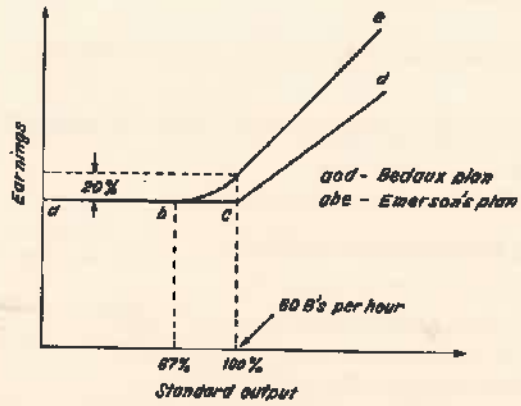


Fig. 30.4. Bedaux and Emerson plans.

(*iii*) for efficiency above 100%, for every 1% increase in output, the worker gets 1% increase in incentive.

(*i*) **Group Incentive Plan.** A group incentive plan is preferred to an individual incentive plan where,

(*a*) the output or effective contribution of each worker cannot be accurately measured. For example : a number of workers unloading freight cars,

(*b*) the output of a worker can of course be measured but it is related with the output of others as in (flow) production of motor-cycles or air-conditioners,

(*c*) all the workers in a group are equally skilled.

The *Principle* of a group incentive plan can be

(*i*) Evaluate the collective performance of the group,

(*ii*) Calculate total incentives and earnings,

(*iii*) Divide the earnings in equal or any other proportion amongst the workers—depending upon the qualities (output, skill, etc.) possessed by each worker. The group leader may be given a bigger share because he is responsible for the successful completion of the job. The division of earnings, if carried out unwisely and without proper thought, may deteriorate team spirit, spoil the job and create conflicts and resentment amongst the workers.

Advantages

(*i*) A team spirit builds up amongst the workers.

(*ii*) Less skilled workers learn from the skilled ones.

(*iii*) The amount of supervision required is less.

(*iv*) Group plans involve less clerical work.

(*v*) Group plans are simpler and less expensive than the incentive plans employed for individual workers (discussed earlier).

Disadvantages

(*i*) In case the total earnings are equally divided amongst all the workers in a group ; a slow worker gets the same money as a speedy worker and this creates dissatisfaction amongst the skilled workers and may add to labour turnover.

(*ii*) Unequal division of earnings amongst the workers may give rise to conflicts amongst them.

(*iii*) It may be difficult to achieve rapid increase in production.

(*iv*) Production rate of slow workers in the line may limit the production capacity of the speedy workers.

(*v*) Group incentive plans do not work well if the group size is large.

Applications

(*i*) In mass and continuous production industries (chemical, petrol, etc.).

(*ii*) Riveting of bridges,

(*iii*) In the manufacture of electronic equipments.

30.5. INCENTIVES FOR INDIRECT WORKERS

30.5.1 Introduction. Workers may be classified as

(*i*) *Direct workers*, who operate the machines and turn out production. A drilling or milling machine operator is a direct worker. It is easy to measure the output of a direct worker and section 30.4.5 describes the various incentive schemes applicable to direct workers.

(*ii*) *Indirect workers*, who assist, guide and supervise the direct workers during production runs. Indirect workers may be categorized as

(*a*) Material handlers, crane operators, set up men, maintenance men, etc.

(*b*) Shop inspectors, foremen and supervisors, and

(*c*) Managers.

The main difficulty associated with the incentive payments to indirect workers is that their contribution towards production cannot be accurately measured and hence it is extremely difficult to reward them effectively and suitably. The wage incentive plans applicable to direct workers cannot be usefully employed for indirect workers. However, many organisations have designed incentive schemes to motivate the indirect workers.

30.5.2. Suggested Incentive Schemes for

(1) Labourers, Crane operators, set-up men, maintenance men, etc.

(*a*) They can be given the same or half the incentive what the direct workers (of their department) get.

(*b*) They can be given a bonus at a flat rate, (say 8-12%).

(2) **Supervisory staff.** Supervisory staff can be paid an incentive on the output for which it is responsible. There are a number of factors on which, incentives can be based. A supervisor can be given a bonus depending upon,

(*a*) the number of satisfactory units produced by his section/department in one day or one week,

(*b*) the number of work hours saved in achieving the same output,

(*c*) reduction in scrap and wastage,

(*d*) net cost saved for the organisation,

(*e*) optimum utilization of workers, and

(*f*) the number of orders in whose case delivery dates were met.

(3) **Managerial Staff.** For running a concern effectively, it is highly necessary to maintain the interest and participation of the managerial staff. Incentives to managerial staff may be in the form of,

(*a*) **Bonus.** Bonus may be given to the managerial staff in proportion to their merits, job requirements, or salary drawn by them.

(*b*) **Issue of Shares.** Company shares may be issued to managerial staff. The number of shares, natu-

rally builds up year after year and this induces a sense of discipline, loyalty and cooperation in the managers who start realising that they are partners in the company and they have to work sincerely and whole heartedly for the same. In this way labour turnover automatically gets minimized.

(*c*) **Profit Sharing.** As per the mutual agreement between the employer and the indirect workers, a portion of the company profits may be shared by the indirect workers, in addition to their normal wages. The share of profit which goes to a particular person may depend upon his salary, length of service, merits and responsibilities.

(*d*) **Fringe Benefits.**

Free accommodation,

Provision of conveyance and phone facilities,

Financial assistance at the time of difficulty.

Subsidized children education, etc.

30.6. PROFIT SHARING

30.6.1. Introduction and Definition

- Profit sharing schemes may effectively supplement other incentive plans discussed earlier.
- Profit sharing is a scheme to augment the compensation of workers through the sharing of profits of the company.
- Profit sharing may be defined as an agreement freely entered into, by which the employees receive a share, fixed in advance, of the profits. This compensation is in addition to the regular wages and bears a definite percentage relationship to company profits. This definition would exclude bonuses based on profits which are not assured on a continuing basis.

30.6.2. Objectives

(*i*) To promote worker's efficiency.

(*ii*) To raise productivity.

(*iii*) To make workers feel that their interests are identical with those of the employer.

(*iv*) To make workers behave in a more responsible manner.

(*v*) To arouse cooperative spirit in the workers and to minimize industrial disputes.

(*vi*) To develop scrap reduction and waste elimination consciousness in the workers.

(*vii*) To develop a proprietary attitude on the part of employees.

(*viii*) To minimize labour turnover.

(*ix*) To foster industrial democracy.

(*x*) To improve employee morale.

(*xi*) To bring workers and management closer so that many problems can be sorted out due to already developed better mutual understanding and cooperative spirit.

30.6.3. Methods to Distribute Profits

- Profits under the profit sharing scheme can be distributed to employees in a number of ways, such as

(*i*) In the form of cash money.

(*ii*) In the form of company shares.

- Profits under the profit sharing scheme can be paid to employees on the basis of :

(*i*) Their years of service with the company.

(*ii*) (A fixed percentage of) their total wages during a stipulated period.

(*iii*) Merit rating of the employees.

(*iv*) Their attendance.

(*v*) Their good performance record.

(*vi*) Their good general record, etc.

30.6.4. Advantages

(*i*) Employees and employers develop better mutual understanding and cooperation.

(*ii*) Industrial disputes tend to reduce.

(*iii*) Productivity increases.

(*iv*) Scrap and waste tends to reduce.

(*v*) Labour turnover reduces.

(*vi*) Worker's efficiency increases.

(*vii*) Worker's morale and motivation improves.

(*viii*) It develops a sense of participation in the employees.

30.6.5. Applications

Beside under other conditions, profit sharing is often used to arouse the interest of workers who cannot be placed on piece work, *e.g.*, executives, men in shipping room, delivery men, etc.

30.6.6. Limitations (or Objections)

(*i*) It is difficult to gauge the varying contributions of individual employees.

(*ii*) Compensation is not paid soon after the employee effort is made.

(*iii*) Compensation amount fluctuates annually and is generally too small to prove an incentive.

(*iv*) Even if workers have put their best efforts, they will not get any compensation if the company goes in loss due to other reasons, *e.g.*, excessive on-cost burden, etc.

(*v*) All workers, semi-skilled or highly-skilled, non-productive or highly productive may receive equal share.

(*vi*) Workers expect some form of profit distribution and if this sum is lower than anticipated, they may become sceptical as to the exact stated amount of profit by the company and may get disappointed and disgruntled.

31

Sales and Marketing Management

31.1. INTRODUCTION

- Business functions can be broadly divided into three areas, namely
  - (*i*) Finance,
  - (*ii*) Production, and
  - (*iii*) Sales.
- Sales function is a very vital phase of the business.
- Actually, the major problem of today's business is not that of production but it is that of sale. With the immense competition at every step of marketing, the problem of sales has outstripped the problem of production.

31.2. SALES MANAGEMENT

- *Sales Management* is the term applied to the process of distributing goods from the producer to the ultimate user. It consists of *advertising* and *selling, storing, transporting* and *handling* and *financing* or *risk-taking.*
- The three biggest problems which seem to be attached with Sales Management are,
  - (*a*) Managing sales force and making them understand the definition of their jobs, *i.e.*, the sales force must know who is selling what, where and to whom.
  - (*b*) Compensation of salesmen, *i.e.*, rewarding sales force suitably.
  - (*c*) Training of sales force.

31.3. SALES (MARKETING) ORGANIZATION

- The actual organization of the sales force or sales department is largely determined
  - (1) by function;
  - (2) by area;
  - (3) by product group;
  - (4) by customer category and end-user category.

1. Functional Organization

- The functional organization (Fig. 31.1) is usual for the small or medium sized company with a limited range of related products.
- Functional organization has various functional (marketing) departments or specialists reporting to a sales or a marketing director.
- Functional organization has the *advantage* of administrative simplicity.
- Functional organization suffers from certain *disadvantages* such as
  - (*a*) Inadequate detailed planning for specific products and markets, since no body is assigned full responsibilty for any product or market.
  - (*b*) Products that are not favourites with various functional specialists tend to get neglected.

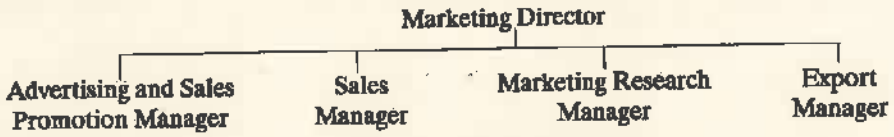


Fig. 31.1. Functional Organization.

2. Area Based Organization

The area based organization (Fig. 31.2) is one of the more common ones in use for concerns with a relatively limited range of products requiring selling and distribution to be on a more or less nationwide scale through many outlets.

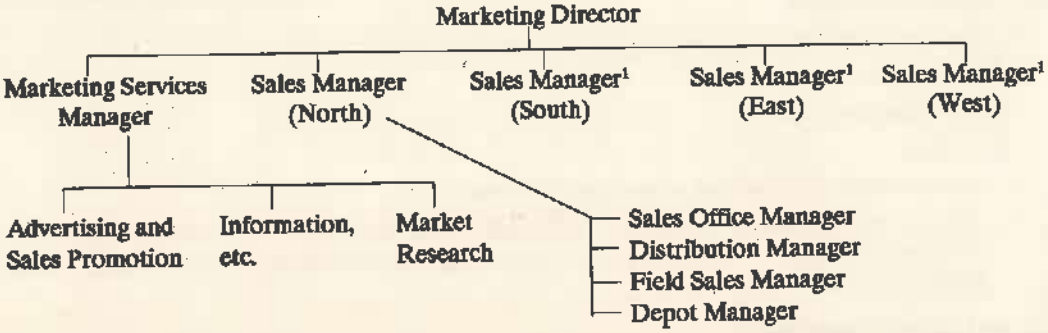


Fig. 31.2. Area Based Organization.

3. Product Group Organization

- This type of sales organization (Fig. 31.3) is employed when there is a wide range of relatively unrelated product groups which require different selling methods and the company sales forces require their own particular market and technical knowledge.

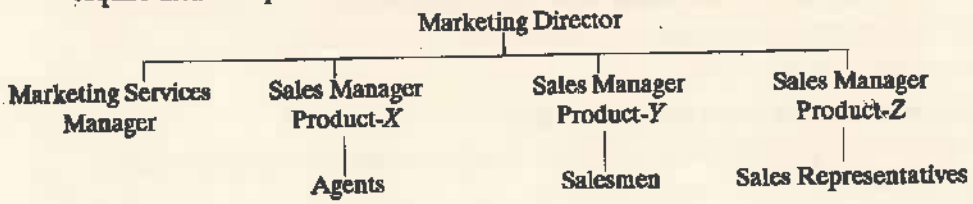


Fig. 31.3. A Product Group Organization.

4. End Use and Customer Class Sales Organization

- If an enterprise is selling a substantial range of products to dissimilar types of customers or for different uses, the selling operations are split up by type of customer or end use.
- Separate sales forces are necessary.
- However, marketing services may either be kept centralised or again split up as per the particular division of the selling operations.
- Fig. 31.4 shows the end use sales organization and Fig. 31.5 the customer class sales organization.

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1. Sales Managers, South, East and West have similar sub-organizations as that of Sales Manager (North).

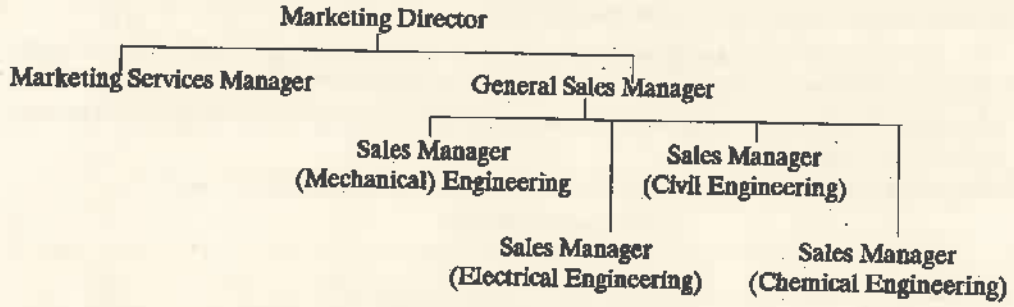


Fig. 31.4. End use sales organization.

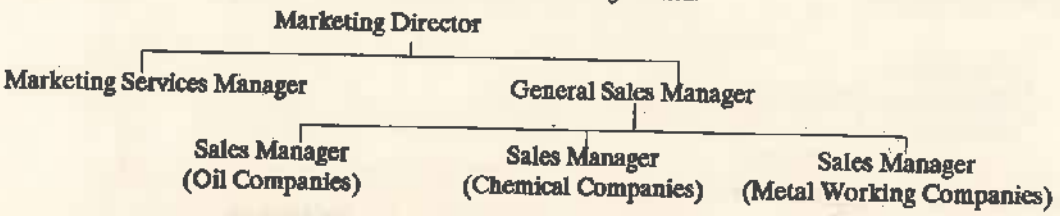


Fig. 31.5. Customer class sales organisation.

– Fig. 31.6 shows a general organization of the sales department of an engineering company.

31.4. FUNCTIONS OF SALES DEPARTMENT

(*i*) Analysing markets thoroughly.

(*ii*) Studying consumer's psychology and demand.

(*iii*) Studying the conditions existing in competitive firms.

(*iv*) Studying the market fluctuations.

(*v*) Preparing market, sales and other relevant business forecasts.

(*vi*) Assisting in the preparation of marketing plan.

(*vii*) Preparing the sales budgets from the marketing plan.

(*viii*) Deciding on the distribution policy, methods and network.

(*ix*) Planning of the advertising campaign.

(*x*) Ensuring suitable packing of the products.

(*xi*) Creating communications network for the department.

(*xii*) Developing systems for sales reporting and statistical analysis.

(*xiii*) Providing technical advisory and other services to the customers.

(*xiv*) Determining sales staff requirements and handling the recruitment, training and compensation of sales staff.

(*xv*) To explore newer markets for selling the company products.

(*xvi*) Ensuring effective coordination with production and financial departments.

(*xvii*) Striving continuously to lower selling costs, to expand sales and to improve the product for its wider acceptability.

31.5. DUTIES OF SALES MANAGER

A good idea of the duties of Sales Manager can be had from the section 31.4.

31.6. DUTIES OF SALESMAN (SALES ENGINEER)

- The distinction between a salesman and a manager of a market area is important ; it is the difference between viewing salesmen as employees or as members of management.
- A salesman's job may be seen as that of managing a market area or the salesman may be looked upon as an order taker.
- In general, a salesman may perform as many as five different activities such as :

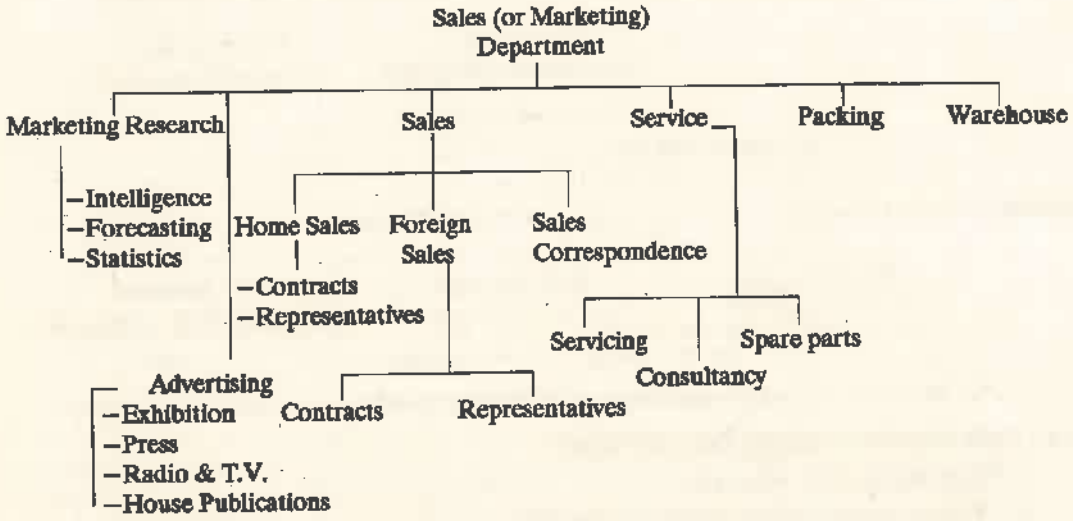


Fig. 31.6. Sales Organisation of a Company.

1. *Prospecting, i.e.,* a salesman is expected to search for additional (business) prospects.
2. *Communicating* information pertaining to company's products and services to existing and potential customers.
3. *Selling company products.*
4. *Servicing, i.e.,* providing service to different customers. Service includes providing technical help, expediting delivery, etc.
5. *Collecting Information, i.e.,* conducting market research and supplying regular reports on his findings to the company.

31.7. THE SELLING CONCEPT *VERSUS* MARKETING CONCEPT

– **The Selling Concept**

The selling concept is a management orientation that assumes that consumers will normally not buy enough of the company's products unless they are approached with a substantial selling and promotion effort.

– **The Marketing Concept**

The marketing concept is a management orientation that holds that the key task of the organisation is to determine the needs, wants, and values of a target market and to adopt the organisation to deliver the desired satisfaction more effectively and efficiently than its competitors.

– The selling concept and the marketing concept are generally confused by many businessmen and by the public. The two orientations distinctly differ from each other (Fig. 31.7) for example :

(*i*) Selling focuses on the needs of the seller whereas marketing focuses on the needs of the buyer.

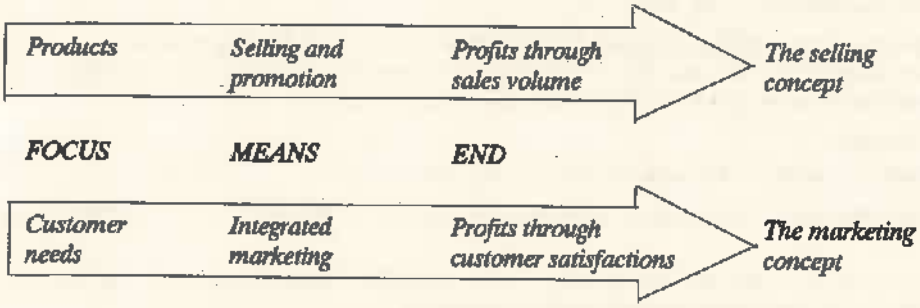


Fig. 31.7. Contrast between the sales concept and marketing concept.

(*ii*) Selling is preoccupied with the seller's need to convert his products into cash, whereas marketing lays emphasis on satisfying the needs of the customer by means of the product.

Marketing tries to know and understand the customer as well as the product or service that fits him and sells itself; marketing results in a customer who is ready to buy himself.

(*iii*) Actually, Marketing is another name for selling, with the inference that it is a rather long-haired method.

(*iv*) Marketing is a more expensive way of selling.

31.8. MARKETING, DEFINITION, PRINCIPLE AND FUNCTIONS

31.8.1. Introduction

- Marketing has its origins in the fact that man is a creature of needs and wants. Needs and wants create a state of discomfort in persons and they tend to get objects (*i.e.,* products) those satisfy these needs and wants. For example in the months of summer, if in an area, ice is not freely available or when eatable tend to get distasted in summer, persons feel discomfort and they satisfy their needs by purchasing a refrigerator.
- The word marketing has been derived from **Market** which may be looked upon as an arena for potential exchanges, *i.e.,* a place where products can be exchanged by money or anything else, *e.g.,* a political candidate offers promises of good government to a *voter market* in exchange for their votes.

There are need markets, product markets, demographic markets, geographic markets, etc.

The size of the market depends upon the number of persons who have both

(*i*) an interest in the product; and

(*ii*) are willing to offer something (say money) in exchange of the product.

31.8.2. Definition

- The concept of markets leads to the concept of marketing.
- **Marketing** means working with markets, *i.e.,* trying to actualize potential exchanges for the purpose of satisfying human needs and wants.
- **Marketing,** therefore, may be defined as human activity directed at satisfying needs and wants through exchange processes ; examples of human needs and wants are food, water, clothing, education and other services.
- Marketing in its broad meaning includes the policy, techniques and methods necessary for selling and distribution. Without marketing function, goods and services cannot be sold.

- Marketing is the total commercial and support activities of any enterprise to effect sales of company end products or services.
- Marketing involves planning and execution of all aspects and activities of a product so as to exert optimum influence on the consumer to result in maximum consumption at the optimum price and therefore producing the maximum long term profit.

31.8.3. Principles

The five basic principles of sound marketing are described below :

1. Marketing must provide a means of classifying, assessing and integrating information relevant to a business.

2. It must provide a sound base for thinking about and studying business problems and provide methods to draw correct conclusions which form basis for action.

3. Marketing must be able to explain, predict and control the process it employs.

4. Marketing must use analytical methods such as O.R., Statistics, Computer Technology, etc., to solve its problems.

5. Marketing should allow the derivation of a number of its principles adaptable to any particular business.

31.8.4. Functions/Objectives

The functions, aims and objectives of marketing are :

(*i*) To give direction and purpose to the marketing division as a whole as well as to its various departments.

(*ii*) To place present activities in perspective.

(*iii*) To discipline various future activities.

(*iv*) To place tactical plans correctly in the strategic setting.

(*v*) To set growth targets.

(*vi*) To establish the organisation and the methods which will be required.

31.9. MARKETING MANAGEMENT AND ITS FUNCTIONS

31.9.1. Concept

- The marketing management concept, which is a break through in the management thinking, by its very nature implies a Systems Approach to the management of marketing effort.
- Marketing management requires a recognition of the interrelations and interconnections between marketing and other business elements.
- Marketing management involves the integration of all the components of the marketing programme into a co-ordinated marketing mix. It demands the establishment of a communications newtork and linkages between the various functionaries and activities necessary for the accomplishment of marketing missions.
- Marketing management concerns itself with the flow of information and resources through a firm to the market place. Even the implementation of the marketing concept requires the grouping of marketing activities and the designation of a top-level executive to integrate both authority and responsibility.
- Marketing management is historically identified with the specialised job of dealing with the customer market for the end products or services of the company.

31.9.2. Definition

– Marketing Management is the analysis, planning, implementation and control of programmes designed to bring about desired exchanges with target markets for the purpose of achieving objectives of the organisation. Marketing Management relies heavily on designing the organization's offering in terms of the target market's needs and desires and using effective pricing, communication, and distribution to inform, motivate and service the market.

31.9.3. Functions

The broad functions of marketing management consist of the following :

1. Marketing Research,
2. Sales Forecasting,
3. Advertising,
4. Sales promotion,
5. Selling,
6. Handling of inquiries and orders from customers,
7. Packing, and
8. Servicing.

31.10. MARKETING RESEARCH

31.10.1. Concept and Definition

– An industrial enterprise, if, develops products for direct market application without having any idea in advance of consumer acceptance of that product, takes quite a risk (if the product is unaccepted).

On the contrary, if another concern tends to learn consumer reaction to the product prior to manufacturing the same, it does not involve any risk associating high expenditures.

– Market research, today, has come to be a very important part of the marketing function. Market research when properly conducted and used on a regular basis is just as valuable to the manufacture as is Technical Research and ensures the continued vitality of a business.

– **Market research** may be defined as an organised approach which includes all research activities involved in marketing problems :

(*i*) gathering, recording and analysing the utility and marketability of the product;

(*ii*) the natue of demand;

(*iii*) the nature of competition;

(*iv*) the methods of marketing; and

(*v*) other aspects of movement of products from the stage of production to the point where they get consumed.

– Market research provides an effective sales forecast.

– Market research promotes soundness of marketing decisions.

– **Marketing** or **Market research** gathers records and analysis all facts about problems relating to the transfer and sale of goods and services from producer to consumer. Essentially it is designed to discover not only how much the company can hope to sell, but where, to whom and how.

– Some part of the *research* can be done right in the company's own office through the use of its recorded data, a *form* of market research known as *sales analysis*. This should provide information on which products are selling best, in what markets, and to what type of customer. It is very important that sales records be set up to yield this type of data in usable form.

– Other *sources* of information on markets are the published statistics that give an indication of the size of the potential market in various localities. Government and consultants are valuable sources of this type of information.

31.10.2. Objectives of Marketing Research

– Market research determines who and where the customer is; what are his needs and wants; what will he buy; where and how he will buy; and how much he will pay.
– Market research tells the future of existing products and the products yet to be introduced into the market.
– Market research measures sale trends and sales potential.
– Market research analysis distribution, economic trends, and profitability.
– Market research determines advertising effectiveness, consumer reaction and dealer reaction.
– Market research studies market potential and market share.
– Market research conducts demand and price studies.
– Market research popularises the company products and makes them acceptable to the consumers.
– Market research keeps a business in touch with its markets.
– Market research explores new markets and helps developing new products.
– Market research safeguards the interests of the company against unforeseen changes in the market.
– Market research guides sales promotion efforts.
– Market research analysis user characteristics, attitudes, and opinions with particular emphasis on any shift in market composition or personal preferences.

31.10.3. Scope of Marketing Research

– Major marketing research activities are :

1. Measurement of market potential,
2. Determination of market characteristics,
3. Market share analysis,
4. Competitive product studies,
5. New product acceptance and potential,
6. Short and long range forecasting,
7. Studies of business trends,
8. Establishment of sales quotas and territories,
9. Testing of existing products,
10. Product mix studies,
11. Acquisition studies,
12. Studies of advertisement effectiveness,
13. Media research,
14. Pricing studies,
15. Plant and warehouse location studies,
16. Packaging research, and
17. Distribution channel studies, etc.

31.10.4. Market Research Procedure

1. Define the problem clearly.

2. Develop a clear set of research objectives.
3. Supervise or subcontract the task of collecting the data from existing and would be consumers, etc.
4. Extract meaningful information from the collected data.
5. Prepare a report presenting the major findings and recommendations coming from the study.

31.10.5. Market Research Techniques

Some of the techniques used by persons engaged in market research for collecting the data [refer(3) of Market Research Procedure] are as follows :

1. Desk research

The data is collected from the information published by the company or outside sources, *e.g.* government agencies, trade associations, etc. Desk research is done on :

(*a*) *Sales analysis, i.e.* past sales, fluctuations sales and promotional expenditures, economics of order size, etc.

(*b*) *Correlation studies,* concerned with finding the relationship between two or more variables, *e.g.,* number of new cars produced and number of car batteries sold.

(*c*) *Ratios,* such as stock-turn (the relationship between sales and stocks), profit per rupee invested (earnings/capital) etc.

2. Postal Questionnaire

Carefully prepared questionnaires, consisting of questions—short, specific and statistical or open-minded are posted to a selected sample of respondents for collecting specific data from them.

3. Telephone interviews

Telephone interviews are conducted at a personal level with a selected sample of people for collecting their views.

4. Personal Interviews

Personal interviews are conducted on a simple question and answer basis. Such interviews give best results with greater reliability.

5. Observational Method

The marketing research personnel silently observe others and collect the desired information, *e.g.,* by standing outside or in a wine shop, the brands more frequently purchased can be found out.

6. Statistical Methods

- Statistical methods make use of large precollected data and logically conclude the market investigations.
- Bar chart, histogram, frequency polygon, frequency distribution curve and the concepts of average, median, and standard deviation help serve the purpose.

(Refer Chapter number 8 for details).

31.11. SALES FORECASTING

31.11.1. Introduction and Importance

- Forecasting is essentially the art of anticipating what buyers are likely to do under a given set of conditions.
- The market research conducted by a firm plus the analyses of current sales experience and trends, form the basis for the construction of a sales forecast.
- The sales forecast is a commitement on the part of the sales department and each of its divisions of the expected sales likely to be achieved in a given period at stated prices.
- Sales forecasting should be very accurate because production and stock holding plans and the whole train of events following from these are based on them.

- Sales forecasting is a basis for developing co-ordinated and goal-directed systems of marketing action.
- The sales forecast is one of the vital tools of marketing planning since adequate planning and the effective deployment of marketing resources are based on sales forecasting data.
- Sales forecasting is essential if more accurate sales budgets, production and purchasing schedules are to be set.
- Accurate forecasts are vital aids to decision making.
- Forecasts provide basis for evaluating the functioning and productivity of various segments of business activity. They can guide marketing and other business actions toward the achievement of implicit and explicit objectives.

31.11.2. Sales Forecasting Factors

The factors to be considered when making the sales forecast are :

1. *Government action.* This is important when most of the purchases are made by government departments, government controlled bodies, nationalised industries, etc., as in U.K.

2. *Economic trends.* The trends at home which are affected by government action and the trends in world market are both of interest.

3. *Competition*—existing competitors and new competitors.

4. *Changes in technology and markets.*

5. *Internal factors* such as capacity, available resources product mix and *Marketing mix*, etc.

Sales Forecasting Techniques

(Refer to chapter 7).

31.12. THE MARKETING MIX

- A *market* is a group of existing and potential buyers or users of a product or service.
- A vital element in every marketing strategy is the *marketing mix.*
- The concept was first expounded by Professor Neil Borden of Harvard University in the 1940's, when he identified *Twelve key variables* in the typical marketing programme.
- These twelve variables have subsequently been reduced to four main headings by later writers.
- The *mix* may now be defined as *the particular group of variables offerd to the market at a particular point in time.*
- These variables are principally (1) product, (2) price, (3) promotion, (4) distribution. Each of these can be further sub-divided as illustrated below :-

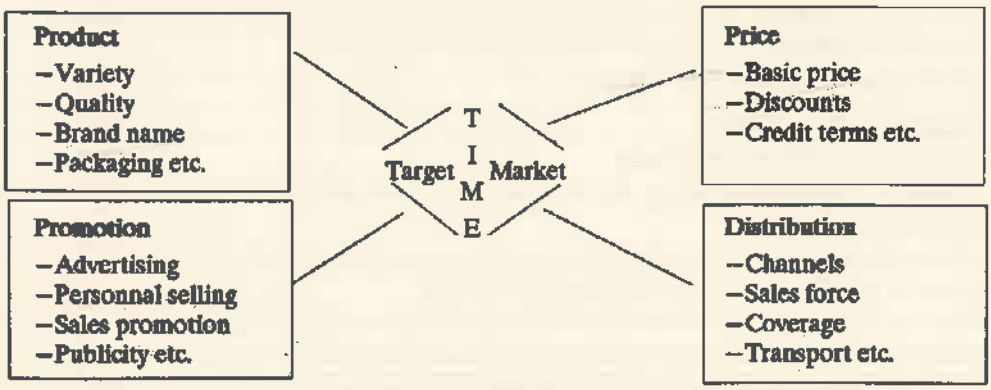


Fig. 31.8. The Marketing Mix.

- The marketing mix is the central part of an organization's marketing tactics. Once the market situation (customers, competitors, suppliers, middle men etc.) have been identified and evaluated, and once the decision has been made to penetrate, or develop particular market, then the role of marketing mix is crucial.
- *Marketing mix* is the combination of *competitive efforts* exerted by a firm to accomplish some *sales* or *profit goal*. These *efforts* usually include :

(*a*) Variations in the *products*/services being offered to customers.

(*b*) Variations in the *prices* of products being offered.

(*c*) Variations in the *promotional* blends utilized.

(*d*) Variations in the *channels of distribution* utilized.

- The firm normally has at its disposal several competitive elements that it can manipulate. For example, a particular firm may charge a very low *price* and not *advertise* at all.

  Another firm may advertise aggressively and charge a relatively high price. These two combinations of efforts represent very simple types of *marketing mix*.
- A cigarette company may elect to : (*a*) emphasize T.V. and radio advertising, (*b*) distribute through high quality tobacco shops, (*c*) charge a premium price, (*d*) sell in 60 mm lengths, and (*e*) feature an air-tight plastic package. This *mix* is more realistic in the sense that most firms confront a relatively large number of controllable competitive variables (as listed in Fig. 31.8.)
- The element of *time* is a vital factor in assessing the particular mix to be offered to a market. Any market situation can change rapidly over even a short period of time, as can be the case when a major competitor is suddenly declared bankrupt.

  By using the marketing mix as a tactical tool of an organization's marketing plans, it is possible to adopt speedily and profitably to changes in the marketing environment.

  Thus the development of the mix to meet conditions at a particular point or period in time is essentially a contingency approach to marketing management.

31.13. ADVERTISING

31.13.1. Introduction and Definition

- Advertising can become an established essential of a country's economy. It contributes to broad geographic system of distribution; to the volume sales, an essential corollary of mass production; and to the pricing of many products within the economic means of the average man.
- Just as communication is vital to good internal management, so is advertising vital to the earning of profit.
- Running a business without advertising is just like winking at a beautiful girl in the dark—you know what you are doing but she does not know it.
- Advertising is generally regarded as a form of communication the purpose of which is to convey concepts about companies, goods and services by means of words, pictures, diagrams, sound, music, colour, shapes and symbol on two levels of significance—the national and the emotional.
- Advertising is any paid form of non-personal presentation and promotion of ideas, goods or services by an indentified sponsor.
- Advertising may be defined as commercial messages to the public, designed to inform potential and established consumers and to encourage sales for the advertiser.
- Advertising can stimulate demand and, where necessary, can even create demand where none exists.
- Advertising arouses public interest, fosters a buying attitude and raises consumer demand for the products of a company.

– Advertising is the pivot of modern trade, commerce and business.

31.13.2. Functions and Objectives of Advertising

1. Advertising introduces existing and new company products to the public.

2. Advertising enhances potential buyer's responses to the company and its offerings.

3. Advertising tells that a product which the customers want exists and from where it can be procured and at what price.

4. Advertising is undertaken to reduce selling costs; because large volume of production will lead to economies, if, through advertising, it can be supported by mass distribution.

5. Advertising makes a product stand against its competitor products.

6. Advertising

- finds new users
- supports salesmen
- increases profit
- reaches customers who would otherwise be inaccessible to sales staff,
- tells the public, the good qualities of the product, *i.e.*, why people should purchase only this brand.

7. Advertising convinces retailers that they should keep the products of that company.

8. Advertising creates a confidence in the minds of buyers regarding quality of those goods or products.

9. Advertising builds up reputation for the company goods and services.

31.13.3. Functions of Advertising Department

In general, the functions of an advertising department may be classified as follows :

1. Preparation and control of advertising budget.

2. Determining the appropriation or allocation of funds to be spent on advertising and sales promotion activities.

3. Liaison with the advertising agency.

4. Supervising advertising and marketing research.

5. Keeping in touch with representatives of important media.

6. Cooperation with the sales and other departments.

7. Distribution of advertising material.

8. Production and supervision of sales promotion material.

9. Merchandising the advertising.

10. Administration.

11. Co-ordination with the employer and public relation department for improving public and employee relations.

31.13.4. The Advertising Agency

– An advertising agency is a group of specialists in

Research
Preparation of copy
Art
Production
Selection and contact of media, etc.

Who provide expert services and counsel to product manufacturers as regards :

The art of advertising
Preparing advertising policies
Planning and preparing advertisements

Sales promotion compaign
Recommendation of media
Arrangements for radio and T.V. programmes
The preparation of copy, etc.

– An advertising agency also acts as liaison between advertiser and media.

31.13.5. Types of Advertising

Advertising may be classed into two principal types :

(*i*) Institutional or goodwill type, and

(*ii*) Direct action type.

Institutional advertising is designed to promote an idea or the name of a company in the eyes of the public. Attractive new year's gifts or calenders bearing the name of the company can be distributed to the public for institutional advertising or special *art* paintings can be run in magazines under the company name.

Direct action advertising is designed to sell a firm's products or services. Newspapers and magazines are full of such advertisements—all inducing the customers to come and buy products of a firm.

31.13.6. Advertising Media

– An advertising medium may be considered as the carrier of the information to be advertised.

– Basically the problem is one of the communications. Modern advertising requires a highly complex thoroughly intergrated communication system, extending from the initiating firm to the consumer.

– The process of communication is as below :

Client Firms → Advertising–Agency → Media → Audience or Public → Activity/Sales

– An important part of advertising job consists of deciding the best media for carrying the advertising message or information to the target market. The advertiser tries to achieve a certain reach, frequency, impact and continuity with his advertising budget. Therefore, he must give considerations to the geographical area to be covered, type of buyer to be reached, his habits and customs, his psychological reactions and the qualities and cost of different advertising media.

– A few commonly used advertising media are

1. Newspapers.
2. Magazines.
   General magazines
   Trade journals
   Business reviews
   Technical journals, etc.
3. Radio.
4. Television.
5. Direct mail.
6. Public transportation.
7. Outdoor billboards.
8. Exhibits and displays.
9. Slides in cinemas.
10. Catalogues, samples and handout leaflets.
11. Distributing gifts, pencils, calenders, shopping bags, etc., bearing the name of company and its products.

31.13.7. Planning and preparing the Advertisement

The various steps involved in planning and preparing the advertisement are :

(*i*) Decide the purpose of advertisment.

(*ii*) Decide the message to be conveyed to public.

The message should be such that it

(*a*) holds the public attention for a long time;

(*b*) is educative and suggestive; and

(*c*) is humorous as well, etc.

(*iii*) Put the idea into symbols of some kind, words, pictures, shapes, music, etc.

(*iv*) Select the advertising media accordingly—to convey the information to the public.

(*v*) Keep a written record of the advertising programme.

31.14. SALES PROMOTION

31.14 1. Introduction

- All the activities that go into the development of sales or those that are intended to raise the demand level for a product very quickly can be grouped under the title *Sales Promotion*.
- Sales promotion includes those marketing activities, other than personal selling, advertising, and publicity, that stimulate consumer purchasing and dealer effectiveness, such as displays, shows and exhibitions, demonstrations, and various non-recurrent selling efforts not in the ordinary routine.
- Sales promotion focuses the attention of the customer at the actual point of sales in the shops with such effectiveness that both the advertiser and the dealer are benefited. The main purpose is to increase sales.
- Sales promotion plays a critical role in introductory and maturity stages of the product life cycle and also appears to be especially effective during periods of rapid inflation.
- Sales promotion, intended to educate the consumers better and to bring about an increase in sales is used more extensively in highly competitive businesses.
- The whole idea behind sales promotion is to bring the name of product and that of the manufacturer constantly before wholesalers, retailers and the consumers in order to stimulate their interest in the product.

31.14.2. Sales Promotion Methods

Sales promotion is the catchall for various promo-tools that are not formally classifiable as advertising, personal selling, or publicity. These tools (methods) may be sub-classified as :

1. **Consumer Promotion**—persuading consumers to buy ; these include samples, money-refund offers, prices-off, premiums, trading stamps, contests and competitions (*i.e.,* the winner customer will have a trip to Europe, etc.)

2. **Trade Promotion**—incentives to distributors and others to hold stocks of company product ; these include special discounts, buying allowance, one or two free units per bulk container, dealer competitons such as free holidays, push money, etc.

3. **Sales force promotions**—bonuses, contests, sales rallies etc., for the salesmen.

4. **Good public relations**, develop goodwill and increase sales. Every proposed business policy should first be analyzed in terms of its effect upon the company image.

5. **Good customer relations**. Good customer relations are basically the result of their past transactions with the company. Speedy handling of complaints, assistance in emergencies, abiding by

announced policies etc., all develop good customer relations and increase future sale of company products.

6. Display. Displays at points of sale, using posters, banners, placards and leaflets, to attract the customer's attention to the product.

7. Product exhibitions, demonstrations, and conferences.

8. Holding competition and awarding prizes to winners.

9. Latest **Product styling** and appealing **product packaging** catch the eye of the consumer and increase sales volume.

31.14.3. Functions of Sales Promotion Department (or Manager)

1. Product package detailing.
2. Service to salesmen.
3. Service to dealers.
4. Making displays.
5. Helping the dealer in demonstrations, door to door canvassing, etc.
6. Publicity, (through slides, films, and calenders, etc.)

31.15. CHANNELS OF DISTRIBUTION

31.15.1. Concept and Definition

- Producers generally do not sell their products directly to the final users. Between them and the final user stand a number of *marketing intermediaries* performing a variety of functions and bearing a variety of names.
- The marketing intermediaries are called *channels of distribution, trade channels or marketing channels.*
- Each company usually confronts a number of alternative ways to make its product reach the market. They vary from direct selling (direct channel) to final user, to using one, two, three or more intermediaries.
- Channels of distribution refer to the exhange of ownership of the product until it reaches the final user.
- Distribution channels are characterized according to the number of channel levels. *Commonly used channels of distribution are :*

(*a*) Manufacturer ----------> Consumer

(*b*) Manufacturer ----------> Retailer ----------> Consumer

(*c*) Manufacture ----------> Wholesaler ----------> Retailer ----------> Consumer

(*a*) represents a two level distribution channel.
(*b*) represents a three level distribution channel.
(*c*) repressents a four level distribution channel.

- It can be observed from the above discussion that goods are sold either
  1. direct from producer to consumer, or
  2. from producer to consumer *via.* a middleman (*e.g.,* a wholeasaler, retailer or both).

1. The direct channel is very effective and profitable for goods which have a high profit margin, *e.g.,* office machinery such as photocopying machines, accounting machines, computers, etc.

Moreover, the more specialized or technical the product (*e.g.,* machine tools), the better is to sell it directly; because the ordinary retailer is seldom in a position to give demostration, etc., and specialized service later on.

In direct selling, the producer has maximum control over selling practices and policies.

2. Selling through a middleman is known as *Indirect Distribution*. This method does vary well for products with a low profit margin, *e.g.*, consumer goods—tooth paste, face creams, etc.

Going through a middleman say a wholesaler usually results in larger orders.

Middleman buys goods in bulk and thus enables a producer to avoid risks connceted with stocking of goods. The risk may be in the form of a fall in price or physical deterioration of the goods.

Middlemen keep the producer informed about the prevalent market trends.

Middlemen such as wholesalers many times pay immediately to the producers the price of goods and thus help producers whose financial resources are not big.

31.16. PRODUCT PACKAGING

31.16.1. Introduction

- *Packaging* is the Art, Science and Technology of preparing goods or products for transport and sale. Packaging is the means of ensuring safe delivery of the product to the ultimate consumer in sound condition at minimum overall cost.
- A package is a complex part of the product. A package most clearly bridges the traditional realms of production and marketing.
- Packaging is an important activity of a sales promotion department because an attractive package catches fast the attention of the customers and speaks itself to them.
- The term packaging means to cover the final product for shipment from the factory to the wholesalers, retailers or the consumers.

31.16.2. Objectives

Until recently, packaging had been considered a minor element in the marketing of products but now it is regarded as a major factor in promoting company sales. Packaging of products is done for the following purposes :

1. To protect the products against damage in transit.
2. To protect the contents from being spoiled (tinned food products).
3. A packaged good is convenient to handle or transport.
4. A packaged good is safe to store.
5. An attractive package possesses considerable sales appeal and thus promotes sales of the product.

When the products are sold on a self-service basis such as in super-bazars (markets) and discount houses, it is only the package that attracts public attention, describes product's features, gives the consumer confidence and makes a favourable overall impression.

31.16.3. Requirements

The package for a product must

(*a*) Speak about the product.

(*b*) Catch the attention of consumers.

(*c*) Look clean and sanitary.

(*d*) Prevent spoilage of product.

(*e*) Be of convenient size and shape to carry.

(*f*) Be easy to open.

31.16.4. Packaging Methods

- A large variety of products taking from food and drugs to automotive parts and hardware all need suitable packaging.

- Methods of packaging depend upon the nature of product, *i.e.*, whether it is
  Liquid Solid Powder Gas
  Corrosive, Inflammable, Volatile, Explosive, etc.
- The properties of the product that help design the packaging system are its
  Size Shape
  Weight Value
  Transport hazard Fragility.

The mechanical properties of the packaging material and the compatibility of the goods and the package also deserve consideration.

- *Product can be packaged in*

(*i*) Corrugated shipping containers.
(*ii*) Metal cans.
(*iii*) Paper foil cans.
(*iv*) Glass bottles.
(*v*) Plastic bottles.
(*vi*) Plastic film pouches and bags.
(*vii*) Paper cartons.
(*viii*) Paper wraps.
(*ix*) Card board cartons.
(*x*) Wooden crates.
(*xi*) Cushioned containers.
(*xii*) Fibre board containers.

- Small products can be packaged in cardbord cartons.
- Large products such as machine tools or refrigerators can be put into wooden crates or packaging cases and (articles) firmly bolted to the side/back and bottom of the case so that there is clearance all round between the outside of the article and the inside of the case or crate.
- Product packaging methods have improved a lot in recent years, *e.g.*

(*i*) A refrigerator can now be packed in a large fibre board container on a completely automatic machine.
(*ii*) Delicate precision instruments that formerly required cushioned containers are now suspended in plastic envelopes in rigid boxes.
(*iii*) Furniture which would be carefully enclosed in costlier wooden crates is now being boxed in fibre board cartons.
(*iv*) Packaging of food in plastic and other special paper containers has contributed to its protection from getting spoiled.
(*v*) Lumber can be shipped in palletized load instead of being piled in a truck.

31.17. PRICING

29.16.1. Introduction

- Pricing is the holy of holies of antitrust enforcement with its *per se* prohibition of price conspiracies and strong suspicion of the conscious parallelism and price leadership of oligopolistic competition and of so called administered pricing.
- The price of the products is the means whereby manufacturers obtain a fair return for their labours and replace and increase their wealth and purchasing power in return for supplying the products.
- All business enterprises face the task of setting a price for their products or services.
- Price goes by many names, *e.g.*, fares, tuitions, rents assessments and plain old price.
- *The task of pricing is faced in the following situations :*

(*i*) When a company makes a new product and it has to set price for the first time.
(*ii*) When circumstances such as inflation or shortages lead a firm to consider initiating a price change.
(*iii*) When market competition initiates a price change.
(*iv*) When a company produces serveral products that have interrelated damands and/or costs.

31.17.2. Factors affecting price fixation

1. *Fair trade laws.* Manufacturers make agreement, with dealers who retail their products, on the price it can be sold to the public.

2. *Nationally advertised prices and government restricted prices of different products.*

3. *Desired customer clientele.* Pricing policy depends upon the buying habits of the customers who buy the products and whether, they (*i.e.*, cutomers) are price conscious people.

4. *Company monopoly.* Wheather the company has a monopoly or it is in a competitive position.

5. *Manufacturer's suggested prices*, depending upon the cost of manufacture and selling the product.

6. *Type of Merchandises, i.e.,* whether they are novelties or special interest items, etc.

7. *Nature of sales.* Whether the product sells seasonally, (*e.g.*, refrigerators) or throughout the year (*e.g.*, televisions and transistor radios).

8. *Price lining* is a policy of keeping merchandise in fairly well defined price range, *e.g.*, selling shoes at Rs. 139.95 Rs. 254.95 and Rs. 371.95, etc.

9. Whether large volume with low unit profit or relatively small volume with high unit profit is desired.

10. *Suitable channels of distribution.*

11. *Sales promotional strategy.*

31.17.3. Pricing Policy

- Pricing policy can be expressed diagrammatically (refer Fig 31.9).
- Assume that company has a sales of Rs. 100,000 and gross margin of Rs 45,000, it means that it has an *average marks up* of 45% on the total sales.
- This does not mean that every product was marked up 45% of sales; actually some product had more than this, and others less than this but the overall average markup reached 45%.

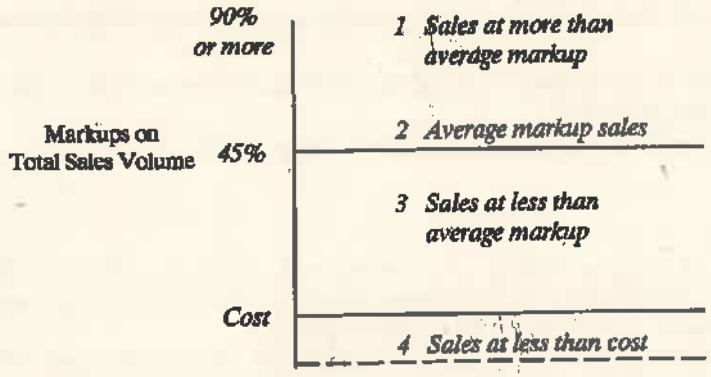


Fig. 31.9. Pricing Policy.

- *What is markup.* Markup or gross margin represents the difference between what the shopkeeper has paid to the wholesaler for getting the product and the price at which he has sold the product to the consumer. In other words markup is the reward or profit to the shopkeeper for rendering a service in bringing the merchandise to the customer.

Markup Covers

1. Operating expenses,
2. Markdowns,

3. Shortages,
4. Damaged merchandise, and
5. Profits

— Four distinct areas namely 1, 2, 3 and 4 can be seen in Fig. 31.9. A dynamic pricing policy demands that the seller must be aware of the aggregate sales volume in each area so that his overall total sales will average out to the markup necessary to provide desirable overall profits. Different products may sell in different areas, some at bigger profits, others at lesser profit but the overall position must not be less than average markup value.

31.18 THE MARKET

31.18.1 Concept

— A *market*, in common parlance, means a place or locality where things are brought and sold and where buyers and sellers personally meet to affect purchase and sale.

— However, for a student of *economics*, the term *market* has no reference to a place, where things are brought and sold. It refers to a commodity and buyers and sellers of that commodity (e.g. wheat).

— In fact the market must be thought of not as a geographic place but as any getting together of buyers and sellers in person, by mail, telephone, telegraph or any other means of communication.

— A *market* is a group of existing and potential buyers or users of a product or service.

— Marketing is the one function of management which has to be more concerned with what is going on *outside the organization* than with what is happening internally.

— Every *business organization* has its market, that is to say, the group of existing and potential buyers or users of its goods and services.

— A market may consist of a mere handful of people (e.g. specialist collectors of a certain type of antique items) or it may consist of millions (e.g, consumers of breakfast eatables).

31.18.2 Various Concepts of Market

The various concepts of market developed so far are discussed below :

(1) Distribution of goods and service concept

It is a traditional concept of marketing according to which marketing is an economic activity that facilitates the distribution (or flow) of goods and services from producer to consumer. This concept has no concern with the production activities of the goods.

(2) Delivery of standard of living concept

According to this concept, marketing includes all those activities that create and give a better standard of living to the society.

The producer tries to know the customer's needs and plans his production accordingly. In this way, customers get quality goods at cheaper rates and thus better standard of living is delivered to the society.

(3) Creation of utility concept

Marketing is an activity that creates *form*, *place*, *time* and *ownership* utility.

To *elaborate*, marketing consists in moving goods from the manufacturer, in a *form* in which they are required at a *time* when they are required, to the *place* where they are to be used and for *those who* are to use them for various purposes.

(4) **Generation of revenue concept**

Marketing should generate revenue or income for the firm. Marketing consists of all activities which are performed with a view to allow the firm to earn maximum profit not by increasing the selling price, but by reducing production and selling costs and other overheads.

(5) **Social system concept of marketing**

Marketing is a total system of interacting business activities designed to plan, price, promote and distribute, want satisfying products and services to present and potential customers which are a part and parcel of society.

(6) **Concept of customer satisfaction – Modern concept**

The modern concept of marketing emphasises the identification and the complete satisfaction of customer's needs.

It is based on two fundamental concepts :

(i) that the company policies and operations should be customer oriented and

(ii) that the goal of the firm should be profitable sales.

31.18.3 Types of Markets

The markets may be classified on the following basis:

(a) **The product sold in the market** e.g., *cloth market, jute market, share market, grain market,* etc.

(b) **Nature and volume of selling** e.g., a *wholesale market,* where goods are sold in large quantities to dealers, and a *retail market* where goods are sold in small quantities to consumers.

(c) **The nature of dealings** e.g., a *spot market* where goods are brought and sold immediately and a *forward/ future* market where actual purchasing and selling may take place at some future time/date as agreed by the buyer and the seller.

(d) **Regulated and Municipal markets.** A *regulated market* is one that is controlled by an *association.* If the municipality owns and controls the market, it is called a *municipal market.*

(e) **Area covered.** Depending upon the area covered, it may be a *home/local market, national market* or an *international market.*

(f) **Time-interval.** Depending upon the time interval, it may be a *short period market* (e.g., *money market*) or a *long period (or term) market* (e.g., *capital market*).

(g) **Economic concept** . On the basis of economics, it may be a *perfect market* or an *imperfect market.* Perfect market refers to perfect competition and imperfect market refers to absence of perfect competition and existence of monopoly.

(h) **Seller's position.** Depending upon seller's position, it may be a *primary/local market, secondary/central market* or a *terminal market.*

In the case of *local market* farmers sell their surplus produce to traders in the village. In the case of *central market,* wholesalers sell to retailers and in the case of *terminal market,* consumers buy from retailers or local dealers.

31.18.4 Cost of Marketing

— Marketing costs are generally high. The study of marketing of wheat, rice and cotton in India indicated that 50 to 60% of the total cost accounted for the marketing costs.

— *Reasons for high cost of marketing*

(i) There is a big gap between the points of production and consumption. This gap is bridged by an army of middle men-both merchants and agents. This results in high cost.

(ii) Moreover, society has also accepted to pay high prices in view of the valuable services that it is getting in return, from the above mentioned marketing system.

(iii) The inefficiency that creeps in various marketing functions and segments due to presence of inefficient and incompetent men, also results in higher cost of marketing.

— *To reduce marketing costs*

(i) Un-necessary crowd of middlemen should be avoided.

(ii) Development of chain stores, multiple shops and departmental stores are the innovations of marketing men to avoid middlemen.

(iii) People in marketing line should be qualified and experts.

(iv) Cooperatives should be developed to provide better services to customers.

(v) Government should provide fast and reliable transportation systems (railways, roadways etc.) and communication systems.

31.18.5 Modern Marketing Process

— Marketing is the process of discovering and translating consumer's wants into products and services.

According to *modern marketing concept*, marketing starts with the product-idea and ends with customer satisfaction.

— *Marketing process* covers *marketing functions* as well as *marketing agencies* or *channels of distribution.*

— Marketing process brings together producers and consumers. Each producer (or seller) has certain goals in making and marketing his products. An *exchange* (or transaction) takes place when market offering is acceptable to the consumer who is prepared to give something of value (i.e., money) in return against the product he wants to buy. In the process of exchange, both (seller and consumer) give up something and both gain something in return. The seller gets the profit and the consumer gets utility (of product) or individual satisfaction. Thus market mechanism brings together a willing seller and a willings and informed buyer together for mutual gain.

— The marketing process is influenced by (1) competition (2) government rules and policies (3) mass media or communication etc. (refer Fig. 31.10)

— *Marketing environment (Fig. 31.10)* affects both producer and consumer.

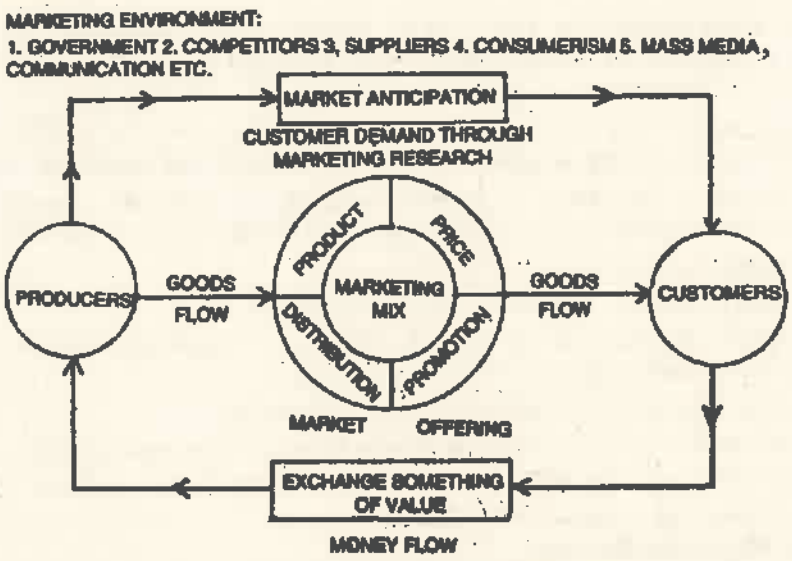
— The marketing process involves three major activities

1. Concentration 2. Dispersion 3. Equalisation

The products which have been *concentrated* at the central markets are *dispersed* from the producer toward the consumer. The process of *equalisation* involves proper adjustment of supply at all centres of distribution in the light of current market conditions.

— The producers carry out *market anticipation* work. They study customer demand through marketing research.

Marketing research is the starting point in the marketing process to ascertain and identify customer needs and desires through market analysis and investigation. Resources of men, money, materials and management are employed in the marketing system to perform marketing functions and thereby achieve the satisfaction of customer demand.



Modern Marketing Process

Fig. 31.10

— Producers manufacture a number of products. Then, marketing is a matching process by which the producer provides a *marketing mix* (product, price, promotion and physical distribution) that meets consumer demand.; thus products/goods flow from producer to the customers.

— When the customers buy the products, the flow of money takes place from the customer to the producers.

31.18.6 Marketing Concept

— *Marketing* is a *philosophy* as well as a *technology*.

— As a *philosophy*, it guides whether to produce something or not to produce.

As a *technology* it decides what should be produced, how and when products could be most effectively distributed among the customers.

— Hence, a producer, always, has to face the changing (mood or) conditions of the human behaviour.

— As a result of the changing human behaviour, the evolution of marketing concept had the following orientations :

(1) ***Exchange oriented marketing***

— In the early period of human history, every human being or a family had to gather their food by hunting or so and they were self sufficient. At this stage marketing was totally absent.

— As the time passed, man started producing more than what he could consume. Somebody produced wheat, other fruits, so they mutually exchanged their surplus with each other. This was nothing but *barter system.*

The (surplus) products used to be brought at central places (called local markets) for the purpose of exchange. This was the first stage in the evolution of marketing.

(2) ***Product oriented marketing***

— This stage came after the *Industrial revolution* when there was a shift from agriculture to industry and the means of transport and communications had also somewhat developed.

The importance of marketing concept was realised, however, no serious efforts were made to satisfy the wants of the consumers. It was because the product demand usually outstripped the production capacity.

This concept of marketing was marked as product oriented because it lay more emphasis on the product rather than on the consumers.

— In the *product-oriented concept/stage*, it is believed that if the product is good and reasonably priced, customer response is bound to be favourable and little marketing effort will be necessary to achieve satisfactory sales and profit. There was a time, in India, when only two brands of cars that is *Ambassador* and *Fiat* were available in the market and (unlike today) the customer had no choice except for to buy this or that. The consumers knew these two brands of cars and therefore no promotion efforts were there on the part of producers of these cars.

(3) ***Sales-oriented marketing stage (selling concept)***

— With the passage of time, there was rise in living standards of the customers and the means of transport and communication had developed. These changes compelled to have an organised marketing procedure.

— Under sales-oriented approach, it was assumed that the customers will normally not buy enough unless approached through incentive sales promotion, advertising and salesmanship efforts. But, under this concept, no efforts were made to satisfy the particular needs of the customers. In other words, more emphasis was laid on increasing the sales than on customer's need and satisfaction.

(4) ***Marketing-oriented approach***

— Marketing-oriented approach developed after the sales-oriented stage.

— In marketing-oriented approach, it is realised that the producer should determine the needs and wants of the customers and deliver the goods accordingly but more effectively and efficiently than its competitors.

The *aim of marketing* is to know and understand the customer so well that the product (and service) fits him and sells itself.

— The selling and the marketing concepts are quite often confused.

However, *selling* focuses on the needs of the seller (i.e., the seller's need to convert his product into cash); whereas *marketing* focuses on the needs (and satisfaction) of the consumers.

(5) ***Customer–oriented marketing***

— This is a modern philosophy of marketing and it was introduced only after 1950, when production went in excess of demand and the competition became keen.

— Under this concept, goods are produced to satisfy the needs and wants of the customers.

— Only such products are brought forward which can satisfy the wants and tastes of the consumers. Customer-oriented approach is related to the needs of the buyer.

(6) ***Socially–oriented marketing***

— The business enterprise engaged in the marketing process itself is influenced by *social*

environment. It consists of political, economic, social, cultural and technological forces. Marketers have to adapt with these everchanging environment forces and fulfil the needs and desires of the society or community.

— According to socially-oriented concept, marketing is a social activity, because (1) marketing provides new goods and improved services to people in the society, thereby raising the standard of living of the people, (2) marketing provides employment to people, (3) sound marketing decreases the distribution cost and increases the National Income.

— In the long run, society monitors the marketing process and controls its effectiveness.

— The modern business enterprise is called upon to demonstrate simultaneously higher level of economic performance and fulfilment of *social responsibility* i.e., high level of consumer/citizen welfare and satisfaction.

Marketing process must reflect social awareness and social responsibility in all business enterprises. Then only the survival, growth and prosperity of the marketing units can be assured.

31.19 PRODUCT MIX

— The **product** means anything that is offered to a market for its use or consumption. The product can be a physical object or a service or some kind. The product offered by a manufacturer consists of physical items, such as machine tools, television sets, loaves of bread or cosmetics. Products offered by service industries include hospital care, dental treatment, holiday arrangements and accountancy services, for example.

— *The range of products offered by an organization is called the product mix.* Since most, if not all, of the organization's revenue is going to be obtained from the sale of its products, it is clearly important that the range and quality of the *product mix* is frequently evaluated and amended. *Examples of a product mix are as follows* :

(1) *Motor car manufacturer* - cheap, basic family runabouts, medium-priced family saloons, estate cars, executive saloons, and sports cars. Within most of these product lines, various other refinements can be offered e.g. two-door and four-door versions of the family saloons, hatch-backs as an alternative to the estate models, variations in engine sizes, and, of course, a range of colours.

(2) *District hospital* - surgical and medical services, diagnostic services, para-medical services, pre-natal advice and others. Within each of the major *product lines* various alternative services are offered e.g. general surgical, accident services, coronary care, X-radiography, physiotherapy, pre-natal classes and so on.

— In considering products, it is important to note that people generally want to acquire the *benefits* of the product, rather than its *features*. For example, in buying a motor car a person is buying such things as luxury or speed or economy or status. The fact that these benefits are achieved by differences in engine size, suspension design or paintwork is really of secondary interest. Similarly, the reason why we want hospitals is for such aims as the preservation of life or the improvement of health or peace of mind. Whether these things are achieved by surgery, or by drugs, or by nursing care, or by modern diagnostic apparatus is, for many people, a matter of secondary importance.

— The very existence of a *product range* is, in itself, a selling point for a product. The same consideration applies to other aspects of the product, such as *quality*, *brand*, *packaging* and *after-sales service*, where applicable. *Where quality is designed* into a product, the

benefits can be long product life, absence of faults and subsequent breakdowns, reliability, increase in value and many others. However, product quality may not be sought after at all. For example, the benefits of disposable goods are immediate and one-off. Such goods do not need to be durable or aesthetic, so long as they are hygienic and functional such as disposable syringes. Thus product quality may be high or low, depending on the wants or preferences of the market, and part of an organization's product strategy is to decide the level of quality to be aimed at.

— One important method used to sell benefits is by *branding products*. This means applying the organization's *signature* to its product by the use of special names, signs or symbols. *Branding* has grown enormously during this century, and there is hardly a product which does not have a *brand name*. Famous brand names include *Coca Cola*, Luxor, Rotomec etc., all of which have become synonymous with certain categories of products, like soft drinks, ball pens etc.

— In general, branding is a feature of consumer products. It is less common in industrial products.

— *Packaging* is an important factor in the presentation of a product to the market. Not only does packaging provide *protection* for the product, but it can also *reinforce* the *brand image* and the point-of-sale attraction to the buyer. The protective aspect of packaging is vital in respect of items such as foodstuffs, dangerous liquids and delicate pieces of machinery. Goods such as soft toys and items of clothing may not need such protection, but here other considerations apply, such as the appearance of the goods on the shelf, or the possibility of seeing the contents through the packaging. Other aspects of packaging may emphasise the convenience of the pack, as for example in cigarette packets which may be opened and reopened several times, or beer cans, which can be opened safely by pulling a ring.

— Some products are sold with a very strong *emphasis on after-sale service, warranties, guarantees,* technical advice and similar benefits. *Mail-order firms* invariably have an arrangement whereby, if customers are not satisfied with the goods received, they may return them at the firm's expense without any questions being raised. *Computer suppliers* frequently provide *customer training* as an integral part of their total product package.

In recent years the growth of *consumerism* or *consumer protection lobbies* has led to many organizations taking action to improve the service to the customer after the sale has been concluded.

— Emphasis *on the make-up of the product* is not only vital because of the need to sell benefits to potential customers, but also to take account of another key factor i.e. the *product life-cycle*. Studies have shown that most products pass through a series of stages - their life-cycle - from the time they are introduced until the time they are withdrawn. A product will typically pass through five major stages in its life. These are shown in the diagram below (Fig. 31.11)

— *The consequences of these stages of the product life-cycle are as follows :*

Introduction Costs are high (because they include the development costs), sales and profits are low. Few competitors. Price relatively high.

Growth Sales rise rapidly. Profits at peak level. Price softens. Increasing competition. Unit costs decline. Mass market appears.

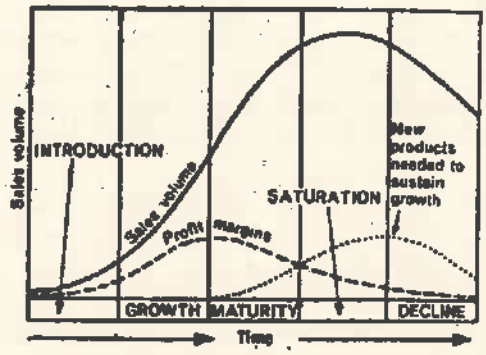


Fig. 31.11 Product Life-Cycle

Maturity Sales continue to rise, but more slowly. Profits level off. Competition at its peak. Prices soften further. Mass market.

Saturation Sales stagnate. Profits shrink. Measures taken against remaining competition. Prices fiercely competitive. Mass market begins to evaporate.

Decline Sales decline permanently. Profits low or even zero. Product is withdrawn from the market.

— The *total length of time* over which a product may decline depends on a variety of factors, such as its *relevance* to basic needs, its *adaptability* in the light of economic trends and whether it is the focus of short-term fads or of longer-lasting *fashions*. A basic foodstuff, such as a packet of ground coffee, will have a relatively long life-cycle. *Conversely*, in an economy where energy costs are high and fuel conservation is the fashion, the *expensive motor car* with a high petrol consumption will tend to have a short life-cycle, but the *economy car* will continue for years.

— Taking into account the various stages of the product life-cycle and the period of time concerned, it is possible *to plan the product mix*, plan the development and introduction of new products, plan the withdrawal of obsolete or unprofitable products, and set the revenue targets for each product within the total range. If the current position of any one product is plotted correctly on its life-cycle, then it is possible to assess the potential growth of sales, or the degree to which prices should be allowed to soften in order to maintain the market share, or whether the product should be superseded by another. Thus the concept of the product life-cycle makes an important contribution to forecasting of sales and planning of products.

31.20 PRICE MIX

— If *product* is the most important single *element in the marketing mix*, then price is usually next. *Price is important* because it is the only element of the mix which produces *revenue*; the *others* all represent *costs*. Sellers have to gear prices to a number of key factors, such as:

(a) the costs of production (and development),

(b) the ability to generate sufficient revenue and/or profits,

(c) the desired market share for the product,

(d) the prices being offered by the competitors

— *Price is especially important at certain times. For example :*
  (a) when introducing new products
  (b) when placing existing products into new markets
  (c) during periods of rising costs of production
  (d) when competitors change their price structure
  (e) when competitors change *other* elements in their marketing mix (e.g. improving quality or adding features without increasing prices)
  (f) when balancing prices between individual products in a product line.

— When a new product is introduced, such as a video or a home computer, the price tends to be high on account of the initial development and marketing costs. This sort of product tends to be directed, initially, to higher-income groups or specialist-interest groups. As the product begins to attract increasing sales, and initial costs begin to be covered, then prices can be reduced and production volume stepped up. However, it is also possible to introduce a product with a very low price in order to obtain a foothold in a new market, or an increased share of an existing market. A bargain price may well attract considerable sales and at the same time discourage competitors. The danger is, of course, that the price may be so low that the business fails to generate sufficient revenue to cover its operating and/or capital costs.

— Few products stand still in terms of their costs. Labour costs increase from year to year; materials costs and energy costs may be subject to less regular, but sharper, increases; interest rates may be extremely variable, and hence the cost of financing products fluctuates. Many costs can be offset by productivity savings. Therefore, the costs which are the most crucial are those which represent sudden and massive increases, which cannot be absorbed by improving productivity. In this situation price increases are practically inevitable, and the question is *by how much should we increase them* ?. In certain situations, it may be possible to gain a temporary advantage over competitors by raising prices by the lowest possible margin, and offering some other advantage such as improved after sales service or credit terms.

— The activities of competitors have an important bearing on pricing decisions. The most obvious example is when a competitor raises or lowers his prices. If your product can offer no particular advantages over his, then if he drops his price, you will have to follow suit. If, on the other hand, you can offer other advantages in your marketing mix, there may be no pressure at all to reduce your price. If a competitor raises his price, perhaps because of rising costs, it may be possible to hold yours steady, provided you can contain your own rising costs. *Pricing is a very flexible element in the marketing mix and enables firms to react swiftly to competitive behaviour.*

— Competitors may throw out a challenge by improving the product and offering a better distribution service, for example. This kind of behaviour, too, can be countered by price changes - in this case by easing prices and/or improving credit terms. Much will depend on the sensitivity of the market to price changes. If price is the dominant issue for buyers, then they will prefer lower price to slightly higher quality or improved distribution arrangements. If price is not the major factor in the buyer's analysis, then marginal extra quality and delivery terms may prove the more attractive.

— Finally price is important in determining the relative standing of one product or product-line vis-a-vis another within the product mix. This issue applies particularly in

highly differentiated products in the consumer area. It is important, for example, that a motor car manufacturer establishes appropriate differentials between different models within a product-line e.g. between 1000 cc and 800 cc models. If 800 cc models are selling well but 1000 cc models are not, it may be in the seller's interests to reduce the differential so as to attract more buyers to the 1000 cc models. Otherwise a reasonable differential will be expected in order to justify the enhanced engine rating of the larger model.

— The concept of a *loss-leader* is often applied to internal *price-differentials.* This means that one product in a line is reduced to below-cost levels with the aim of attracting attention to the product-line or range as a whole. So, for example, a new fibre-tipped pen, in a range of such pens offered by a newcomer to the market, may be sold at a loss in order to draw attention to the range as a whole, and to establish a share of the total market. Loss-leaders naturally represent very good value for money to the buyer, and can be a very useful way of establishing a range in the market-place.

31.21 PROMOTION MIX

— *Every product need to be promoted* that is to say it needs to be drawn *to the attention of the market-place*, and its benefits identified. *The principal methods of promotion are*: *advertising*, *personal selling*, *sales promotion* and *publicity*. It is in these areas that Marketing departments come into their own. They provide the bulk of the expertise, and carry the biggest amount of responsibility, in respect of these aspects of the marketing mix.

— The *aim of an organization's promotional strategy* is to bring existing or potential customers from a state of relative unawareness of the organization's products, to a state of actively adopting them. Several different stages of customer behaviour have been identified. These can be stated as follows :

Stage 1 Unawareness of product
Stage 2 Awareness of product
Stage 3 Interest in product
Stage 4 Desire for product
Stage 5 Conviction about value of product
Stage 6 Adoption/Purchase of product

— The *four different methods of promotion* mentioned earlier are applied, where appropriate, to each of the stages of customer behaviour. *Advertising* and *publicity* have the broadest applications, since they can affect every stage. *Personal selling* and *sales promotion* activities, by contrast, tend to be more effective from Stage 3 onwards.

— Before describing each of the methods in greater detail, one further point can be made about them as a whole. This is that they have a different emphasis according to whether they are being applied to *consumer markets* or *industrial markets. For example*, whilst advertising is very important in reaching out to consumer markets, it is of relatively little significance to industrial markets, where personal selling is the most popular method. Publicity and sales promotion activities appear to rank equally between both types of market.

(A) ADVERTISING (Refer article 31.13 also)

— Advertising is the process of communicating persuasive information about a product to target markets by means of the written and spoken word, and by visual material. By

definition the process excludes personal selling. There are five principal media of advertising as follows :

(a) the press – newspapers, magazines, journals etc
(b) commercial television
(c) direct mail
(d) commercial radio
(e) outdoor – hoardings, transport advertisements etc.

— Whatever the medium a number of questions must be decided about an organization's advertising effort. These are basically as follows:

1. How much should be *spent* on advertising?
2. What *message* do we want to put across?
3. What are the best *media* for our purposes?
4. When should we *time* our advertisements?
5. How can we *monitor* advertising effectiveness?

1. Advertising expenditure

— If the product is at the introductory stage, a considerable amount of resources will be put into advertising. Conversely, if the product is in decline little or no expenditure on advertising will be permitted. If the product is at the saturation stage, advertising may well be used to score points off the competition e.g. "our vehicle does more miles per gallon than theirs (naming specific competing models)."

— *Advertising expenditure* may be related to *sales revenue* or it may base on what the *competitors* are *spending.*

2. Advertising message

— Probably the most important aspect of any advertising campaign is the decision about *what* to say to prospective customers, and *how* to say it. This is the *message which aims* to make people aware of the product and favourably inclined towards it. Advertising copy (i.e. the text) also aims to make people desire the product. The entire process is the fundamental one of turning customer needs into customer wants.

— The advertising message should aim at, to :

(a) increase customer *familiarity with* a *product* (or variations of it e.g. brand, product-range etc.).
(b) inform customers about specific *features* of a product.
(c) inform customers about the key *benefits* of a product.

3, 4. Choice of media and time

— *The choice of media depends on the organization's requirements in terms of:*

(a) the extent of coverage sought to reach customers
(b) the frequency of exposure to the message
(c) the effectiveness of the advertisement i.e. is it making a relevant impact?
(d) the timing of the advertisement
(e) the costs involved

— If *wide coverage* is sought (e.g. for a new Do-it-Yourself product or a new consumer

banking service), then a *television* advertisement put out at *a peak viewing time* would be the most effective.

— For effectiveness, *magazines and journals* tend to reach the most relevant markets, provided they are selected carefully in the first place. For example, advertisements for camping enthusiasts will tend to produce better results in camping magazines than in national newspapers or magazines aimed at other interest groups, such as collectors of antique furniture. One of the problems with magazine advertisements, however, is their relatively long lead-time before an advertisement appears. *Newspapers* are better media on this score. *Direct mail* scores high on relevance-it can be directed very specifically at certain markets, but because of the personnel costs, it can be expensive. In the final analysis, organizations have to weigh up the anticipated benefits of particular media against the costs involved. This brings us on to the question of how do organizations assess the effectiveness of their advertising?

5. **Advertising effectiveness**

There are *two main ways* of looking at the question of *advertising effectiveness* - the *first* is to consider the results of the advertising in achieving target improvements in specific tasks e.g. increasing brand awareness in a specific market; the *second* it to consider the impact of advertising on sales.

(B) PERSONAL SELLING

— However vivid the message put over by *advertising*, there is no substitute for the final *face-to-face meeting* between the buyer and the seller or his representative. Advertising creates the interest and the desire, but *personal selling* clinches the deal. In industrial markets, personal selling plays an even more extensive role. For the moment, let us consider the *basic sales process*. This is generally understood to mean:

(a) establishing customer contact
(b) arousing interest in the product
(c) creating a preference for product
(d) making a proposal for a sale
(e) closing the sale
(f) retaining the business

— So far as *consumer* markets, and especially mass markets, are concerned, advertising must play a vital role in the first three stages of the process. After that, advertising becomes rapidly less important, and personal selling takes over. By comparison, advertising plays a much less important role in *industrial* markets. Where even the first stage is dominated by personal selling.

However, personal selling is the most expensive form of sales promotion.

(C) SALES PROMOTION

— Sales promotion activities are a form of *indirect advertising* designed to stimulate sales mainly by the use of incentives. Sales promotion is sometimes called "below-the-line advertising" in contrast with above-the-line expenditure which is handled by an external advertising agency. Sales promotion activities are organized and funded by the organization's own resources. They can take a number of different forms, as, for example:

- * Free samples
- * Twin–pack bargains (Two for price of one)
- * Temporary price reductions
- * Point–of–sale demonstrations

} Promotions directed at consumers

- * Special discounts
- * Cooperative advertising
- * Bonuses/prizes for sales representatives
- * Provision of display material

} Directed at trade customers

— There are 'push' and 'pull' strategies. Sales promotion falls into the first category. It aims to push sales by offering various incentives at, or associated with, the point-of-sale. Its use is most frequent in the field of *consumer products. The objectives of a promotion directed at consumers could be to :*

(a) draw attention to a new product or line
(b) encourage sales of slow-moving items
(c) stimulate off-peak sales of selected items
(d) achieve higher levels of customer acceptance/usage of a product or product-line

— *Objectives for a trade-orientated promotion could be to*:

(a) encourage dealer/retailer cooperation in pushing particular lines
(b) persuade dealers/retailers to devote increased shelf-space to organization's products
(c) develop goodwill of dealers/retailers

— The most popular *method of evaluating a sales promotion* is to measure sales and/or market share before, during and after the promotion period. The ideal result is one which shows a significant increase during the promotion, and a sustained, if somewhat smaller increase *after* the promotion. *Other methods* of evaluation could include interviewing a sample of consumers in the target market (e.g. to check if they had seen the promotion, changed their buying habits etc.), and checking on dealers' stock-levels, shelf-space etc.

(D) PUBLICITY

— Publicity differs from the other promotional devices mentioned in this chapter in that it often does not cost the organization any money! Publicity is news about the organization or its products reported in the press and other media without charge to the organization. Of course, although the publicity itself may be free, there are obvious costs in setting up a publicity programme, but, these are considerably lower than for advertising, for example.

— Publicity usually comes under the heading of public relations, which is concerned with the mutual understanding between an organization and its public.

— *Sponsorship events* in the *arts and sports* are becoming an increasingly popular form of publicity. Concerts, both live and recorded, have been promoted jointly by the musical interests concerned and by industrial and commercial interests. Athletics meetings, tennis tournaments and horse-races have all been the subject of sponsorship. Again, although the publicity itself is free, the costs of sponsorship are not. Nevertheless, such activities can contribute significantly to an organization's public image. Organizations which are selling products that are the target of health or conservationist lobbies are often to be

found sponsoring activities such as sporting events and animal welfare campaigns.

Thus patronage of sports, the art and learning are all useful means of gaining publicity in a manner which casts a favourable light on the organization, and, ultimately, on its products.

31.22 DISTRIBUTION MIX

— Moving the *product* or *service* to the final customer/consumer is the **purpose of distribution.**

— Distribution is primarily concerned with

(a) Channels of distribution

(b) Physical distribution

(a) **Channels of distribution** (*refer article 31.15 also*)

— Channels of distribution are the marketing institutions which facilitate the movement of goods and services from their point of production to their point of consumption. Some channels are *direct* as when a computer firm sells its product direct to the users. Others, the majority, are *indirect.* This means that there are a number of *Intermediaries* between original producer and eventual buyer, as in the case of the box of foreign-made chocolates bought at a local retailer.

— The *choice of channels* utilised by a producer is determined ultimately by the customer, and in recent years there has been a trend towards shorter channels, as customers, especially in consumer markets, realise that there are price advantage to be gained when middlemen, or retailers, are by-passed in the chain of distribution. Thus direct mail, cash and carry, and 'pick your own' (fruit, vegetables etc.) operations are increasing in response to consumer interest in this approach.

— The most common channels of distribution and the role played by the various intermediaries in them is explained below.

A. Manufacturer ⟶ Customer

B. Manufacturer ⟶ Wholesaler ⟶ Retailer ⟶ Customer

C. Manufacturer ⟶ Wholesaler ⟶ Customer

D. Manufacturer ⟶ Retailer ⟶ Customer

— *Channel A represents* a direct marketing channel. This is to be found more in industrial markets than in consumer markets. Manufacturers of goods such as machine tools, computers, ships and other large or expensive items tend to move them direct to the buyer without involving middlemen or intermediaries. However, this practice is becoming more frequent in consumer markets as well. For example, in mail order operations and in door-to-door selling (e.g. cosmetics, household wares and double glazing). The reasons for direct channels are basically as follows:

Industrial markets. Relatively small number of customers; need for technical advice and support after the sale; possible lengthy negotiations on price between manufacturer and customer; dialogue required where product is to be custom-built.

Consumer markets. Lower costs incurred in moving product to consumer can lead to lower prices in comparison with other channels; manufacturers can exercise greater control over their sales effort when not relying on middlemen.

— *Channel B represents* the typical chain for mass-marketed consumer goods.

Manufacturers selling a wide range of products over a wide geographical area to a market numbered in millions would find it prohibitively expensive to set up their own High-street stores, even if they were permitted to proliferate in this way. For such manufacturers (e.g. of foodstuffs, confectionery, footwear, clothing and soaps, to name but a few), middlemen are important links in the chain. Wholesalers, for example, buy in bulk from the manufacturers, store the goods, break them down into smaller quantities, undertake advertising and promotional activities, deliver to other traders, usually retailers, and arrange credit and other services for them. Their role is important to both manufacturer and retailer. The role of the latter is to make products available at the point-of-sale. Individual consumers need accessibility and convenience from their local sources of consumable products. They also need to see what is available, and what alternatives are offered. A retail store, whether owned by an independent trader or a huge supermarket chain, offers various advantages to consumers: stocks of items, displays of goods, opportunity to buy in *small* quantities, and convenient access to these services. So far as manufacturers and wholesalers are concerned the retailer is, above all, an outlet for their products, and an important source of market intelligence concerning customer buying habits and preferences.

— *Channel C represents* one of the shorter indirect channels, where the retailer is omitted. This kind of operation can be found in mail-order businesses, and in cash-and-carry outlets. The former are usually composed of the larger mail-order firms, offering a very wide range of goods (and some services, too). They buy from manufacturers, store and subsequently distribute direct to customers on a nation-wide basis. Their ability to attract customer in the first place relies heavily on (a) comprehensive, colourful and well-produced catalogues, and (b) the use of part-time agents, usually housewives, working on a commission basis. Whilst such an operation does not generally offer any price advantage over a retail business, it is a very convenient way of choosing goods and there is always extended credit available. With the wider use of computers in the home, and the prospects, in the not-too-distant future of being able to order goods via a telephone link, mail-order business seems likely to grow. *Cash-and-carry outlets* usually deal in groceries, and many are open only to trade customers. They tend to rely on a rapid turnover of stock, to keep down inventory levels. Their main advantages for buyers are (a) price, which is significantly lower than in a retail operation, and (b) the opportunity to buy small-bulk quantities. Unlike mail-order businesses, they serve relatively local and specialised markets.

— *Channel D* is another version of a shorter, indirect channel. In this case. it is the wholesaler who is removed from the scene.

Not surprisingly, the retailers who dominate this channel are powerful chains or multiples in their own right. Some such retailers, as in the footwear trade, concentrate on one range of goods only. They buy in bulk from manufacturers and importers, and distribute direct to their retail outlets. They usually offer a wide selection of lines, and are very competitively priced. Other large retail groups handle a diversity of goods, which are again competitively priced, and made available in prime shopping areas.

— *Market segmentation* is undertaken by suppliers in order to get a clearer picture of the market-place in order to offer a particular marketing mix to one or more segments. The concept assumes that within any single market there are invariably other sub-markets.

— Consumer markets are usually segmented on the basis of *geography, demography* and

buyer-behaviour. Industrial markets are segmented in a roughly similar fashion, but also include consideration of trade groups and end-use.

Geographical variables — Region, population density, climate etc.

Demographic variable — Age, sex, family size, occupation, social class etc.

Buyer-behaviour variables — Usage rate, benefits sought, brand loyalty, life-style etc.

(b) Physical distribution

— Whereas *channels of distribution* are marketing *institutions*, physical distribution is a *set of activities*. The former provide the managerial and administrative framework for moving products from supplier to customer. The latter provide the physical means of so doing. *Physical distribution* is concerned with order processing, warehousing, transport, packaging, stock/inventory levels and customer service. In recent years a number of attempts to integrate and coordinate these functions has come to be called *Physical Distribution Management*. This aims to integrate the activities of marketing, production and other departments in this aspect of the organization's marketing task.

— The degree of *attention paid to physical distribution* depends considerably on the proportion of total costs taken up by distribution costs. If the product is a high-quality, high-cost item, then distribution costs will probably represent a small proportion of total costs of manufacturing and marketing it, and so physical distribution may be considered very much a secondary issue. Where the product is offered at a very competitive price, and hence where profit margins may be tight, all overhead costs will be carefully examined. In this situation distribution costs will form an important issue for the supplier. An important feature of such costs is that they tend to increase rather than decrease with sales volume. Whereas unit production costs tend to benefit from increased volume of production, distribution costs tend to worsen. A high level of customer service also tends to greatly increase distribution costs. For example, if a customer requires 100% delivery from stock within two days, this means carrying extra stock levels as a buffer against any shortfall in supplies to the warehouse. If that customer could be persuaded to reduce his requirements to, say, 80% delivery within two days, this might effect useful savings in distribution costs.

31.23 INTERNATIONAL MARKETING

Introduction

— Foreign trade is one of the most important factors that contribute to the economic development of a nation.

— *Economic theory* recognizes two major types of *advantages*. An absolute advantage exists when a country can produce a product more efficiently than any other country. This type of advantage is quite rare.

A *comparative advantage* exists when a country can produce a product at a *lower cost* than a competitor can.

— When a firm decides to expand from being a purely domestic business to an international operation, it can choose to become one of several types of venture:

(1) Exporting

(2) Licensing

(3) Joint ventures

(4) Direct foreign investment

(1) Exporting

Exporting occurs when goods are produced in one country for consumption in another. For example, Komatsu Ltd. a Japanese heavy-equipment maker, exports its construction equipment worldwide. India is exporting tea, coffee, spices, ready-make garments, handicrafts, railway coaches, heavy electrical machinery, maruti cars, refrigerators etc. to other countries.

(2) Licensing

In international business, a **license** is a privilege to manufacture or sell a product in all or part of a country or to extract a natural resource from a particular location. Coca-Cola, for example, has had to obtain licenses to produce and sell its soft drinks in the over 155 countries in which it does business.

A license is a contract, and its provisions are therefore subject to negotiation. A license can require a company to pay the issuing government

- A one-time fee
- A percentage of annual receipts
- A **royalty** or share, usually of the gross output, from the extraction of a natural resource

Licenses often have a limited duration. Some licenses grant monopolies, whereas others simply allow their holders to compete for business within the country issuing the license.

(3) Joint Ventures

A **joint venture** is simply an agreement between two businesses to combine their resources to accomplish a particular objective. They may agree to produce a product jointly or just market it, store it, or transport it. The financial arrangements between **coventurers**, the parties in a joint venture, can vary as much as in a partnership. For small firms, joint ventures can provide entry into international business that they could not otherwise afford. In other instances, companies must form joint ventures with foreign corporations to crack a foreign market. Since 1980, AT & T, for example, has formed joint ventures with Dutch. Italian, Spanish, South Korean, Taiwanese, and Japanese coventurers.

(4) Direct Foreign Investment

Direct foreign investment describes the situation in which a corporation forms a subsidiary in another country to produce a product and market it in that country. Volkswagen, for instance, is a West German company. Its subsidiary, Volkswagen of America, manufactures and markets cars in this country. Similarly, the Ford Motor Company has subsidiaries across Europe. A corporation does not have to be especially large to have a foreign subsidiary. However, ownership of a foreign subsidiary is an essential requirement if a company is to become a multinational corporation.

However, Nations often attempt to protect their domestic industries by means of **trade barriers**. *Tariffs* represent one method of placing imports at a disadvantage in their competition with domestic goods. *A tariff is a tax imposed by a country on imported goods*. A second barrier to imports is the *import quota*, a limit on the quantity of a particular good that may be brought into a country. An *embargo* is a law or government order forbidding either the importing or the exporting of specified goods.

The Multinational Companies

— A large firm with a home base in one country, operating wholly or partially owned subsidiaries in other countries is a multinational company.

— *Examples* of some multinational companies are : General Electric, Phillips, British Petroleum, Nestle etc.

— As with domestic companies, *profit* — not national boundaries — determines the business strategies that these corporate giants develop. In a fully developed multinational; capital, technology, personnel, information, goods, and services flow freely from one country and one subsidiary to another. If you buy an IBM PC, you will own a video monitor made in Korea; floppy disk drives made in Singapore, semiconductors made in Japan, and a product that was assembled in the United States. Often, managing this type of flow is the multinational's biggest operational problem.

32

Small Scale Industries and Entrepreneurship

32.1. INTRODUCTION

- The role of small scale industries is significant in the over all growth of the economy of our country.
- The role of small scale industries has been emphasised, from time to time, keeping in view the over all plan objectives of economic growth coupled with social justice. *The small scale sector has a distinct advantage of low investment with high potential for employment generation.*
- In order to create substantial employment opportunities, the Industrial policy laid stress on effective promotion and development of cottage and small scale industries in the country.
- The small scale sector continued to show impressive growth. The production of small scale industries during 1988-89 was estimated to be Rs 106875 crores at current prices (Rs 82400 crores, at 1984-85 prices) and provided employment to about 113 lakh persons during the same period.

  Exports from this sector were estimated at Rs 4535.01 crores (provisional) during 1987-88 as against Rs 3617.33 crores (estimated) during previous year. The exports of small scale sector in 1987-88 constituted about 29% of the total exports from the country.
- Table 32.1 shows the growth trend of small scale industries during the first four years of the Seventh Plan.

TABLE 32.1

Seventh five year plan period

	1985-86	1986-87	1987-88	1988-89
	1	2	3	4
No. of units (lakhs Nos.)	13.55	14.76	15.76	17.01
(Cumulative)	(9.09)	(8.93)	(6.78)	(7.93)
*Production at current prices	61228	72250	87300	106875
(Rs in Crores)	(21.20)	(18.00)	(20.83)	(22.42)
*Production at 1970-71 prices	17840	20187	22326	25790
	(12.84)	(13.16)	(10.60)	(15.52)
Employment (in lakhs Nos)	96.00	101.40	107.00	113.00
	(6.67)	(5.62)	(5.52)	(5.61)
Export at current prices	2753.23	3617.33@	4535.01@@	Not
(Rs in Crores)	(7.84)	(31.38)	(25.37)	available

N.B. Figures in Brackets indicate percentage increase over the previous years.

*Estimated, @ Revised, @@ Provisional

32.2. ROLE AND SCOPE OF SMALL SCALE INDUSTRIES

(1) Small Scale industries provide vast scope for increasing employment.

(2) They are labour intensive and require comparatively little capital to start with.

(3) They help production of consumer goods and therefore can meet the demand for consumer products.

(4) They help reduction of prices.

(5) They accelerate the rate of industrial growth.

(6) They help in equitable distribution of national wealth.

Everyone, who has the spirit of enterprise in him, can contribute to the prosperity of the country by starting a small industrial unit.

32.3 CONCEPT OF SMALL SCALE AND ANCILLARY INDUSTRIAL UNDERTAKINGS

– A *Small Scale Industrial Undertaking* shall mean an industrial undertaking in which the investment in fixed assets in plant and machinery, whether held on ownership terms or by lease or by hire purchase, does not exceed Rs 35 lakhs.

– An *Ancillary Industrial Undertaking* shall mean an industrial undertaking which has both the following features, that is to say :-

(a) The investment in fixed assets in plant and machinery whether held on ownership terms or by lease or by hire purchase, does not exceed Rs 45 lakhs; and

(b) The undertaking is engaged or is proposed to be engagad in the manufacture or production of parts, components, subassemblies, tooling or intermediates or the rendering of services* and the undertaking supplies or renders or proposes to supply or render at least 30% of its production or services*, as the case may be to one or more other industrial undertakings.

Provided that no small scale or ancillary industrial undertaking referred to above shall be subsidiary of, or owned or controlled by, any other industrial undertaking.

– All such industrial units will be eligible to avail facilities such as credit on liberalised terms, allotment of factory sheds/plots in industrial estates, supply of machinery on hire purchase, participation in Government stores purchase programme, training and industrial extension services, allocation of indigenous raw material etc.

– A *tiny unit* is an undertaking having investment in fixed assets in plant and machinery not exceeding Rs 2 lakhs.

– When manufacture is carried out by the owner himself with the help of his family members or relatives or a few wage earners, it is said to be a *cottage or household industry*. Some such industries are handloom-cotton, Khadi, Gur, and Khandasari etc.

– A small scale industry, whether a tiny unit, a cottage unit or an ancillary industry, when set up in rural areas is referred to as a *village industry*.

32.4. HOW TO START A SMALL SCALE INDUSTRY

The steps involved in starting a small scale industry are :

1. Product Indentification : Conduct Market Survey and study the products as regards their demand in the market.

– Check whether it is a seasonal product or it has demand throughout the year.

– Study similar products available in the market that can be probable competitors. Analyse them as regards their utility, quality and cost.

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* Such as sand-blasting, machining, grinding or pressure cleaning facilities, etc.

- Find whether the product can be exported.
- Explore the possibility whether some product can be manufactured in collaboration with a foreign country. This provides ready made technical know-how and saves a lot of time and money otherwise wasted in developing a suitable method of manufacture.
- Decide the product that you are going to manufacture, on the basis of

(*a*) Market survey (as explained above).
(*b*) Financial implications involved.
(*c*) Technical know-how available.
(*d*) Experience in the line, etc.

2. Preparation of preliminary project report to get rough idea on Machinery, raw material and financial requirements.
3. To decide form of ownership which may be sole-proprietorship or partnership etc.
4. To decide factory location.
5. To buy land or take built-up shed.
6. To invite quotations for machinery and equipment.
7. To prepare detailed project report which will include: Analysis of Industry, present demand, future demand, requirement of equipment, raw material, labour, power, finance, breakeven analysis, profitability etc.
8. Apply for registration.
9. Plan finance.
10. Follow up sanction of loan.
11. Open bank account.
12. Place order for machinery.
13. Apply for Power.
14. Plan layout of machinery.
15. Apply for Income tax and Sales tax numbers.
16. Apply for (imported) raw material.
17. Recruit personnel.
18. Plan buying of raw material.
19. Conduct trial run to see whether the desired quantity and quality of product is Coming.
20. Decide on pricing policy.
21. Organise marketing.
22. Plan account keeping.
23. Plan commercial production.

32.5. PROCEDURE FOR REGISTRATION OF SMALL SCALE INDUSTRIES

Registration of Small Scale Industrial undertakings would be done in two stages;

(*a*) *Provisional registration*
(*b*) *Permanent registration*

(*a*) *Provisional registration*

- Provisional registration helps the party to take necessary steps to bring the unit into existence. It should be converted into a permanent registration once the unit comes into existence.

- The provisional/permanent registration are granted at the state/UT/district level by state D.I. or his designated authority.
- A provisional registration is valid for one year in the first instance and thereafter may be renewed for a period of two more years in four six monthly extensions by the designated authority on submission of satisfactory proof that the party is taking concrete steps to establish the unit.
- The issue of provisional registration certificate normally should be automatic and should be given within a period of seven days after the receipt of the application.
- *The provisional registration may entitle the party to* :

(1) Apply for a shed in an industrial area.

(2) Apply for power connection.

(3) Apply for financial assistance to State financial corporation/Nationalised Banks or other financial institutions on the basis of a project report as may be required by them.

(4) Apply to the NSIC/SSIC/other institutions for procuring machinery on hire purchase basis.

(5) Obtain sales tax, excise tax registration etc.

(6) Take other steps such as obtaining import licence for capital goods/raw material etc.

(*b*) ***Permanent Registration***

- When the party has taken all steps to establish the unit *i.e.,* (1) factory building is ready, (2) all requisite machinery, testing equipment, etc., is installed, (3) power connection is obtained, application for permanent registration can be made.

  On being satisfied after inspection that the unit is capable of production, a permanent registration certificate may be issued by the Directorate of Industries within one month of the receipt of application for permanent registration.
- All registered units should submit half yearly reports of the raw materials received/utilized, stocks on hand, production and sales to the Directorate of Industries in triplicate.
- The Director of Industries will maintain a list of all registered small scale units at his headquarters office.

De-registration of units

- A small scale unit already registered may be de-registered on any one or more of the following grounds:-

(1) If the unit remained closed continuously for a period exceeding one year.

(2) If the unit failed/refused or avoided to give full and truthful information as called upon by the registering authority.

(3) If the unit has misutilised the raw materials allocated to it.

(4) If a unit is found to be a subsidiary of or owned or controlled by medium and large scale undertakings.

(5) If the fixed investment in plant, machinery etc, exceeds the ceiling prescribed for the unit.

- Any unit aggrieved by the order of de-registration authority may appeal to the next higher prescribed authority as notified by the state Government within one month of the receipt of the order of de-registration.

32.6. LIST OF ITEMS RESERVED FOR EXCLUSIVE MANUFACTURE IN SMALL SCALE SECTOR

A few of the many items reserved for exclusive manufacture in small scale sector are listed below. Detailed list can be had from Ministry of Industry, New Delhi.

(1) *Food and Allied Industries*
Ice-cream, pickles and chutneys, vinegar, bread, biscuits, poultry feed, synthetic syrups etc.

(2) *Textile products including hosiery*
Cotton vests knitted, cotton socks knitted, cotton under garments knitted, woollen cloths, under garments etc.

(3) *Art silk/Man-made fibre hosiery*
Synthetic knitted socks and stockings, vests, briefs cardigans, pullovers etc.

(4) *Wood and wood products*
Sawn timber, wooden crates, sewing machine covers, tent poles,handles, furniture etc.

(5) *Paper products*
Waxed paper, decorative papers, corrugated papers and boards, paper bags etc.

(6) *Leather and Leather products including footwear*
Sole leather, hides, shoes, leather garments, purses, hand bags, watch straps etc.

(7) *Rubber products*
Rubberized cloth, canvas hoses, cycle and rickshaw tyres and tubes etc.

(8) *Plastic products*
Full PVC footwear chappals, sandals, shoes, acrylic sheets, spectacle frames etc.

(9) *Injection moulding thermo plastic products*
Handles, soap cases, cups, lunch boxes, water jugs, tumblers, hair brushes etc.

(10) *Chemicals*
Ammonium sulphate, cadmium acetate, cobalt nitrate, ferrous sulphate etc.

(11) *Dye stuff*
Basic dyes – basic yellow, basic green, basic blue etc.

(12) *Organic chemicals and drugs*
Tartrates, sterate of zinc, paracetamol, resin etc.

(13) *Glass and Ceramics*
Fire clay, bricks and blocks containing less than 40% alumina.

(14) *Roofing and flooring tiles*
Wooden, clay and granite tiles.

(15) *Mechanical Engineering excluding transport equipment*
C.I. manhole covers, weights, circlips, bright bars,etc.

(16) *Electrical machines, appliances and apparatus including electronics*
Transformers, boosters, voltage stabilizers, PVC wires etc.

(17) *Bicycle parts, survey instruments, sports goods, stationery items, clocks and watches* etc.

32.7. FINANCIAL ASSISTANCE

A net-work of

1. State financial corporations,
2. National Small Industries Corporation (NSIC) and
   State Small Industries Corporations (SSICs),
3. State Directorates of Industries,
4. Commercial Banks,
5. Industrial Development Bank of India, and
6. Regional Rural Banks, provide financial assistance to small scale units.

Industrial Development Bank of India provides re-finance to the industrial loans advanced by these institutions to small scale sector.

1. **State Financial Corporations (SFCs)**

- State Financial Corporation grants term loans for the *purchase* of *land*, construction of *factory* premises and purchase of *machinery* and *equipment* for the setting up of new industries or for *expansion* or *modernisation* of the existing ones.
- SFCs generally prescribe a margin of 25% and allow an initial holiday of two years for the loan repayment (this period can be increased to five years in backward districts).

2. **NSIC and SSICs**

- NSIC and SSICs supply machinery on hire-purchase basis to small scale and ancillary industries, the value of which should not exceed Rs 35 lakhs and Rs 45 lakhs, respectively, inclusive of the value of machinery and equipment already installed.
- The payment for the machinery and equipment is made directly to the suppliers.
- The hire-purchase value is generally recovered in 13 half-yearly instalments and a rebate of 2 % allowed if the instalments are paid before the due date.
- While NSIC supplies both imported and indigenous machinery, SSICs supply only indigenous machinery.

3. **State Directorates of Industries**

State Directorates of Industries extend assistance ranging between Rs 10,000/- and Rs 50,000/- for the construction of a factory premises, purchase of machinery and equipment and working capital. These loans are repayable in five to seven years.

4. **Commercial Banks**

- Commercial banks provide *short term* and *medium term* financial assistance.
- The *short term* credit facilities are granted for working capital requirements of the units like those for raw materials, goods-in-process, finished products, bills receivables and book debts.
- The *medium term* loans are granted for the acquisition of land, construction of factory premises, purchase of machinery and equipment and operative expenses.
- These loans are generally granted for periods ranging from five to seven years.
- They also establish letters of credit on behalf of their clients favouring suppliers of raw material/ machinery (both Indian and foreign) which extend the bankers' assurance for payment and thus help their delivery.
- Certain transactions, particularly those in contracts of sale to government departments, may require guarantees being issued in lieu of security/earnest money deposits for release of advance money, supply of raw materials for processing, full payment of bills on assurance of performance, etc. Commercial banks issue such guarantees also.

5. **Industrial Development Bank of India (IDBI)**

- The IDBI, the apex development body for small, medium and large industries, extends assistance to SSI units through two major schemes :-

  (*a*) *Bills Re-discounting Scheme,* under which the manufacturers of indigenous machinery/capital equipment can offer deferred payment facilities to their buyers (the period of such payment being not less than six months and not more than five/seven years), the relative bills accepted/ guaranteed by the buyer and or his bankers, can be discounted by the manufacturer with his own bank to realise the cost of machinery immediately. The latter, in turn, rediscounts the bills with the IDBI and obtains the amount paid. Subsequently he takes them back before their due dates and presents them for payment before the buyer/his guarantor.

(*b*) *Refinance scheme* under which IDBI refinances eligible term loans granted by banks to the SSI borrowers.

6. **National Bank for Agricultural and Rural Development (NABARD)**

The National Bank for Agricultural and Rural Development was set up in July 1982 to provide re-finance assistance to State Co-operative Banks, Regional Rural Banks and other approved institutions for all kinds of production and investment credit to small scale industries, artisans, cottage and village industries, handicrafts and other allied activities.

32.8. OTHER ASSISTANCE PROVIDED TO SMALL UNITS

(1) Supply of machine and equipment on hire-purchese.
(2) Supply of scarce raw materials and imported components.
(3) To demonstrate to them the use of modern technical processes and equipments.
(4) To train small industrialists.
(5) To render marketing (including export) assistance.
(6) Allotment of sheds.
(7) To provide power, water and transport facilities.
(8) To provide subsidy on fixed capital investment (*i.e.* land, building and machinery).
(9) To provide interest free loans.
(10) To provide loans at concessional rate of interest.
(11) Reservation of items for exclusive production in small scale sector.
(12) Reservation of items for exclusive purchase from small scale sector.
(13) Export promotion of specific commodities or groups of products such as chemicals, Gem and Jewellery, Handloom, Leather products etc.

32.9. SPECIAL INCENTIVES

(*a*) Special inducements are offered for development of entrepreneurship among the persons in *hilly, rural and backward areas*. For example, transport subsidy is given in remote and hilly backward areas in selected states/union territories. Capital subsidy up to 15% is also given to persons setting up their units in specified backward areas.

(*b*) New entrepreneurs are *exempted* for five years from *income tax payment* on their profits, up to 7.5% P.A. of the capital invested.

(*c*) Entrepreneurs are entitled to *deduction of depreciation* (on building, plant and equipment) out of the net profit.

(*d*) Entrepreneurs are completely or partially *exempted* from payment of *central excise duty*.

(*e*) *Concessions* are also given *in stamp duty* payable on the agreements and mortgage deeds executed to take loans from the government.

(*f*) Sales tax is not charged on machines purchased for setting up small scale industries in certain states.

(*g*) *Import licences* are given to those entrepreneurs who require raw material, machines and their spares to be purchased from other countries for running their units successfully.

(*h*) Training courses are organised exclusively for *women entrepreneurs* in technical and management subjects, in order to provide them opportunities for self-employment. They are also assisted in preparing projects on specific industries.

(*i*) *Indians residing abroad* and desirous of starting industries in India can bring machinery up to C.I.F. value of Rs. 25,00,000 and raw materials worth Rs. 5,00,000 or annual requirement of the unit,

whichever is less. In addition to this, they are also given all the facilities normally available to all other prospective entrepreneurs in the country.

32.10. ASSISTANCE TO EDUCATED UNEMPLOYED

- With a view to help the educated unemployed to set up their own small industrial units, the state provides assistance in a package form so that they may take minimum possible time to set up their ventures. The following types of assistance is made available, under this scheme.

1. Project profiles

In order to help the entrepreneurs to choose items of manufacture, the Directorate gets project profiles prepared from reputed consultants on items of manufacture having scope for sale. This enables the entrepreneurs to know the viability of manufacture of various items at the first instance.

2. Training

The training enables the entrepreneurs to prepare the project report according to their requirement, government documentation and various other aspects of the manufacture/marketing of the items of manufacture.

- The trainees are also given a stipend.
- In-plant training is also provided to the entrepreneurs through the State Government Quality Marking Centres and Industrial Development Centres.
- Besides *Entrepreneurship Courses, Management* (marketing, export, production, finance, personnel, etc.) and Technical Courses (tool maker, machinist, foundrymen, electroplating, foot wear manufacture, etc.) are also run by Small Industries Service Institutes (SISI).

3. Seed money

The educated unemployed after getting their major loan sanctioned from financial institutions are provided seed money to the extent of 10% of the cost of their project. This 10% is recoverable in 5 instalments after their major liability of financial institution is over. This proportion of financial assistance is given at a nominal rate of 4% only and is counted as entrepreneurs own equity for the purpose of financial appraisal of their scheme.

4. Interest subsidy

- Degree and Diploma holders is Engineering, who pass three month entrepreneurship course from the Institutions prescribed by the Government of India are eligible for the interest subsidy.
- The entrepreneurs have to pay only 7% rate of interest on loans sanctioned by financial institutions. The difference between 7% and the rate of interest to be charged by the financial institutions is reimbursed to the entrepreneurs by the state government. This facility is available only for a period of three years.

5. Educated unemployed are given industrial accommodation on priority.

This scheme covers all educated unemployed youth who are matriculate and are within the age group of 18-35 years. Women and technically trained persons are given due consideration/weightage. From 1986-87, a minimum of 30% of the total sanctions has been reserved for Scheduled castes/Scheduled Tribes persons. ITI passed youth are also now eligible to set up industry/service ventures.

32.11 A MODEL SCHEME TO START A SMALL SCALE INDUSTRY FOR EXAMPLE A JOBBING WORKSHOP

Introduction

- A jobbing workshop can undertake *job order work* which is available in plenty from large and medium scale industries, for example, a large or medium industry manufacturing Tractors can give job orders to make fuel tanks, silencers, etc.

Basis and Presumption

- The scheme has been made on the basis of 75% efficiency on single shift considering 25 working days in a month.
- The rate of interest has been taken on 15% at an average.
- The job work will be procured from outside industries along with raw material.

Process outline

(*a*) Turning (*b*) Boring
(*c*) Milling (*d*) Drilling
(*e*) Heat-treatment if required from local units.

Rate of Machine

Lathe	Rs 60 per hour
Milling	Rs.90 per hour
Shaper	Rs 50 per hour
Drilling machine	Rs 38 per hour

Land and Building

Covered area 80 sq.metre @ Rs.40/-per sq.mt (rented) — Rs 3200.00 ...(*i*)

Machinery and Equipment

1.	*Precision Lathe Machine all geared* Max. swing over bed Distance between centres Width of bed Width of gap Motor 5 HP, 1500 RPM speed Coolant pump.	2 Nos each 90,000 500 mm 1,000 mm 300 mm 160 mm	Rs 1,80,000.00	
2.	*Milling Machine* Working surface of table No of spindle speeds Motor 3 HP, 1420 RPM speed.	1 No. 1064 ×254 mm 16	1,00,000.00	
3.	*Shaper* 610 mm stroke (geared)	1 No.	50,000.00	
4.	*Drilling Machine* 18 mm capacity	1 No.	25,000.00	
5.	*Bench grinder* 25 mm wheel size	1 No.	7,000.00	
		Total	Rs 3,62,000.00	...(*ii*)

Precision Instruments

1.	Micrometer	2 Nos.	500.00
2.	Vernier calliper 15 cm, 30 cm	2 Nos.	1,000.00
3.	Surface plate 60 cm size	1 No.	5,000.00
4.	Marking block	1 No.	200.00

5.	Height gauge 45 cm size	1 No.	5,000.00	
6.	Dial indicator with stand		500.00	
		Total	Rs 12,200.00	...(*iii*)
	Electrification and Installation		33,000.00	
	Tools, jigs and fixtures		10,000.00	
	Office furniture and equipment		20,000.00	
		Total	Rs 63,000.00	...(*iv*)
	Total of (*ii*), (*iii*) & (*iv*) =		4,37,200.00	...(*v*)
	Working Capital per month			
	Staff and labour			
1.	Skilled workers	4 Nos @ 2000/-	8000.00	
2.	Semi-skilled workers	2 Nos @ 1500/-	3000.00	
3.	Helper	1 No @ 800/-	800.00	
		Total	Rs 11800.00	...(*vi*)
	Overhead Charges			
1	Repair & Maintenance		750.00	
2	Postage and Stationery		300.00	
3	Travelling expenses		1500.00	
4	Transportation		750.00	
5	Consumable stores		700.00	
6	Miscellaneous		1000.00	
		Total	5000.00	...(*vii*)
Utilities				
	Electricity and power		2000.00	...(*viii*)
Total Working Capital (as calculated above)				
	Staff and Labour		11800.00	...(*vi*)
	Overhead charges		5000.00	
	Utilities		2000.00	(*viii*)
	Rent		3200.00	(*i*)
		Total	Rs 22000.00	(*ix*)
Capital investment				
	Fixed Cost-machinery and equipment		4,37,200.00	(*v*)
	Working Capital for 2 months		44,000.00	(*x*)
	2×22000	Total	Rs 4,81,200.00	(*xi*)
Cost of production (per year)				
	Working Capital, 22000 ×12		2,64,000.00	

Depreciation on Machinery @ 10% [of (*ii*) + (*iii*)]		37,420.00	
Interest on capital investment @ 15% [of (*xi*)]		72,180.00	
	Total	3,73,600.00	(*xii*)
Turnover (per year)			
–Lathe output @ Rs 60/- per hour for 6 hours a day for 25 days	2 Nos.	2,16,000.00	
–Milling output @ Rs 90/- per hour for 6 hours a day for 25 days	1 No.	1,62,000.00	
–Drilling out put @ Rs 38/- Per hour for 6 hours a day for 25days (∵38×6×25×12×1)	1 No.	68,400.00	
–Shaper output @ Rs 50/- per hour for 6 hours a day for 25 days.	1 No.	90,000.00	
	Total	Rs 5,36,400.00	

Profit = Turnover – cost of production

= 5,36,400.00 – 3,73,600.00 = 1,62,800.00

$$\text{Rate of Return} = \frac{\text{Profit}}{\text{Capital investment}} \times 100 = \frac{162800}{481200} \times 100$$

$$= 33.83\%$$

Machinery Suppliers

1. Hindustan Machine Tools, Pinjore.
2. R.K. Machine Tools, Ludhiana.
3. ----------
4. ----------

32.12. ENTREPRENEURSHIP

- Doing new things or doing things that are already being done, in a new way is, a simple difinition of *entrepreneurship*.
- *Entrepreneurship* can be described as a creative and innovative response to the *environment*. Such responses can take place in any field of social endeavour - business, agriculture, education, social work and the like.

  Knowledge about the economic–political *environment*, more particularly about the economic policies of the government and the financial as well as commercial institutions, is important for the entrepreneur.

32.13. ENTREPRENEUR, CONCEPT OF

- The word *entrepreneur* has its origin in the French language. It refers to the organiser of musical or other entertainments.
- An entrepreneur is one who organises, manages, and assumes the risks of an enterprise.

  An entrepreneur visualises a business, takes bold steps to establish undertaking, coordinates the various factors of production and gives it a start.
- *Entrepreneurs* are the owners of the business who contribute the capital and bear the risk of uncertainties in business life.

- Entrepreneur is action - oriented and highly motivated. He has the ability to evaluate business opportunities, to gather the necessary resources to take advantage of them and to initiate appropriate action to ensure success.
- Entrepreneur is associated with innovations. He is the main factor of production.
- Entrepreneur takes decision regarding what to produce, how to produce, where to produce and for whom to produce. He mobilises other factors of production namely, land, labour, capital, organisation and initiates production process. He is responsible for both the profit or the loss.
- In India, Birla, Tata, Modi are big entrepreneurs.

32.14. PROFILE OF AN ENTREPRENEUR

The following list of characteristics and Traits provides a working profile of entrepreneurs :-

Characteristics	Trait
Self confidence	Confidence, independence, individuality, optimism.
Task-result oriented	Need for achievement, profit-oriented persistence, perseverence, Determination, hard-work, drive, energy, initiative.
Risk-taker	Risk taking ability, likes challenges.
Leadership	Leadership behaviour, gets alongwith others, responsive to suggestions and criticisms.
Originality	Innovative, creative, flexible, open-minded, resourceful, versatile, knowledgeable.
Future oriented	Foresight perceptive.

The list includes traits that an entrepreneur should possess. He may not need all these traits, but the more he has, the greater chance there is of his being a successful entrepreneur.

32.15. ENTREPRENEURIAL PHILOSOPHY

1. To take calculated risk.
2. Willingness to accept responsibility for one's own work.
3. Failure must be accepted as a learning experience.
4. Goal orientedness.
5. Acceptable results are more important than perfect results.
6. Personal growth.

32.16. FUNCTIONS OF AN ENTREPRENEUR

1. He manages business and takes decisions.
2. He studies the market and selects the business.
3. He makes a selection of plant size.
4. He selects plant site.
5. He organises sales and holds the customers.
6. He promotes new inventions.
7. He coordinates different factors of production.

8. He arranges raw material, machinery and finance.
9. He employs labourers.
10. He deals with government departments such as sales tax, labour, electricity, export-import, railways etc.
11. He decides pricing policies.
12. He distributes wages of labourers, interest to the capitalist etc.

32.17. QUALITIES OF ENTREPRENEUR

1. Risk taking ability.
2. High level of motivation,
3. Business acumen.
4. Self confidence and positive self concept.
5. Leadership qualities.
6. Flexibility.
7. Managerial Competence.
8. Problem solving.
9. Ability to perceive opportunities and threats.
10. Realistic approach to planning.
11. Independence of thought and action.

32.18. ENTREPRENEURIAL FAILURE

Different *factors* contributing to the failure of entrepreneurial ventures are as follows:-

1. **Poor Management**
   (*a*) Incompetence.
   (*b*) Unbalanced experience.
   (*c*) Inexperience in management.
   (*d*) Inexperience in line.
2. **Production problems**
   (*a*) Lack of production planning and control.
   (*b*) Frequent Machine breakdowns.
   (*c*) Poor raw material.
   (*d*) Power cuts.
   (*e*) Labour problems.
   (*f*) Lack of technical knowhow.
   (*g*) Insufficient quality control.
   (*h*) Wastage in material.
   (*i*) High rate of rejection, etc.
3. **High fixed cost**
   (*a*) Heavy investment in land and building.
   (*b*) Increased administrative and other overheads.
   (*c*) Market borrowing at high interest rate, etc.

4. **Marketing problems**
   (*a*) Competition from larger and already established units.
   (*b*) Insufficient sales force.
   (*c*) Low quality of finished goods.
   (*d*) Recession etc.
5. **Financial problems**
   (*a*) Allowing long credits to the purchasers of finished goods.
   (*b*) Diversion of short term funds into long term uses.
   (*c*) Wilful diversion of funds for investments in assets not connected with production.
6. **Neglect of business.**
7. **Fraud.**
8. **Disaster.**

32.19. ENTREPRENEURIAL DEVELOPMENT

- The main objective of the entrepreneurial development schemes is to motivate and assist prospective and potential entrepreneurs to set up small scale units of their own and thereby become self-employed and continue to contribute significantly to production and employment in the country.
- Entrepreneurial development programmes increase entrepreneurial spirit and provide scope for self-development by focusing attention on the self and on self-directed motivational change.
- In order to motivate *engineers* to take up industrial ventures, an interest subsidy scheme was started in 1974 as one of the follow-up assistance measures of the engineers training programme. It envisages financial assistance to the trained engineers in the form of subsidy on interest payments on loans taken by them from any of the recognised financial institutions for the acquisition of fixed assets.

  The scheme was subsequently liberalized in 1976 to cover non-trained engineers also for setting up their units.
- With the new Thrust for the development of Industries in backward areas and for promoting the weaker sections Small Industries Development organisation (SIDO) diversified its entrepreneurship training programmes in the year 1978-79 to serve new categories of entrepreneurs like rural artisans, educated unemployed, weaker sections of the society, women entrepreneurs, students and physically handicapped persons and Defence personnel. The entrepreneurial development training programmes for the non-engineers are broadly divided into two categories :

  (*a*) Indentification, selection and motivation of entrepreneurs and

  (*b*) Entrepreneurial development training programme for
  - (*i*) Women,
  - (*ii*) Rural artisans,
  - (*iii*) Weaker sections of society,
  - (*iv*) Educated unemployed,
  - (*v*) Physically handicapped, including blind persons,
  - (*vi*) Defence personnel,
  - (*vii*) Students, etc.

32.20. EXPORT PROMOTION

- Export development in the small scale sector has been accorded high priority in the economic strategy of the country as it results in creation of more employment opportunities, ensures utilisation of capacity for production and improves the quality of products, apart from bringing the much needed foreign exchange.
- Apart from direct exports, products of a large number of small scale units are exported indirectly through merchant exporters, export houses, etc. Parts and components from small scale sector which are part of the finished products are also being exported by large units.
- Small Industries Development organisation (SIDO) through its network of Small Industries Service Institutes (SISIs) and Extension Centres throughout India provides assistance for promotion of exports of SSI (Small Scale Industry) products.

  The activities in this regard include dissemination of information about (1)foreign markets (2) consultancy services in matters of export procedures for claiming replenishment (3) identification of small scale units already possessing necessary equipments and skills to undertake production of items having export potential (4) organising of training programme on export marketing (5) maintaining liaison with concerned export development agencies (6) meetings and seminars on export promotion etc.

  Small Industry Export Bulletin covering important areas of interest to exporters continued to be brought out by SIDO. Information on export prospects, Govt. policy announcements and procedures relevant to small industry exports, market/commodity reports prepared by professional agencies, etc. were included in these bulletins.

32.21. EXPECTATIONS OF ENTREPRENEURSHIP

It is expected from the entrepreneurs that they will help :-

1. Increase number of industries.
2. Increase production.
3. Increase employment opportunities.
4. Earn foreign exchange through exports.
5. Develop the underdeveloped parts of the country.
6. Economic development.

33

Environmental Pollution

33.1. INTRODUCTION

- Environment refers to the ecological, economic,political, social and technology consideration that impact on engineering and in turn are impacted by the results of engineering.
- Scientists and engineers develop technology that impacts the environment in which we live.
- Sometimes back in a certain wooded area located remote from industry, the air was pure and the waters were clean.

  As the first few people settled in that area, the water had no problem in assimilating their wastes and the smoke from their fires could easily dissipate in the atmosphere.

  However, with the growth of population, industry thrived and the affluence of the community increased steadily. An almost unavoidable concomitant of this developmental pattern was the increase in water and the air pollution.
- Deterimental effects of increased waste, and water and air pollution are controlled through the implementation of environmental specifications and standards, which in turn place more stringent constraints on future technology.

33.2. ECOLOGY

- In general *Ecology* pertains to the study of relationships between various organisms and their environment. This includes consideration of plant, animal, and human populations in terms of rate of population growth, food habits, living habits, reproductive habits and ultimate death.
- Human ecology is a social science that studies the relationships between man and his environment.
- The ecological study of man may be divided into two fields :

(i) Human ecology proper, which studies the relationships between human biological factors and the natural environment

(ii) Social ecology, which studies the relationships among natural environment, population, technology and society.

- During last few decades, the world population growth combined with the technological changes associated with our living standards, has created a greater consumption of our resources; concurrently the amount of pollution waste has increased significantly. The net effects of this have caused alterations to the basic biological process and to some extent these alterations have been harmful. Of particular concern are those problems, dealing with air pollution, water pollution etc.

33.3. FACTORS CAUSING/AFFECTING POLLUTION

- The level of pollution is a function of so many factors. It varies directly with the level of population and per capita income and inversely with the extent of recycling, technology and waste treatment.

  P=*f* (Proplation, per capita income. 1/recycling, 1/technology, 1/treatment)

- Pollution increases with the population density, because, as the population increases, more burden is placed on the environment.
- Environmental pollution further increases as the standard of living goes up. This is becaue of the fact that, the goods and services demanded per person increase.
- Pollution is inversely related to the degree of recycling. In other words if the waste product is cleaned and reused, the pollution level will decrease.
- Technology also acts to ameliorate pollution. Engines which are more efficient produce less pollution/waste for the same degree of utility.
- The intensity of pollution also depends upon the amount of waste treatment. There are several methods available to clean air and water discharged from industrial processes.

For example, pollutants in air can be removed by electrostatic precipitators and waste waters can be cleaned by mechanical filtration to chemical and biological processing.

33.4. EFFECTS OF POLLUTION ON HUMAN HEALTH

- Pollution develops respiratory diseases which may cause disability and death.
- Given below is a list of various health problems associated with pollution.

(i) Occupational skin diseases e.g. chemical burns or inflammations.

(ii) Dust diseases of lungs e.g. silicosis found in foundry workers.

(iii) Respiratory conditions due to Toxic agents e.g. acute congestion due to chemicals, dusts, gases or fumes.

(iv) Poisoning e.g. by Pb, Hg,Cd, H_2S, benzol,plastics and resins etc.

(v) Disorders due to physical Agents such as environmental heat or low temperature.

(vi) Disorders due to repeated Trauma e.g. noise-induced hearing loss.

33.5. AIR POLLUTION AND CONTROL

Introduction

- Air pollution may be defined as any gaseous, liquid or solid material suspended in the air which creates an undesirable effect. Air pollution is injurious both to life and property.
- Polluted air is present over almost every industrialized community. Much of the blame for the contaminated atmosphere can be directed toward automotive exhaust but industrial wastes are also big contributors. Factories and electric-power generating plants emit sulphur dioxide and fly ash and microscopic pieces of metal or metal oxides.
- Air pollution is growing at a rate that alarms experts throughout the world and it will continue to grow despite measures being taken to alleviate it. Only the most drastic steps can reverse the present trend.

Sources of air pollution

- Sources of air pollution include
  - (*i*) Factory chimneys
  - (*ii*) Home furnaces
  - (*iii*) Burning refuse
  - (*iv*) Burning fuel for light, heat, power and transportation.
  - (*v*) Gaseous emissions from automobiles.
- It is estimated that about 60% of the air pollution is caused by transportation vehicles, 20% comes from combustion processes for heating, power generation and incineration and 20% comes from industrial, commercial and other sources.

Nature of Air-pollutants

There are two types of air pollutants

- Particulate matter
- Gases

The gases are far more dangerous to humans.

(i) Particulate Matter. Particulates are small solid or liquid substances in the air resulting primarily from fuel combustion, incineration of waste materials, or industrial process losses.

Particulate matter includes smoke, soot, flyash, dusts, mists and fumes.

Individuals who breathe such substances into their lungs may suffer from respiratory diseases.

(ii) Sulphur oxides are formed by the combustion of fuel oil or coal; both are widely used to produce heat and power, Fog or thermal inversions can transform sulphur dioxide into toxic sulphur trioxide sulphuric acid mist, which can injure humans, animals, plant life and even damage buildings.

(iii) Ozone is a toxic gas that can cause irritation of eyes and the respiratory system.

(iv) Nitrogen oxides are toxic pollutants. They come from stationary combustion sources or from motor vehicle exhausts. They damage vegetation and corrode metals.

(v) Carbon monoxide is a notoriously deadly gas. It results from the incomplete combustion of carbon-containing materials, such as gasoline. In nonfatal quantities it can affect the eye-sight, produce nervous reactions,, cause headache, nausea etc.

(vi) Hydrocarbons are chemical compounds such as olefins, paraffins, naphthenes and aromatics. Hydrocarbons emit as a result of incomplete burning of gasoline in automobiles. Hydrocarbon pollution contributes to photochemical smog, lung and eye irritation and may inhibit vegetation growth.

(vii) Organic and inorganic acids are formed in the atomosphere as a result of combustion and various industrial processes. The organic acids include acetic, fumaric and tannic acids. The inorganic acids include sulphuric, hydrochloric hydrofluoric and hydrobromic acids.

Air Pollution Control

- Since unlike water, air is not self-purifying, the way the air can be cleansed is by cleaner air pushing the dirtier away or by particulate matter settling out from the air and contributing to ground pollution.
- For controlling air pollution, old plants/factories responsible for pollution will have to install air purifying equipment and new plants, even if they contribute minimally to air contamination, will have to locate in areas not subject to inversion cycles.
- Transport vehicles cause maximum amount of air pollution. The exhaust from cars, trucks, buses and aeroplanes is an example of this. Since the vehicles are mobile, the pollution control is more difficult.
- To obtain effective control over the discharge levels of these forms of transport, it is necessary to establish and enforce federal standards.
- In the case of nonmobile sources of pollution such as thermal power plants, industrial plants etc., pollutants may be prevented from entering the atmosphere by *electrostatic precipitators, scrubbers* or by some other means of removal.

Effects of Air Pollution

- Various effects of air pollution are :

(1) *Visibility reduction*

The first effect of air pollution is the reduction in visibility produced by the scattering of light from the surfaces of air-borne particles.

(2) *Material damage*

Direct damage to structural metals, surface coatings, fabrics and other materials is a frequent and widespread effect of air pollution.

(3) *Agricultural damage*

A large number of food, forage and crops have been shown to be damaged by air pollutants. The curtailed value results from leaf damage, stunting of growth, decreased size and yield of fruit, and destruction of flowers etc.

(4) *Physiological effects on Man and Domestic Animals*

Air pollution can result in *bronchitis, lung carcinoma, opticirritation, changes in blood chemistry* etc.

(5) *Psychological effects*

Since fear is a recognizable element in public reactions to air pollution, the psychological aspects of the phenomenon cannot be ignored.

Source testing and monitoring air quality (or pollution)

- The basic difference between source testing and monitoring is that the former implies a relatively elaborate and complete set of measurements to establish a starting or final condition, whereas the latter implies simpler and less complete measurements at regular intervals of a property which increases or decreases in proportion to others.
- Monitoring of an effluent source involves the use of
  - (*i*) Smoke density meters
  - (*ii*) Closed circuit TV systems
  - (*iii*) Mirrors, which reflect the stack effluent to an observer in the plant.
  - (*iv*) Continuous recording analytical equipment.
  - (*v*) Equipment for periodic grab sampling and analysis over long periods of time.
- A simple and commonly used stack–monitoring device for particulate material consists of a source of light focused through the gas stream onto a photoelectric cell which in turn is wired to automatic recording equipment. As the stack loading increases, the light transmittance decreases and the index value increases.

Continuous Monitoring Devices for Flue Gases

- Devices are available for analyzing sulphur and nitrous oxides, CO, H_2S, etc., in either ambient air or stack flue gas emissions.

These devices tend to be selective, analyzing only the portion of the gas intended. Systems include

- (*i*) Gas Chromatography
- (*ii*) Photometry
- (*iii*) Fuel cell sensors
- (*iv*) U.V. absorption
- (*v*) Light scattering techniques etc.

Air Pollution Control Devices

Various air pollution control devices are

- (*i*) Mechanical collectors
- (*ii*) Electrostatic precipitators
- (*iii*) Filters
- (*iv*) Wet scrubbers
- (*v*) Absorbers
- (*vi*) Adsorbers.

(i) Mechanical Collectors use gravitational and /or centrifugal force to remove particulate matter.

- Where the air becomes laden with large particles, gravity provides a good means of separation. A gravity settling chamber is merely a *wide spot in the line* where the velocity of smoke or gas is reduced to allow particles to settle out.
- A Cyclone separator subjects the particles to forces several times that of gravity.

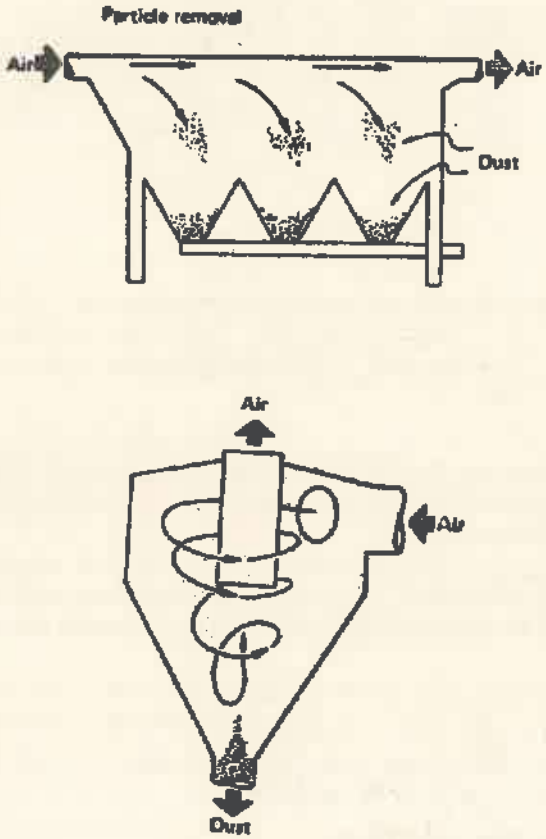


Fig. 33.1. (*a*) Gravity settling chamber (*b*) Cyclone separator.

(ii) Electrostatic Precipitators. An electrostatic precipitator is a means of putting an electric charge on the particles. The charge difference between the particle and the collecting plate causes attraction and collection.

(iii) Filters Consist of fibrous media, felted media and porous media. Filters are one of the most effective particle collection devices. The filter media stops the particles by impaction, interception diffusion settling and electrical attraction.

(iv) Wet Srcubbers

- Wet scrubbers can function as either or both particulate and gas control devices. They can handle hot gases and sticky particulates and liquids.
- Scrubbers remove particulate matter mainly by inertial impaction and they remove gases by absorption.

– Most wet scrubbers utilize atomized liquid drops as the collection targets for particle removal. Particles in the air are impinged against the water droplets.

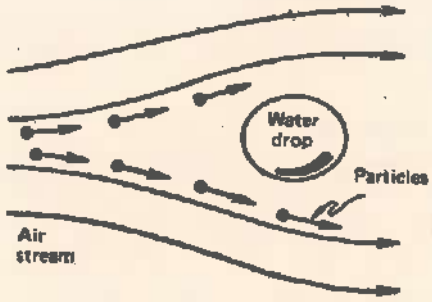


Fig. 33.2. Principle of Scrubber.

(v) Absorbers.

– Absorbers, as related to air pollution control, are a special category of wet scrubbers.

– Absorption towers work as effective pollution control devices. They utilize simple mechanical methods of achieving good contacting between the gas and the liquid phases to provide favourable overall mass transfer.

(vi) Adsorbers

– Adsorption process consists of contacting the solid with a gas mixture to remove any or all odor, taste, moisture, solvents or other pollutants from the gas. A few adsorbents are Activated carbon, Silica gel, Activated alumina etc.

– Adsorption is the taking up of a gas on the surface of a solid (or liquid). Physical adsorption consists of attracting gas molecules usually by electrostatic or van der Waals forces which result from gas molecule polarity and strongly positive or negative ions on the surface of the adsorbing solid.

– Adsorbers are usually constructed with the gases to be cleaned entering from the top and the cleaned gases leaving at the bottom. There are horizontal stationary adsorbent beds.

Dirty gases enter between the beds and adsorption occurs as part of the gases pass through the bed above and part pass through the bed below the gas inlet.

33.6. WATER POLLUTION AND CONTROL

Introduction

– Pollution is defined as something that adversely and unreasonably impairs the beneficial use of water. It includes addition of anything to water which changes the natural quality of water so that the downstream user does not receive the natural water of the stream.

In other words, water pollution is the specific impairment of water quality by agricultural, domestic or industrial wastes (including thermal and atomic wastes), to a degree that has an adverse effect upon any beneficial use of water yet that does not necessarily create an actual hazard to the public health.

– Water pollution may be defined as the addition to a natural body of water of any material which diminishes the optimal economic use of the water by the population which it serves.

– A waste is dumped into a body of water because a city, industry or individual wishes to eliminate a useless and somewhat noxious mess from its environment.

Classification of Water Pollutants

Water pollutants may be classified into following categories :-

(A) Chemical (B) Physical

(C) Physiological (D) Biological

(E) Radioactive

(A) Chemical pollutants

– Chemical materials discharged into a receiving water may be broadly classified as Organic, and Inorganic pollutants.

– Undesirable results from the discharge of inorganic materials include changes in the pH of the water caused by soluble salts and toxicity caused by heavy metals or other toxic materials.

Inert insoluble inorganics such as clay create sludge deposits on the bottom of the river and adversely affect the biological life.

– The major cosideration with respect to organic materials is the depletion of dissolved oxygen. Oils will form surface films, phenols will affect the taste and odor of water and refractory organics will cause death of fish and other aquatic life.

(B) Physical Pollutants

– Physical pollutants include

(*i*) Colour (*ii*) Turbidity

(*iii*) Temperature (*iv*) Suspended solids

(*v*) Foam (*vi*) Radio-activity.

– Colour though not necessarily harmful, is obviously undesirable in drinking water.

– Turbidity is primarily caused by either colloidal or very finely divided suspended matter which settles slowly and with difficulty. Turbidity caused by the hydrous oxides of Fe and Mn is quite objectionable in domestic water and may require special treatment for removal.

– Temperature increase (due to the use of water as cooling media in power generation) has only recently been considered as a water pollutant.

– Suspended materials may go in water from erosion processes or by various waste discharges.

– The resultant foam produced in many waters from detergents manufacturing industries may be objectionable from an aesthetic stand point.

(C) Physiological

– Undersirable taste and odor present in water used for drinking or food processing is objectionable to the consumer.

– Taste and odor of water can easily change if chlorophenols or H_2S is present in it, even in very small quantities.

(D) Biological

– It is most important of all water pollution problem. In fact, the single most important process in the water treatment plant is disinfection, which helps insure the absence of pathogenic organisms in the drinking water.

– Biological pollutants cause bacterial bone diseases, amoebic dysentery, cholera etc.

(E) Radioactive

– Radioactive pollution is the discharge of a radioactive waste material into a receiving body.

Sources of Water Pollution

Water, after being used for the following purposes, when drained out in a bigger and clean source of water, creates pollution problems over there

(*i*) Domestic life
(*ii*) Industry
(*iii*) Agriculture
(*iv*) Wild life watering
(*v*) Propagation of fish and other aquatic life
(*vi*) Swimming and bathing pools
(*vii*) Boating ponds/lakes
(*viii*) Water power generation
(*ix*) Transport etc.

Measurement of Water Pollution

- Waste water sampling and flow data are the two most important factors of any water pollution control program.
- Proper selection of sampling points assures samples that will yield representative and reliable data.
- Samples of water may be taken at plant outfalls, branch streams to main drain etc.
- Once the drain discharge and sample points have been established it is necessary to determine the type of sample to be collected at each point.

Samples are either *grab* or *composite*

A grab sample is a single sample, while the composite is one composed of a series of samples collected over a period of time and blended for analysis.

- Waste water streams can be continuously and automatically monitored and analyzed by reliable on-stream effluent monitoring equipment.
- A wide variety of instrumental methods for the chemical analysis of water constituents exist such as
  (*i*) Atomic Absorption Spectrophotometry
  (*ii*) Infrared Absorption Spectrophotometry
  (*iii*) Electrochemical Analysis
  (*iv*) Chemical Spectrophotometry
  (*v*) Molecular Absorption Spectrophotometry.

Control of water pollution

- In order to maintain satisfactory water quality, effluents containing excessive amounts of objectionable materials must be treated to remove the offensive matter prior to the discharge of the effluent into a receiving water.
- In order to define the various processes available for water pollution control, it is necessary to categorically describe the process in generalized terms. The various phases of waste treatment are usually described as follows:-
  (*i*) Pretreatment
  (*ii*) Primary treatment
  (*iii*) Secondary treatment
  (*iv*) Tertiary treatment.

(i) Pretreatment

- It includes processes to remove larger aggregates of floating and suspended solid matter, grit and also much of the oil and grease content.
- It may also include flow measurement and sometimes prechlorination to prevent odors from emanating from the subsequent processes.
- The most common methods of removing large solid particles are passing the waste effluent

through screens consisting of spaced metal bars or using comminutors to grind the solids into small pieces which subsequently settle out in the primary sedimentation tanks.

(ii) primary treatment

- It consists of the pretreatment processes plus tank sedimentation and usually chlorination prior to discharge into a receiving water.
- A primary treatment plant will often include the sludge digester, in which the solids removed from the sedimentation tank are subjected to anaerobic fermentation *i.e.*, stabilisation in the absence of free oxygen.

(iii) Secondary treatment

- It is a biological process following primary treatment.
- The most common biological process in use today is probably either the activated sludge process or an aerated lagoon.
- Activated sludge process consists of maintaining an active floc in a tank well supplied with oxygen in such a way that maximum contact is made between the incoming waste water and the organisms in the floc.
- Another secondary treatment process is *Trickling Filteration*. This process is identical to activated sludge process, except that the micro organisms working to stabilize the organic waste material are attached to a fixed bed rather than being of a floating and suspended nature. The waste water is distributed from rotary nozzles over the bed which gives support to the biological film. The material in the waste is oxidized after assimilation by the bacteria, and then released in a more stable form.

(iv) Tertiary treatment

- If the effluent from a secondary treatment plant is not considered satisfactory, tertiary treatment may be required.
- Tertiary treatment may consist of many different processes including

Coagulation	Membrane separation processes
Filtration	Adsorption etc.
Coprecipitation	

- *Coagulation* may be defined operationally as the reactions that take place upon the addition of a coagulant (*e.g.*, inorganic metal salts* and organic polymers) to water and result in the formation of insoluble products of reaction between the coagulant and the impurity to be removed.
- *Membranes* have been used to concentrate and separate soluble ions and molecules, colloidal species, particulates and micro organisms in waste water. The capabilities of membranes to exclude species by virtue of their size (dialysis and membrane filtration) and to adsorb or exclude due to specific chemical interactions (ion exchange and osmosis) have been utilized.
- In *Coprecipitation* an ion is removed from the solution phase with a precipitate (carrier), even though its solubility is not exceeded. The two principal mechanisms for this process are *Adsorption*, in which the ion coprecipitating is adsorbed onto the surface of the primary precipitate ; and *occlusion*, in which the ion is found in the interior of the primary precipitate, this category includes both solid solution formation and ion entrapment.
- The most common type of water treatment, except disinfection, is *filtration*. This was almost the only form of treatment practised prior to the advent of chlorination.

* e.g. aluminium Sulphate, Sodium aluminate etc.

Today, almost all water supplies are filtered as an integral part of the purification process. Filtration should be done after coagulation as most of the filters will not remove colloidal impurities by themselves.

Filters amay be made up of sand, anthracite coal or diatomaceous earth.

33.7. SOLID WASTE MANAGEMENT

Introduction

Solid waste management can be divided into two major areas

(*i*) *Collection* including storage, transfer and transport, and

(*ii*) *disposal*, including any accompanying treatment.

The *collection* operation can be sub-divided into two unit operations, *collection* and *haul*. The *collection* operation consists of removing solid waste from the storage point. The *haul* operation includes the total round trip travel time (for the vehicle) from the collection route to the (waste) disposal site.

Three alternatives are normally considered for solid waste disposal

(1) Direct shipment from municipalities to a sanitary landfill.

(2) Direct shipment from municipalities to a transfer station where solid waste is transferred to larger vehicles and then shipped for ultimate disposal.

(3) Direct shipment from municipalities to an incinerator where the solid waste is burned and the residue is shipped for ultimate disposal.

Solid waste management planning requires an assessment of many complex interactions among transportation systems, land use patterns, urban growth and development, and public health considerations.

Waste handling methods

The physical nature of a waste may determine its handling characteristics. The following are common handling methods:——

(*i*) Solids,semi-solids, some wet materials, sticky, or tarry substances may be handled by front-end loaders or buckets.

(*ii*) Viscous liquids may be pumped by special pumps.

(*iii*) Liquids are handled by normal pumping equipment.

(*iv*) Packages may be handled in cartons, and

(*v*) Some materials are handled in fiber-pack drums.

Solid waste shredders

— Such machines can convert rubbish into a form more easily and economically handled for processing. Hammer mills in one adaptation or another, are the most commonly used size reduction machines.

Compactors

Such machines can compact refuse. Hydraulic or pneumatic cylinders exert forces as high as 50 tons and reduce the original volume of refuse by 60 to 80%.

Incineration equipment

Solid and chemical wastes are often disposed of with the help of incinerators. Incinerators can be classified on the basis of burner chamber or fuel bed.

Common practices for solid waste disposal

— In most solid waste disposal methods, the main aim is to treat the refuse in such a way as to render it safe and sterile so that upon returning it to the environment, it will not pollute the air, water or land.

– There are presently only three disposal methods which are practical for most industrial applications:–

(1) *Haulaway loose.* Waste is removed from plant for disposal by means such as landfill, incineration etc. Hauling away means exporting the refuse as loose material.

(2) *Haulaway Compacted.* If the amount of refuse is large, refuse is compacted and then disposed off. It is a very popular waste disposal method for industrial installations.

(3) *On site incineration* is generally accepted as a good method for disposing of solid wastes. Industrial waste is burned efficiently and economically without polluting the air.

Solid Waste Salvage and Recovery

Many experts feel that the only lasting solution for the solid waste disposal problem lies in recycling and reuse of wastes (Fig. 33.3).

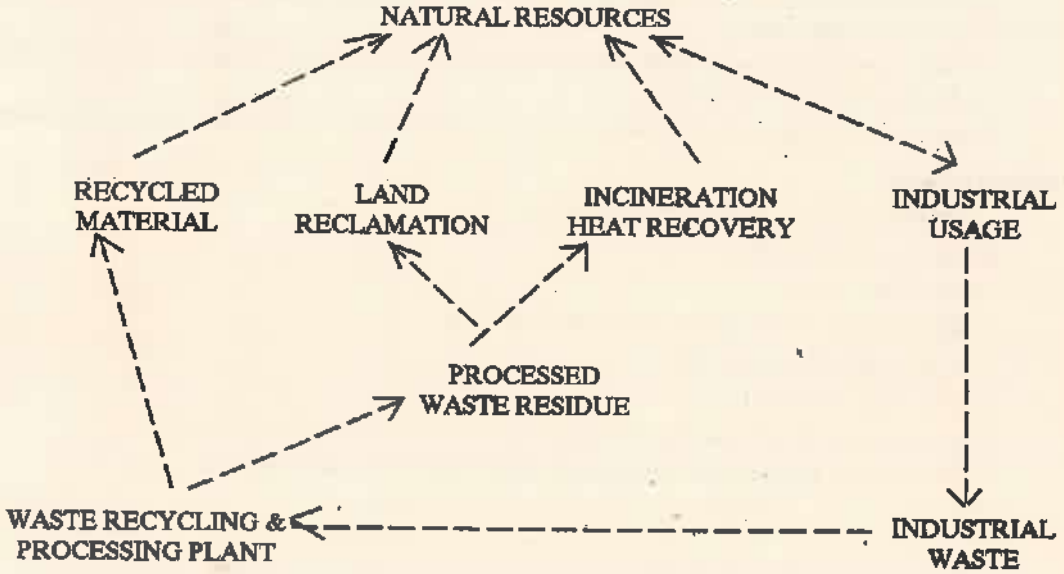


Fig. 33.3. Recycling industrial waste.

Waste processing has the following advantages:–

(*i*) Added revenue

(*ii*) Less waste to be disposed of.

(*iii*) Less transportation costs of waste.

(*iv*) Processed residue waste is put into a form which makes it suitable for land reclamation.

– *Steps involved in salvaging and recovery*

(*i*) Receiving the raw industrial waste and conveying it to a salvage-separation area.

(*ii*) Separating the salvageable materials from waste materials to be further processed.

Ferrous and nonferrous materials can be separated using magnets, cardboard and paper products can also be removed and placed onto the paper salvage conveyor for entry into the paper processing system

(*iii*) Unsalvaged waste residue is conveyed to the main pulverizer unit,

(*iv*) Compaction system is employed to compact the pulverized residue for disposal.

33.8. NOISE AND ITS CONTROL

Introduction

- Noise may be defined as *unwanted sound.*
- Sound is caused by any disturbance in the air. Sound travels in air at a speed of approximately 350 m per second. When the pressure waves meet human ear they cause a sensation which we also call sound.
- Noise is a form of air pollution and like other forms of pollution, it affects the quality of life and so can be thought of as a social cost.
- The noise producers bear only a part of this cost and for them this is outweighed easily by the benefit they get from their industry.

The major part of this burden falls upon people who live around or are present there and they are not directly party to any benefits.

- Noise annoys, distracts, disturbs and when exposure to it is sufficient, noise can cause physiological effect leading to deafness.

Noise causes disturbance with consequent reduction in productivity, efficiency, accuracy and safety.

Sources of Noise

- Sources of noise may be classified as follows:–

(*i*) *Outdoor sources* such as

road traffic noise

noise around airports [peak level over 110 dB(A)]

construction site noise, and

noise from industries.

(*ii*) *Indoor source* implies noise from within the factory and other places of work.

- Given below are the noise levels produced from different sources of noise.

Noise	dB(A) (Decibel)
Large jet airliner	140
Riveting on steel plate	130
Train on steel bridge	110
Weaving shed	100
Heavy road traffic	85
Light road traffic	55

Noise Control

(*a*) *Method of measuring noise level*

Sound level meters are placed around the source to measure the noise level from different noise sources.

(*b*) *Approach*

- Once the noise has been established in the air, there is almost no way in which it can be controlled by means of a power driven device or an electrical *noise level controller.*
- Noise control can be achieved mainly by planning and forethought.
- As long as there is some method of controlling the noise, the method of approach can be analysed into

(*i*) Control (of noise) at the source.
(*ii*) Control along the path of sound between the source and receiver (listener or victim) and
(*iii*) at the receiver.

Noise Control at the source

- The control of noise at the source is usually the cheapest and most reliable method of noise control.
- Noise from a particular source can often be reduced by means of an *enclosure. Sound absorbing material* should be included within the enclosure.
- To control noise, the impacting parts of the machines should be enclosed.
- All rotating or impacting machines should be based on antivibration mountings.
- All rigid connections of the machine in the way of electricity, water, air, gas, etc., should have vibration decouplers around the machine.
- Internal combustion engines should be properly silenced.

Noise control along path of sound.

- Once the sound has left its source, it must travel some distance before reaching the place at which the noise nuisance will occur. Common paths for noise are airborne paths such as ducts and corridors and it is usual to include here walls that break up airborne sound paths.
- When a noise source is directly coupled to conducting paths such as pipes or air ducts, these paths can carry sound energy. To control noise along the path, one need to consider how sound is transmitted through ducts, corridors, directly through walls and along pipes and through the structure of buildings. In such cases contacting the manufacturers of fans and ducting system can be of much help. However, the following points may also be kept in mind.

(*i*) An effective method of increasing the sound insulation of a wall is to construct the wall of a number of separate layers.

(*ii*) Sound absorbing material has a definite role to play in improving sound transmission loss of a panel.

- To control noise along the path in a factory the following, may be employed :

(*i*) *Noise barriers*, which involve frequency dependent diffraction effects which depend on the size and geometry of the barrier. Noise barriers do not eliminate sound energy, but merely reflect and/or diffract it somewhere else.

(*ii*) *Enclosures* having inside lined with sound absorbing material such as fibre glass.

(*iii*) *Noise refuges* which are nearby rooms where the factory produced noise level does not exceed 85 dB (A). Employees can use these rooms for off-time activities, paperwork etc.

(*iv*) *Noise screens* limit the spread of noise and provide quiet area at places of sedentary work. Noise screens are used where noise refuges cannot be provided such as in large areas where many processes are occurring.

Noise control at the receiver

- Noise reaches the people and the delicate instruments. The noise level therefore is controlled by treating the area within which the receiver is located. For this, one has to study the acoustics of the situation.
- The use of sound absorbers is very effective. Soft furnishings, carpets, human beings, windows, resonant panels and so on all contribute to the sound absorption and so does the air within the room.

34

Management By Objectives (MBO)

34.1. DEFINITION & CONCEPT

- Many approaches have been utilized to integrate individual and group goals with overall goals of the organisation of an enterprise.
- Management by objectives is basically :

A process whereby the superior and subordinate managers of an *enterprise* jointly,

(*i*) identify its common goals,

(*ii*) define each individual's major areas of responsibility in terms of results expected of him, and

(*iii*) use these measures as guides for operating the unit (or enterprise) and assessing the contribution of each of its members.

- The goals are jointly established by the manager and his subordinates and agreed upon in advance.

  These goals emphasize either output variables or intervening variables, or some combination of both.
- At the end of the predecided time period, the subordinate's performance is reviewed in relation to present goals. Both superior and the subordinate participate in this review/evaluation.

If, after evaluation, it is found that there is some discrepancy between the work planned (to be done) and the work accomplished, steps are suggested to overcome the problems or to make necessary adjustments in the original plan. This sets the stage for the determination of objectives for the next time period.

- To conclude, MBO implies managing by properly identifying the objectives of an organisation.

34.2. OBJECTIVES

- An objective is an intended goal which prescribes definite scope and suggest direction to efforts of a Manager.

Need for

Management is the art of getting things done through people. In a competitive economy, things will not get done well unless every one concerned in an enterprise knows what the objectives and targets are and accepts them as being worth attaining.

Requirements of

- Objectives, whether those of individuals or those of the organisation must

  (*i*) Work in the same direction towards achieving company goals.

  (*ii*) Be clearly defined and communicated to all.

  (*iii*) Be such that they can be reasonably attained.

  (*iv*) Be reviewed after definite time period for adjustments if necessary.

Nature of

– Objectives may be

(*i*) Short term, *e.g.,* expediting the works lagging behind the schedule.
(*ii*) Long term, *e.g.,* planning for diversification.
(*iii*) Specific, *e.g.,* decision of pricing policies.
(*iv*) General, *e.g.,* profit objective, objective of increasing productivity.

Types of

– There are three basic types of objectives :

1. Broad objectives.
2. Major objectives.
3. Lesser objectives.

1. *Broad or corporate objective* is a wordy statement of the standing the company wishes to achieve.

For example :

(*i*) To supply to public with the best of modern utility services at reasonable rates;

(*ii*)To manufacture high quality products and to strive to make them better at lower costs, etc.

2. *Major objectives* are distilled from *Broad* objectives and set the tactical areas into which company wishes to move.

Major objectives include market shares, product plans and plans to expand the customer population.

3. *Lesser objectives* are targets, budgets and departmental objectives, including those governing the performance standards of managers and the other members of the staff.

34.3. STEPS IN SETTING UP MBO

– Fig. 34.1 shows different steps in setting up MBO.

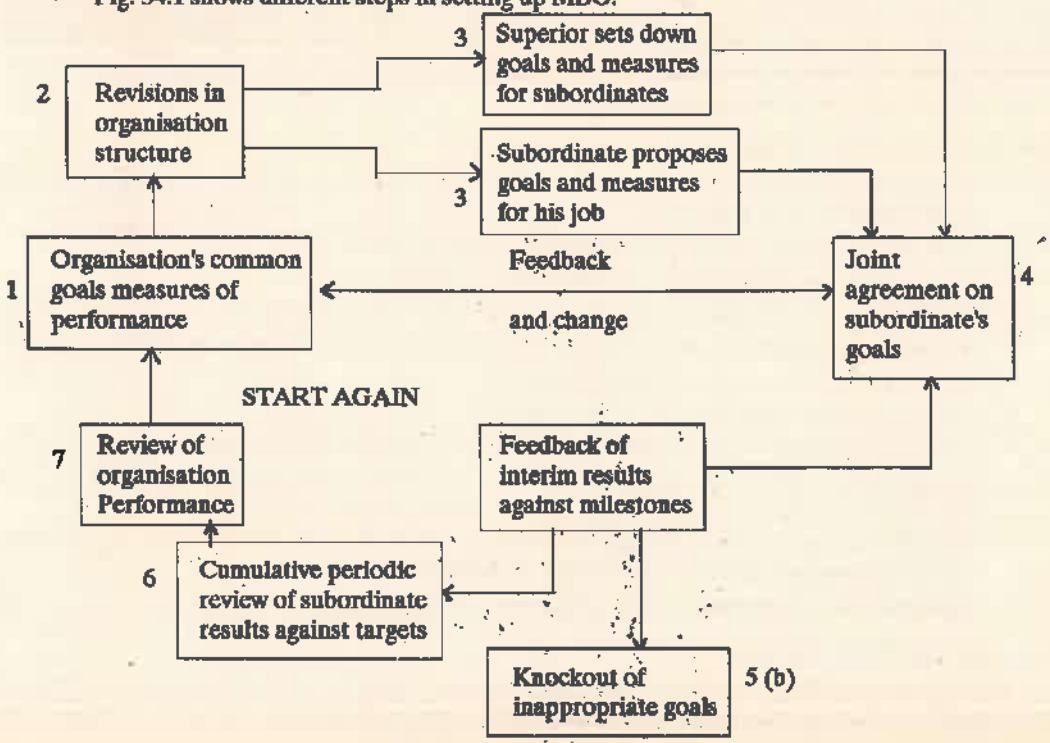


Fig. 34.1. Steps of the cycle of MBO.

(1) The first step is to clarify and set the common goals of the entire-organisation.

(2) To achieve the goals of the organization, any appropriate changes in the organization structure may be made; changes in titles, duties, relationships, authority, responsibility, span of control, and so forth.

(3) Superior sets down goals for his subordinates; subordinates also propose goals for their jobs and select the areas in which they must be effective during the period of Company plan.

Usually there are five or six vital areas where the subordinates concerned must think to obtain the desired results. These results may be a straight drive to

Some targets of growth,

Achievement of greater efficiency, productivity or profitability,

Elimination of certain problems etc.

(4) Superior and subordinates sit together, discuss the objectives and reach on joint agreement on a subordinate's goals to be achieved by him during a stated time period. In other words, the goals are jointly established and agreed upon in advance.

(5) Throughout the time period what is to be accomplished should be compared with what is being accomplished; necessary adjustments should be made and inappropriate goals or unattainable goals should be discarded so that resources are not unnecessarily wasted.

(6) The performance of all subordinates against their MBO plan (or targets) must be formally reviewed at predetermined times during the plan.

Usually a major review is made annually but it is advisable for quarterly reviews to be undertaken. In the latter, attention is given to the areas where progress has been slow or where some unforeseen bottlenecks have occurred. These may be due to poor performance of some other subordinate's MBO achievements.

(7) Ultimately the performance of the entire organization should be reviewed with respect to the objectives set at the start. If there is a discrepancy between the objectives decided and those achieved, efforts should be initiated to determine the steps to be taken to overcome the problems responsible for the discrepancy. This sets the stage for the determination of objectives for the next time period and the entire cycle of MBO is started again from step 1.

34.4. ADVANTAGES OF MBO

- Management by objectives may become a powerful tool in gaining mutual commitment and high productivity for an organization.
- MBO keeps company objectives/targets constantly in view.
- It gives meaning and direction to people in an organization.
- It coordinates the efforts of various departments of an organization.
- It provides motivation to people because they work on objectives decided with their consent.
- It prevents flittering away of efforts and money.
- It allows greater consistency in decision making.
- It forces management to think ahead in respect of its short term and long-term goals.
- It helps an enterprise to focus on the areas where it is vital that management should be effective and isolate the problems preventing progress towards company objectives.
- It assists managers in their own self development and leads to an analysis of training requirements if subordinates are to improve their performance in future years.
- MBO leads to a better understanding between superiors and the subordinates.

34.5. LIMITATIONS OF MBO

Management working by objectives may follow too rigid a pattern in thinking and action. There is always need for flexibility in management thinking and the provisions of written objectives should not be allowed to affect this adversely.

35

Engineering Economics

35.1. DEFINITION AND CONCEPT

– Economics is a study of men as they live and move and think in the ordinary business of life. But it concerns itself chiefly with those motives which affect, most powerfully and most steadily, man's conduct in the business part of his life.

Economics examines that part of individual and social action which is most closely connected with the attainment and with the use of the material requisites of wellbeing.

– Economics is a the study of economic problems of the people living in a community.

– Economics is that Art and Science which studies those activities of social, real and normal human beings, which are related to wealth.

– Economics deals with what everyone is doing every day in ordinary life, that is, getting a living. It is a human study, a branch of social sciences, a study of business activities with the emphasis on their social aspect. It is concerned with the organisation of society for the *production and distribution of wealth.*

– Economics is the science which studies human behaviour as a relationship between *ends* and *scarce means* which have alternative uses. *Ends* imply *objectives* or *wants* of a man. Thus the definition becomes – – Economics is the science which studies human behaviour which aims at meeting maximum objectives of an individual with the help of scarce means i.e., limited means (or resources).

35.2. IMPORTANCE OF ECONOMICS FOR ENGINEERS

– Engineers have a special interest in economics. They are engaged in

(*i*) improving and increasing production,

(*ii*) reducing human effort and in increasing wealth, and in

(*iii*) making the world a more comfortable place to live in.

– Economics enjoys a very important place in all engineering decisions. Many of the decisions which have to be taken concern costs quite as much as performances and items such as interest, depreciation and profits.

– Economics plays a major role in Industrial Engineering, starting from the selection of an adequate plant site to production planning and control, to replacement analysis and to wage structure of the workers.

35.3. WEALTH

– Wealth implies desirable things, that is, things which satisfy human wants directly or indirectly.

– Desirable things may be represented by the term *Goods*.

– All goods which satisfy human wants are not necessarily wealth, as they may be unlimited in quantity or may not be transferable *e.g.,* air and rain, but water stored in a dam is wealth.

Shares, copyrights etc., constitute wealth just as much as buildings, machinery and tools.

– Wealth has got exchange value. In other words, wealth consists of all those commodities which

are exchangeable. A thing is wealth because man wants it.

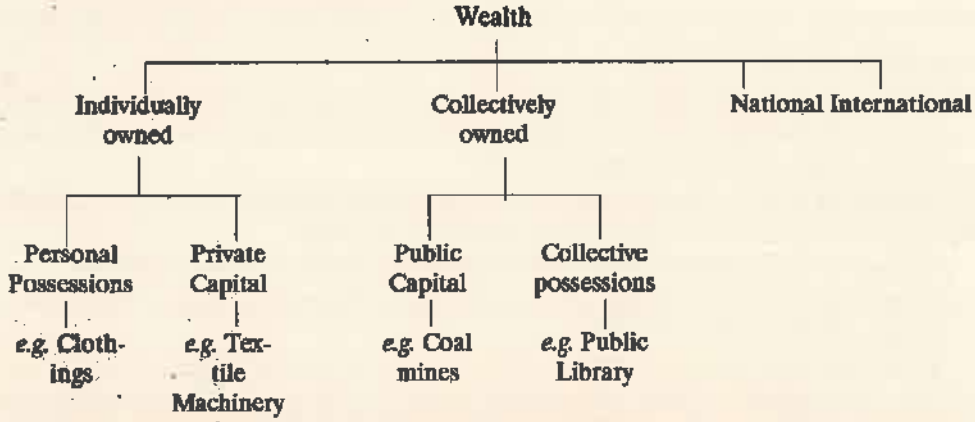
– A thing known as wealth must possess the following *qualities:*

(1) *Utility i.e.,* it can satisfy some human want.

(2) *Scarcity i.e.,* it is scarce in relation to demand.

(3) *Transferability i.e.,* it is transferable from one man to another.

– *Wealth* may be *classified* as follows:



– *Personal* or *private wealth* is that wealth which belongs to a certain person.

– *Collectively owned wealth* is one owned by Municipal Boards or Provincial and Central Government such as coal mines, harbours, public buildings etc.

– *National wealth* includes collective wealth of the Nation, mineral resources etc.

– *International wealth* includes wealth belonging to all the world nations, oceans, inventions etc.

35.4. GOODS

– They may be defined as anything (material or non-material) which can satisfy human wants.

– *Material goods* consist of useful material things (and of all rights to hold, or use, or drive benefits from material things, or to receive them at a future time).

Material goods include:

(*i*) Gifts of nature, land, water, air and climate.

(*ii*) Products of agriculture, mining and fishing.

(*iii*) Buildings, machinery and implements.

(*iv*) Mortgages, other bonds and shares of companies.

(*v*) Patents, copyrights and many more things.

– *Non-material goods* fall into following categories:

(*i*) The first consists of one's own qualities and faculties for action and for enjoyment; such as muscular strength ; business ability, professional skill etc. All these goods lie within the individual and are called *internal.*

(*ii*) The second category known as *external,* consists of relations (beneficial to a man) with other people. For example, goodwill and business connections of traders.

– Goods may further be *classified* as

(*a*) *Transferable e.g.,* land or building of an individual which can be transferred to another person.

(*b*) *Non-transferable e.g.,* a person's qualities.

– *Free goods* are those which are not appropriated and are afforded by Nature without requiring the effort of man *e.g.,* air.

Free goods do not bear a price, in distinction to *Economic goods* which are scarce and do bear a price.

35.5. WANTS

Concept

– Human wants and desires are countless in number and very various in kind : but they are generally limited and capable of being satisfied.

– Want is that desire which can be fulfilled and which is backed by the ability and willingness to fulfill (or satisfy) it.

Sources of want. Want springs from the

1. Desire for the minimum of goods that are necessary for existence, for example, desire for food, clothes etc.

2. Desire to maintain the standard of living, for example, serving rich food to guests.

3. Desire for distinction and excellence, for example, wearing costly jewellery.

4. Aesthatic motives.

Characteristics of wants

(*i*) Wants in general are unlimited.

(*ii*) Each particular want is capable of being satisfied.

(*iii*) Wants vary in urgency and in intensity *i.e.*, for an individual, some wants are more important than the other wants.

(*iv*) Wants are recurrent *i.e.,* a want may be felt again after some time.

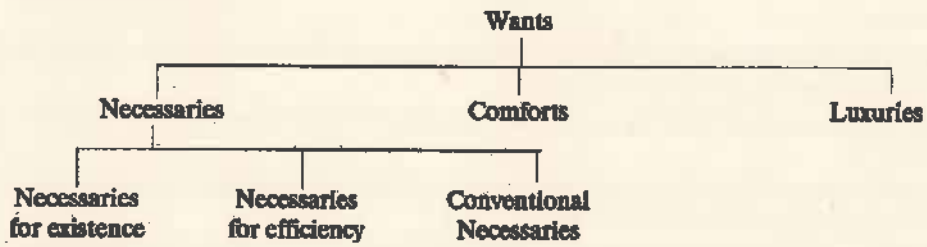
(*v*) Some of the wants are complementary to each other.

(*vi*) Present wants appear more important than the future wants.

(*vii*) Knowledge increases wants. A person being in a big city has more wants than a villager.

(*viii*) Wants are determined by social standards or tastes.

Classification of wants



Necessaries:

– They are wants of primary importance.

– Food, clothing and shelter are *necessaries for existence* and without them life cannot be preserved.

– Balanced diet, education, medical facilities *e.g.,* are *necessaries for efficiency* and are necessary for maintaining the efficiency of an individual.

– Offering tea and biscuits to guests is one of the *conventional necessaries* which are consumed for

maintaining social convention and prestige in society.

Comforts

- Comforts are those wants which add to the comfort, efficiency and pleasure of an individual *e.g.,* air--conditioned offices, well decorated houses etc.

Luxuries

- Luxury is a superfluous want, which if satisfied gives great pleasure, but if not satisfied, it does not cause pain or inefficiency. Many important items *e.g.,* costly cars, cosmetics etc. may be classified as luxuries.

35.6. VALUE AND PRICE

Value

- The notion of *value* is intimately connected with that of *wealth*. The word value has two different meanings : value sometimes expresses,
  - (*i*) the *utility* of some particular object,
  - (*ii*) the power of purchasing other goods,
- The value, that is the *exchange value*, of one thing in terms of another at any place and time, is the amount of that second thing which can be got there and then in exchange for the first.

Thus the term, value is relative and expresses the relation between two things at a particular place and time.

Price

- Instead of expressing the values of lead, tin, wood and other things in terms of one another, we express them in terms of *money* in the first instance ; and call the *value* of each thing thus expressed its *price*. In other words, value expressed in terms of money is called *price*. For example, the *price* of 1 Kg. of rice is Rs. 20. In actual life, all transactions are usually conducted in terms of money.
- The price of everything rises and falls from time to time and place to place ; and with every such change the purchasing power of money changes so far as that thing goes.
- Price of anything will be taken as representative of its exchange value relatively to things in general or in other words as representative of its general purchasing power.

35.7. CAPITAL

- *Capital* may be *defined* as wealth which is used for the purpose of producing further wealth. While all capital is wealth, not all wealth is capital.
- Capital may also be defined as that part of one's stock from which one expects to derive an income.
- Capital is a factor of production, and the extent of a country's stock of it is an important influence on that country's volume of production.
- From an economist's approach, capital is considered as a stock of producer's goods used to assist in the production of other goods.
- Two requirements of capital are
  - (*i*) the capital goods should be articles of wealth, and
  - (*ii*) they should be used for further production of wealth.
- Rs. 10,000 possessed by a man and then invested in business are known as his capital, but the same amount kept in cash box is not capital.

Types of Capital

(*i*) *Fixed capital* is of permanent nature and is used in production again and again *e.g.,* that used in the form of building and machinery.

(*ii*) *Circulating Capital* renders service to production only once *e.g.,* that used to purchase bricks to make factory building.

(*iii*) *Production Capital* includes raw material, tools, equipment etc.

(*iv*) *Consumption Capital* consists of goods which provide direct substenance to workers such as food, clothes, housing facilities etc.

(*v*) *Sunk Capital*

Sunk capital is one which can be used only for a particular process and cannot be withdrawn from the investment without loss *e.g.,* capital in making a railway bridge.

(*vi*) *Floating capital*

Floating capital is one which can be transferred from one productive use to another, *e.g.,* money.

(*vii*) *Material Capital*

Material capital includes goods (*e.g.,* raw material) which are used in production and can be purchased and sold.

(*viii*) *Personal Capital*

Personal capital is skill, efficiency and ability of an individual(*e.g.,* of a doctor or an engineer).

(*ix*) *Remuneratory and Auxiliary Capital*

- Remuneratory Capital consists of wealth devoted to the payment of wages of the workers.
- Auxiliary Capital aids labour in production *e.g.* raw material, machinery, tools etc.

35.8. MONEY

Definition

- Money is anything which has general acceptability and passes freely from hand to hand as a medium of exchange and is generally received in final discharge of debts.
- Money is a form of the medium of exchange –– metallic coins, currency notes, cheques etc.

Functions of Money

- Money is the link between production and consumption. The producer of goods exchanges them for money and then exchanges the money for other goods he desires.
- Money is essentially a *medium of exchange*, a debt settling mechanism, as well as a unit of account, that is, a unit for the purpose of calculating exchange values as a metre is a unit for calculating linear values.
- Money be also regarded as a *store of value* in as much as the holder of money does not necessarily wish to exchange it for goods at once. Money can be stored much more conveniently (*e.g.,* by depositing in a bank) and safely as compared to other goods.
- Since value of goods can be expressed in terms of money, it becomes automatically a basis for the measurement and comparison of the values of all goods and services. This facilitates the exchange of goods. Thus money becomes a *measure of value.*
- Money acts as a *standard of deferred payments*. Loans are usually made in money and not in tobacco or any other commodity. Since this is the case, it would be a little odd if repayments were made otherwise than in money. It is also always convenient for debts to be measured in terms of what is usually a stable store of value *i.e.,* money.

Qualities of a good money

A good money should possess the following qualities:

1. *General acceptability or utility e.g.,* gold and silver besides their monetary uses are in great demand for their use in ornaments also.

2. *Durability.* Good money should not deteriorate easily either in itself or as a result of wear and tear.

3. *Portability.* A good money is easily portable. It possesses high value in small bulk.

4. *Homogeneity.* All portions of the material used as money should have same quality so that equal weights have exactly equal value.

5. *Malleability.* The material used for making coins should be capable of being stamped with intricate designs.

6. *Stability of value.* Money material should have a stable value over a considerable period of time.

Kinds of Money

Money may be classified in the following manner :

1. *Legal tender* is that money the use of which is authorized by law.

2. *Limited legal tender* is the money which is tendered in settlement of debts only upto a limited extent *e.g.,* fifty, twenty five and ten paise coins are limited legal tender upto Re. one only.

3. *Full legal tender* money may be offered in settlement of debts of any amount. Rupee and Reserve Bank notes are unlimited legal tender.

4. *Intrinsic value money* is one whose face or legal value is equal to its metallic or commodity value (one time — Gold sovereigns).

5. *Token money* is one in which the face value exceeds the commodity value *e.g.,* copper coins and paper money.

6. *Standard money* is one which is used as the unit of account.

7. *Convertible money* is the token money that may be exchanged for intrinsic value money.

8. *Metallic money* is the money in the form of metal coins and it has some value independent of its monetary value. Earlier silver and gold were used for making metallic money, but now cheaper metals are being employed for the purpose.

Coins are metal pieces which have weight and fineness certified by the integrity of designs impressed upon the surface of metal. The art and practice of making coins is known as coinage.

Coinage may be *free* or *limited.*

If mints are open to the public who may take the metal to the mint and get it converted into coins, the system is known as *free coinage.*

If nobody except the Government is allowed to take metal to the mint and get it converted into coins, the system is called the *limited coinage.*

Paper money is the one printed on paper and has no intrinsic value. Paper money is the money which is very much in use today.

Paper money is simple, convenient and economical for making exchanges and discharging obligation on an extensive scale. The term paper money refers to Government or Central Bank notes which pass freely from hand to hand. Currency notes were previouly issued by the government of India but now it is done so by the Reserve Bank of India.

Convertible paper money consists of paper notes which carry a promise of the issuing authority for conversion into standard metallic money of the land on presentation by the holder.

Inconvertible paper money is one for which standard metallic money cannot be obtained on demand

from the issuing authority. For such money there is no backing of silver and gold. The Re. 1 note at present in India is an example of inconvertible paper money.

Advantages of paper money

1. It is light and handy.

2. It is more economical to manufacture than metallic money.

3. Paper money reduces the loss to the community which otherwise occurs due to wear and tear of metallic money.

Disadvantages of paper money

1. The temptation to over-issue is too much with a government in difficulty.

2. The value of inconvertible paper money is generally unstable.

3. Since some countries do not accept the paper money of other countries, there comes difficulty in foregin trade.

Monetary Standards

- Monetary standards refer to the material (*i.e.* paper or metals) of which the money is made
- Monetary standard of a country has vital effects on its economy.
- Various monetary standards are :



(b) Bi-metallism-Gold and silver standards.

(c) Paper standard

(*a*) In **Mono-metallism** standard coins of only one metal either gold or silver are made and circulated. Between 1835 and 1893, India had a silver standard.

- The *gold standard* makes use of gold coins only for free coinage and being unlimited legal tender. The value of the monetary unit is kept equal to the value of a given quantity of gold. Various gold standards are :-

(i) Gold currency standard. Under the system the gold coins are put into actual circulation and currency notes are convertible into these gold coins.

It is a very expensive system.

(ii) Gold bullion standard. In this system, gold coins are not circulated rather they can be had in exchange of currency notes. This saves coining gold and the resultant loss due to wear and tear.

(iii) Gold exchange standard. This system is still more economical, because gold coins and bullion are not availabe for transactions withing the country. They are given only for the purpose of foreign exchange.

(*b*) **Bi-metallism**

- In bi-metallism standard, two metals usually gold and silver are used for the coinage and coins of both the metals are circulated. The coins of one metal are convertible into the coins of another metal at a fixed rate.
- In bi-metallism, when both the metals are full legal tender, and one (usually silver) is not freely minted, the system is known as **Limping Standard.**

(*c*) **Paper standard**

- Paper standard involves the production and circulation of paper money (*e.g.* currency notes).

This system is common in almost all countries.

Value of Money

Concept

- *Value of money implies what money can buy.* In other words, by value of money one means the amount of goods and services which one unit of money can purchase.
- Thus, value of money is measurable in terms of general goods and services.
- The value of money is said to have fallen, when with one unit of money you purchase less amount/ quantity of goods than you could buy earlier.

Quantity Theory of Money

- In the seventeenth century it was noticed that there was a connection between the quantity of money and the general level of prices and this led to the formation of the Quantity Theory of Money.
- In its crudest form, the theory stated that an increase in the quantity of money would bring about a proportionate rise in prices.
- The Quantity Theory as modified by Irving Fisher came to be expressed by the equation of exchange

$$MV = PT \qquad \text{...(i)}$$

where M represents the total amount of money in existence, Bank notes etc., and bank deposits.

V represents the velocity of circulation. Velocity of circulation means the average number of times each unit of money is used during a period. Therefore, MV represents the amount of money used in a period.

P represents general price level, a sort of average of the prices of all kinds of commodities, producers goods as well as consumers' goods-and services.

T is the total volume of trade in goods and services.

Equation (i) above explains that the price level (P) and therefore the value of money, can be influenced not only by the quantity of money (M) but also by (a) the rate at which money circulates (V) and (b) the output of goods and services (T).

Thus, price (P) might rise without any change taking place in the quantity of money(M) if a rise occurred in the velocity of circulation. On the other hand, prices might remain stable in spite of an increase in the quantity of money (M) if there was a corresponding increase in the output of goods and services (T).

Index Numbers

- Index numbers of prices are used to measure changes in the value of money.
- A number of these indices have been compiled, but the main principle in all cases is the same: a group of commodities is selected, their prices noted in some particular year which becomes the base year for the index number and to which the number 100 is given.

If the prices of these commodities rise by 1% during the ensuring twelve months, the index number next year will be 101. A fall in price of 1% would be shown by an index number of 99.

So many indices have been compiled, one of the best known index number is *cost-of-living index.*

- *Cost of living index numbers* indicate through their movement whether real wages are rising or falling, money wages remaining the same. They may assist in granting extra allowance to employees to meet the increased cost of living.
- Other indices are

1. Trade indices measure the change in the general economic activity of a country and give an approximate idea of the fluctuations in the real national income of the country.

2. Indices of Investment are of great value to those interested in the stock market.

3. Wholesale Price Index Numbers.

Appreciation and Depreciation in the value of money

- A *rise* in the value of money is called *appreciation.*
- A *fall* in the value of money is called *depreciation.*

Inflation of Currency

- Inflation is usually applied to a stage of over-issue of currency consisting mostly of inconvertible paper money and debased metallic coins, brought about deliberately by a Government in order to stem the period of financial stringency.
- Inflation results in depreciation and a rise in the general level of prices.
- During inflation, the value of money declines. Inflation describes an unstable situation.
- Inflation is present when the volume of purchasing power is *persistently* running *ahead* of the output of goods and services, so that there is a continuous tendency for prices to rise because the supply of goods and factors of production fail to keep pace with the demand for them.

Demand inflation is an inflation which is mainly induced by excessive demand when supply constantly fails to keep up with demand.

Cost inflation is an inflation which is mainly induced by rising costs of production, particularly rising wages.

Demand inflation and cost inflation are types of *persistent inflation.*

Hyperinflation

The danger in persistent inflation is that it may become a hyperinflation when not in contol. In such cases value of money declines rapidly. Sooner or later currency ceases to be acceptable and transactions take place either in a foreign currency or in terms of some commodity.

Deflation

- Deflation is just opposite to inflation.
- Deflation is present when the volume of purchasing power or supply of money runs *behind* the output of goods and services and there is a tendency for the prices to fall. This results in a rise in the value of money.

Gresham's Law

- This law is after the name of Sir Thomas Gresham, Elizabeth I's finance minister, to whom fell the task of putting the currency on a sound basis again. The problem was that new coins which were issued in England over and over again, used to disappear as soon as they were put in circulation. After careful study Mr Gresham gave the following law :

  "Bad money tends to drive good money out of circulation, when both of them are full legal tender."

Bad money means the money which is inferior and cheaper in substance value. For example, when both metallic coins and paper money are in circulation, paper money is bad money as it is made up of a material which is cheaper than the material of coins. Coins of valuable material are either hoarded or melted for better profits.

35.9. INCOME

Definition

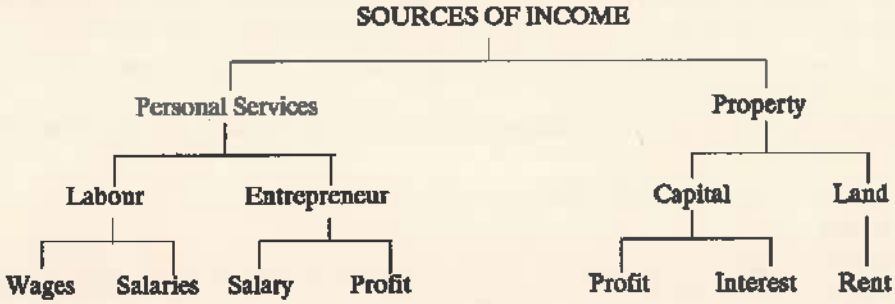
- Income *(Personal)* may be *defined* as those incomings which are in the form of money; including 'payment in kind' (such as free use of a house, free gas, water) which are given as a part of an employee's remuneration and in lieu of money payments.

- If a person is engaged in business, he is sure to have to incur certain outgoings for new material, the hire of labur etc. And, in that case, his true or *net income* is found by deducting from his gross income, 'the outgoings that belong to its production'.
- Anything which a person does for which he is paid directly or indirectly in money, swells his nominal income ; while no services that he performs for himself are commonly reckoned as adding to his nominal income.

Sources of

- Income may be derived from two sources
  - (*i*) the performing of personal services,
  - (*ii*) the ownership of factors providing impersonal services.

The term *property* is used for any impersonal thing that yields an income. Different sources of income are given below.



National Income

- National income may be regarded either as the money value of all goods and services produced during a particular period-usually a year, or the sum of all *personal incomes* derived from economic activity during that time.
- National income may also be defined as "the aggregate net product of, and the sole source of payment for, all the agents of production."
- The national income consists of a collection of goods and services reduced to a common basis by being measured in terms of money.
- The calculation of national income can be approached either from the side of the *output of goods* or from the side of *income*.

A third approach is possible-from the side of consumption. Since income is either spent or saved, the total amount spent on consumer's goods, added to savings, should also be equal to the national income.

35.10. MARGIN

- *Margin* indicates the smallest possible increase or decrease in the stock or supply of anything.
- The marginal unit of anything is the *last* unit to be added to a supply or the *first* unit to be taken away from it at a moment of time.
- If a person possesses three shirts and is planning to buy the fourth one, this fourth shirt might be considered as his marginal unit. Whether the person will buy the fourth shirt or not, depends on whether he thinks that the additional benefit to be derived from this fourth shirt is worth the price he will have to pay for it—that is, he considers its marginal worth to him.
- The term margin can be used in connection with cost, income or production, so that one can speak of marginal cost, marginal income, marginal utility, marginal product etc.

35.11. UTILITY

- Utility is taken to be correlative to desire or want.
- Utility of a commodity may be defined as its value in use.
- Utility is the capacity of a commodity to satisfy human wants and depends upon the intensity of the want which it satisfies.
- Utility may also be defined as the amount of satisfaction to be derived from a commodity or service at a particular time.

The utility of bread is the satisfaction to be obtained from consuming bread at a particular moment of time.

There are two points to note. In the first place, the utility of a commodity has nothing to do with its usefulness; it may or may not be useful, though it must yield satisfaction. Nor has utility any ethical connotation. The second point to be emphasised is its applicability to something at a particular *time*. To a starving man, bread will have great utility, whereas for a man who has just dined well, bread for the moment may possess no utility at all. Utility therefore depends on the individual's own *subjective* estimate of the amount of satisfaction to be obtained from something.

- *Marginal Utility* of a commodity will be the amount of satisfaction to be obtained from the possession of a little bit more of it, or alternatively, the loss of satisfaction due to giving up the smallest possible amount of it.
- *Total Utility*. It is the sum total of the utilities of all the units of a commodity consumed at a particular time. When one consumes more and more of commodity (say mangoes), the total utility derived from its consumption first increases, then reaches the point of satiety and then begins to fall as marginal utility becomes negative.
- **Law of Diminishing Utility**

The law of Diminishing Utility is a general law of life, as in fact it applies to everything.

Every addition to a person's stock of a commodity possesses less and less utility, *e.g.* if one has only one shirt,its utility is enormous; a second shirt is not so precious; a third still less, till ultimately one has a large number of shirts and additions might be considered a positive nuisance. This is the *law of diminishing utility*; the more one has a thing, the less one wants a little more of it.

Another method of illustrating the law of diminishing (marginal) utility is to consider(refer table below) how much Mr. A would be willing to pay for each successive one piece of banana. For example, for the first banana he might be willing to pay 50 paise, for the second 45, for the third 40, the fourth 30 and so on reducintg (Table 35.1)

TABLE 35.1

Diminishing Marginal Utility

Price	*No.of bananas purchased*
50 p	1
45	2
40	3
30	4
25	5 and so on.

TABLE 35.2

No.of Bananas Purchased	*Total Utility (Units of Utility)*	*Marginal Utility (Units of Utility)*
1	50	50
2	50+45=95	45
3	95+40=135	40
4	165	30
5	190	25

Table 35.2 shows that marginal utility of first banana stands at *50 units of utility*. After purchasing 1 banana, its marginal utility falls to 45 and with each successive 1 banana purchased, the marginal utility of the commodity falls. This shows that as one's stock increases marginal utility declines.

35.12 DEMAND AND SUPPLY

Price *(Refer article 35.6 also)*

- The price of anything is the rate at which it can be exchanged for anything else.
- A commodity has a price because on the one hand, it is useful, and on the other hand, it is scarce in relation to the uses to which people want to put it.
- When a *price* of any good is determined in the market for that good, it is because usefulness and scarcity express themselves concretely in the demand of buyers on the one hand and supply by sellers on the other. Price is determined by the interaction of two sets of influences, those of *demand* and *supply*.

Market

- Since prices are determined by demand and supply, so then it is worth to study the way in which demand and supply interact in the market.
- *Market* is any organisation whereby buyers and sellers of goods are kept in close touch with each other.
- A market can be in the same building as the Stock Exchange or buyers and sellers are able to speak to each other by telephone as happens in the foreign exchange market.
- In some markets buyers and sellers actually met and handle the commodity, in others, samples of the goods only are present, in yet others sales is by description.
- Some markets are local *(fruits and vegetables)*, others are world wide (steel) with dealers and stocks, no matter where placed.
- A *perfect market* is very wide, deals in standardized commodity, with buyers and sellers equally well-informed and with bargaining on a basis of quality.
- Markets may be *Spot—goods* dealt in for immediate delivery—or futures—a present contract for future delivery.

Spot prices are influenced by immediate demand and supply, while future prices will depend on estimates of the spot prices at the future date.

- An absolutely perfect market exits only as a theoretical concept though some markets approach fairly near to perfection. Examples of these are the markets for foreign exchange, the securities markets (stock exchanges) etc. In the real world, markets are to a lesser or greater extent *imperfect*.
- Some retail markets are really *imperfect*, for most people will not spend the time going round all the shops to find where prices are lowest. In the retail trade it is impossible for all buyers to be

in close touch with the sellers.

- Market in antiques, where there are only a few buyers and sellers, the market tends to be imperfect as buyers and sellers, lack knowledge of what is happening elsewhere in such market.
- *Types of markets*–Some of them are :

1. *Factor markets* in which entrepreneurs require some of each of the factors of production–land, labour etc.

2. *Markets for Consumer goods*–wholesale and retail markets.

3. *Capital market*–market for new securities.

4. *Money market*–market for short term loans.

5. *Foreign exchange market*–market for foreign currencies.

35.13 DEMAND

- Demand in Economics means demand backed up by enough money to pay for the good demanded.
- By demand is meant the quantity demanded at a particular price, for it is impossible to conceive of demand not related to price.
- Demand means *effective desire* that is the desire coupled with purchasing power in order to become demand.

A person may like to possess a scooter, refrigerator and what not; but until and unless he arranges money from somewhere his desire is not a demand.

Demand therefore may be defined as :

(*i*) the desire to possess a thing coupled with

(*ii*) the means of purchasing it, and

(*iii*) the willingness to use the means for the purpose.

Demand Schedule

- The demand schedule of an individual or market is the list of different amounts of a commodity that individual or individuals will purchase at different prices at a particular place and time.
- The market demand schedule is composed of the demand schedules of all the individuals in the market.
- Table 35.3 shows an *individual demand schedule :*

TABLE 35.3

Price per kg. (Rs)	*Demand per month (No. of kgs.)*
20	3.5
18	3.5
16	4.0
14	4.0
13	4.0
12	4.5
11	4.5

- Theoretically, the demand schedule of all consumers of tea can be combined to form a *composite demand schedule,* representing the total demand for tea at various *prices. This might be called the market demand schedule* (Table 35.4).

TABLE 35.4

Price per Kg. (Rs.)	*Quantity demanded per month (Kgs.)*
40	100,000
36	120,000
32	135,000
28	150,000
26	165,000
24	180,000
20	240,000

The Law of Demand

– The greater the amount to be sold, the smaller must be the price at which it is offered in order that it may find purchasers; or, in other words the amount of goods demanded increases with a fall in price and diminishes with a rise in price.

There will not be any uniform relation between the fall in price and the increase of demand.

– The law of demand is clear from the Demand Schedule table given above which shows that the lower the price of tea per kg, the greater is the quantity demanded per month.

– The law of demand is based upon the law of diminishing (marginal)utility.

– The law of demand holds goods when population, income of customers, price of alternate goods, taste of consumers, etc., do not change.

The Demand Curve

– Demand schedule data when plotted in the form of a curve or graph, it becomes *Demand Curve*.

Demand Curve again shows that higher the price, lower will be the demand and vice-versa.

– Fig. 35.1 shows a Demand Curve. A Demand Curve normally slopes downard from left to right.

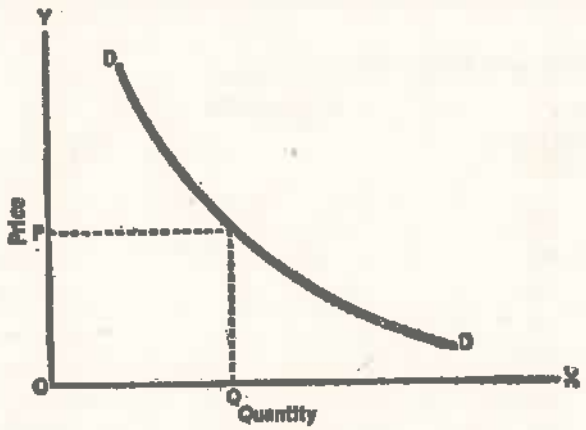


Fig. 35.1. Demand Curve

– Demand Curve shows that as the price of a good falls, people who were previously unable to buy it will enter the market, and the amount of the goods demanded will rise.

- Some people will buy this good, now that its price has fallen, in preference to other goods which they bought before but which are now relatively more expensive.
- Again, some people who bought some of the good even before its price fell will be able to buy more now because it is Cheaper.

For these reasons economists assume that demand curves slope downwards to the right.

Elasticity of Demand

- It can be seen from demand curve that the demand for the good is *responsive* to a fall in its price; however there are differences in the degree of responsiveness of different goods to price changes.
- *Elasticity of demand* describes the degree of responsiveness of the demand for a good, to a fall in its price. Strictly speaking, elasticity of demand refers to the way in which the demand for a good responses to a *change* in its price, whether a rise or a fall.
- The elasticity (or responsiveness) of demand in a market is great or small—according as the amount demanded increases much or little for a given fall in price, and diminishes much or little for a given rise in price.
- Elasticity of Demand

$$= \frac{\text{Proportionate change in amount demanded}}{\text{Proportionate change in price}}$$

$$= \frac{\text{Change in amount demanded}}{\text{amount demanded}} \div \frac{\text{change in price}}{\text{price}}$$

This formula holds strictly only in the limiting case where the changes in price are infinitesimally small. It should be noted that when elasticity is measured numerically, all elasticities will be between two limits.

- Numerical measures of elasticity of demand enable one to tell whether demand on any demand curve is more or less responsive to price changes than on another curve.
- The elasticity of demand is *unity* when the amount demanded at a price multiplied by the price remains constant. For example, when the price is Rs. 5000, people demand 100 refrigerators and when price falls to Rs 4000, the demand increases to 125 refrigerators, in both cases, $5000 \times 100 = 4000 \times 125 = 500{,}000$ constant and thus the elasticity of demand is unity.
- The elasticity of demand is *less than unity* when a small fall in price will lead to such a small increase in demand that the total sum spent on the commodity decreases or vice versa. For example, when a price is Rs. 5000, people demand 100 refrigerators but when the refrigerator price fall to Rs. 4000, the demand goes to 120 refrigerators. The aggregate expenditure is Rs. 500,000 in the first case and Rs. 480,000 in the second case. Elasticity of demand is therefore less than unity.
- The elasticity of demand is *greater than unity* when a small fall in price leads to such a large increase in demand that the total expenditure on the commodity increases. For example, when the price is Rs. 5000, people demand 100 refrigerators, but when the price falls to Rs 4000, the demand goes to 140 refrigerators.

Factors affecting the elasticity of demand

1. *Type of good.* The demand for luxuries is elastic, while that for necessaries is inelastic.
2. *Existence of substitutes.* The demand of a commodity is elastic if it has substitutes.
3. *Number of uses of goods.* The demand is elastic if the commodity has a variety of uses.
4. *Time element.* The demand is elastic if the use of commodity can be postponed.
5. *Price of the commodity.* The demand is elastic for high price and moderately high price goods; but it is inelastic for very low price goods. The reason is, when the price of commodity is very low *i.e.*, within

the reach of everybody, a slight rise or fall in price will neither retard, nor increase consumption resulting in inelastic demand (of the commodity).

6. *Taste and Tradition* also effect the elasticity of demand. One accustomed to wear fine cloth will continue to do so irrespective of an increase in cloth price.

7. Also, the demand is inelastic if the total expenditure incurred on a commodity forms only a small fraction of the total income.

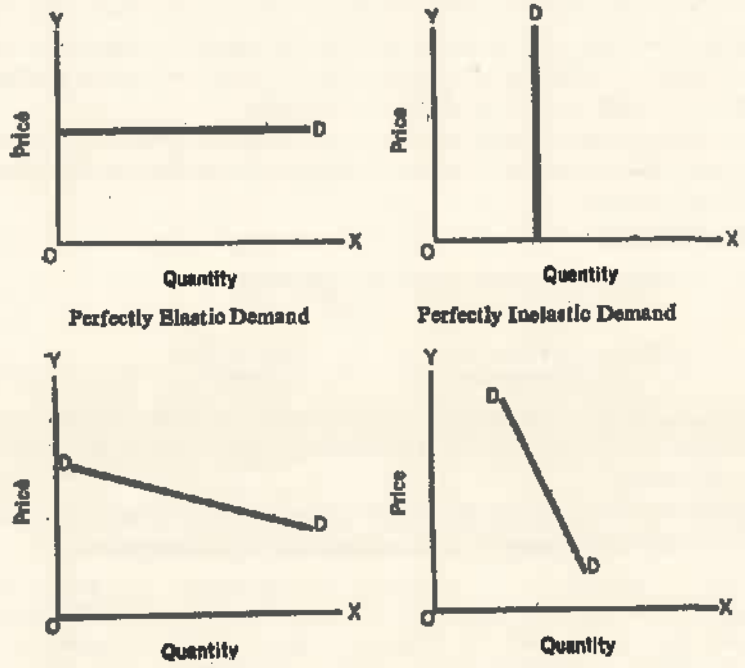


Fig. 35.2. Curves showing elastic and inelastic demands.

35.14 THE LAW OF SUBSTITUTION

– People exchange their commodities with one another because one feels less desire for the things he possesses and comparatively more desire for what he does not have and every exchange transaction adds to one's satisfaction. The Process of exchange continues as long as the utility received in exchange is greater than the utility parted with.

Ultimately a stage reaches when further exchange does not bring any benefit and it (*i.e* the exchange of commodities between two persons) stops. This is the principle underlying the *law of substitution.*

– The law of substitution finds application in the fields of production, consumption and distribution.

1. Production. A producer tends to maximize his production by substituting less important factors with more important ones to obtain higher production. Factors such as Land, Labour, Capital, Machinery etc., are readjusted in their quantity to obtain higher production and profits.

2. Consumption. A consumer always tends to substitute a thing that would yield him greater satisfaction in the place of another yielding less satisfaction, until the marginal utility from all the commodities is just equal.

The law of *Equi-marginal Utility* states that maximum satisfaction out of the expenditure of a given

amount, can be obtained if the utility derived from the last unit of money spent on each object of expenditure is more or less the same.

3. Distribution. A businessman, distributes his capital in many resources so that his total profit is maximum.

35.15 SUPPLY

- The first factor affecting price is demand and the second factor that affects price is supply.
- By the supply of a commodity is meant the quantity that is called forth into the market-over a particular period of time by a certain price.
- Just as demand is not the same as need, and implies effective demand or demand at a price so it is with supply.
- The supply of a commodity does not comprise the entire stock of it in existence, but only that amount drawn into the market by the price ruling at the time.

The supply of crude oil is not the estimated resources of all the world's oil fields, but only that amount which particular price will bring into the market.

- Supply depends upon scarcity, just as demand depends on usefulness. Whilst it is comparatively simple to say whether or not a good is useful, one cannot say whether a good is economically scarce except in relation to the demand for it.

Supply price

- As the price required to attract purchasers for any given amount of a commodity, was called the *demand price* for that amout during a year or any other given time; so the price required to call forth the exertion necessary for producing any given amount of a commodity, may be called the *supply price* for that amount during the same time.
- An increase in the amount demanded generally raises short period supply price.

Supply Schedule

- The construction of the list of prices at which a thing can be supplied is known as its *supply schedule.*
- The supply schedule (Table 35.5) shows the amounts that will be offered for sale at different prices by individual firms, these then being combined to form a market supply schedule for the commodity.
- *Supply Schedule* is a list showing the relationship between various prices and the supply of a particular commodity in a particular market on a particular day and at a particular time.
- The supply schedule for packs of coffee is given in Table 35.5.

TABLE 35.5

A Supply Schedule

Price Per pack (Rs.)	*Quantity offered for sale per month*
20	400,000
19	370,000
18	350,000
17	320,000
16	285,000
15	240,000

Supply Curve

- *A supply curve* is plotted from the data given in *the supply schedule.*
- Fig. 35.3 Shows a supply curve.

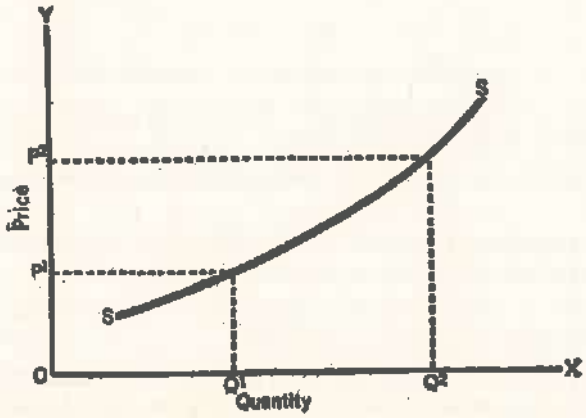


Fig. 35.3. A Supply Curve.

- It can be seen from the supply curve that as the price per pack of coffee reduces, the quantity offered for sale per month also reduces.
- A typical supply curve slopes upwards from left to right. This illustrates the second Law of Supply and Demand – 'the higher the price, the greater the quantity that will be supplied for sale'.
- From Fig. 35.3 it can be observed that at the higher price, OP_2, a greater quantity OQ_2 will be put on to the market than at the lower price OP_1; the amount offered for sale at this price being only OQ_1.

Elasticity of Supply

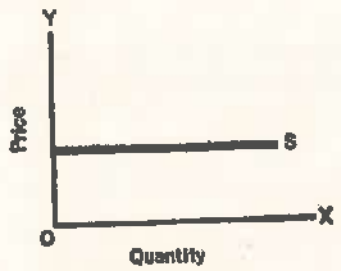


Fig. 35.4. Perfectly Elastic Supply.



Fig. 35.5. Perfectly Inelastic Supply.

- Elasticity of supply implies the responsiveness of supply to a change of price, and can be seen from the shape of the supply curve (Fig. 35.3).
- If a change of price causes a more than proportionate change in supply then supply is elastic.
- If a change of price causes a less than proportionate changes in supply, then supply is inelastic.
- If the factors of production are more specific, supply tends to be more inelastic and it is more elastic, the less specific the factors are.

– Fig. 35.6 shows a supply curve with varying elasticity *i.e.,* in which elasticity varies over different parts of the same supply curve.

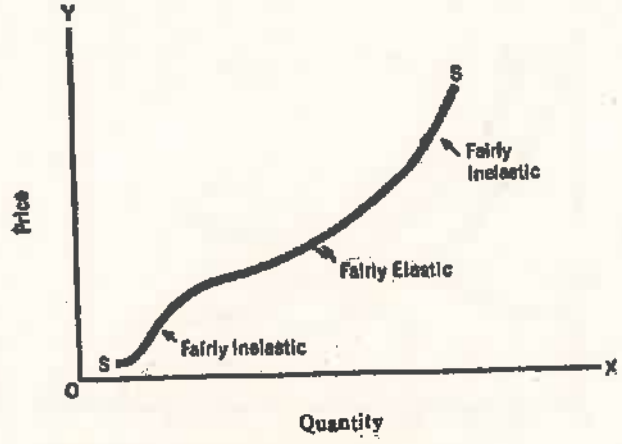


Fig. 35.6. Supply curve with varying elasticity.

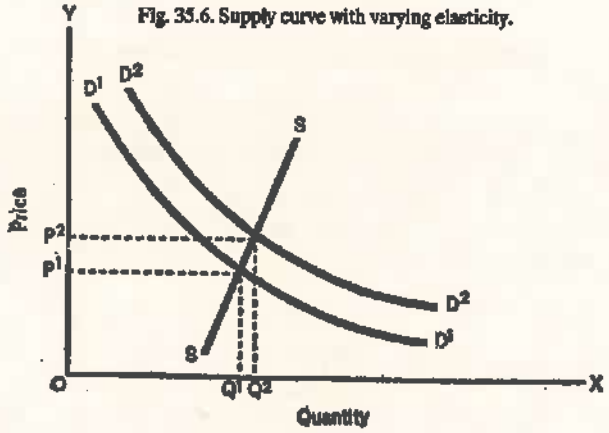


Fig. 35.7. Inelasticity of Supply and Change of demand.

– Elasticity of Supply determines the effect of change of demand on prices.

If supply is fairly inelastic, an increase in demand will bring about only a small increase in quantity supplied, but there will be a big rise in price (fig 35.7).

– On the other hand, if supply is fairly elastic, an increase of demand will result in a big increase in quantity and only a small increase in price (Fig 35.8).

The more elastic the supply, the less variable will be the price.

35.16 EQUILIBRIUM AND PRICE DETERMINATION

– Having discussed *Demand* and *Supply* in detail, the next step is to study how demand and supply interact in the market to determine the price of a good and the amount of it which is bought and sold.

– Demand and supply are like two forces pulling in opposite directions. They are balanced or in *equilibrium,* at that market price at which the amount demanded equals the amount supplied. This price can be called the *equilibrium price,* and the amount demanded and supplied at this price is called the *equilibrium amount.*

– In order to determine equilibrium price, Fig. 35.9 is plotted from a combined Supply and Demand Schedule like one given as Table 35.6.

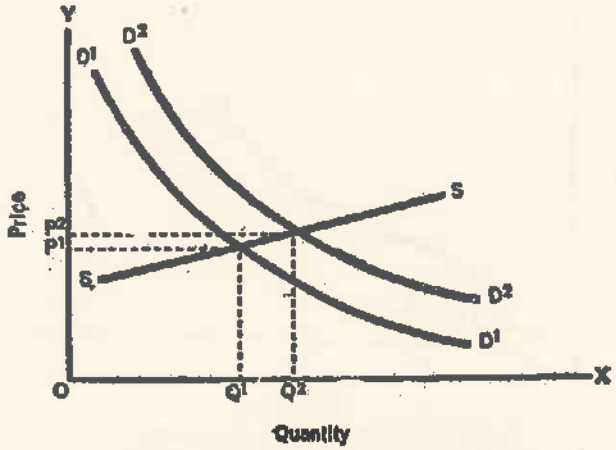


Fig. 35.8. Elasticity of Supply and Change of demand.

TABLE 35.6.

A Combined Supply and Demand Schedule		
Price (Rs). per pack	*Quantity demanded (No. of packs)*	*Quantity supplied (No. of packs)*
20	135,000	350,000
18	150,000	320,000
16	165,000	285,000
14	180,000	240,000
13*	200,000*	200,000*
12	240,000	160,000
11	300,000	120,000

– Fig 35.9 is plotted from the data given in table 35.6. *SS* is the supply curve and *DD* is the demand curve.

– Fig 35.9 shows that at price *P*, quantity demanded=quantity supplied=*Q*.

– Price *P*=Rs. 13 is the equilibrium price because at this price quantity demanded = quantity supplied

= 200,000 no. of packs. (Refer Table 35.6)

This is Third Law of Supply and Demand.

– At any price higher than the equilibrium price, the sellers will find some of the articles left unsold : at a lower price than the equilibrium price demand will exceed supply and there will be shortage of the commodity.

– The actual price charged in the market may be only the *short term equilibrium price*, for in the short period the forces of supply and demand may be subject to temporary influences.

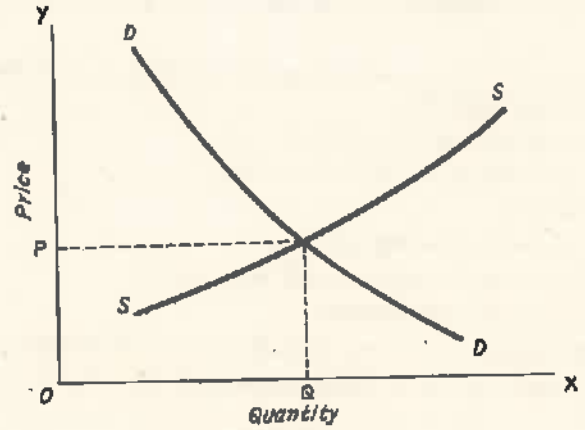


Fig. 35.9. The Equilibrium Price.

The short period equilibrium price is the *Market Price.*

When conditions of supply and demand have settled down fairly well and the rate at which commodity is consumed is equal to that at which it is produced, then a *long-period equilibrium price* will be established.

The long period equilibrium price is the *Normal Price.*

Equilibrium of an Industry

– An industry will be in equilibrium where there is no tendency for the size of the industry to change.

Equilibrium of the Firm

Under perfect competition, a firm will be in equilibrium when it is of no advantage to it to increase or decrease its output or to change its method of production by altering the proportion in which its factors of production are combined.

35.17 PRODUCTION

Meaning

– Economics is concerned with the *Production* and *distribution* of wealth.

– Production is any process or procedure developed to transform a set of input elements like men, materials, capital, information and energy into a specified set of output elements like finished goods, in proper quantity and quality, thus achieving the objectives of an organisation.

– Production covers the following activities also

(*i*) Changing the situation of a good as, for example, from a factory in Hyderabad to a retail shop in Delhi.

(*ii*) Changing the position of a good in time as, for example, holding stocks of goods until they are required, and

(*iii*) The provision of some kind of service, such as retailing, banking etc.

35.18 FACTORS OF PRODUCTION

– The agents or factors of production are classified as

(*i*) Land and other natural resources

(*ii*) Labour (human efforts)

(*iii*) **Capital** (factory building, machinery, raw material etc.)

(*iv*) **Organization** (that organizes other factors of production into an operating unit).

(*i*) **Land**

- Land implies the material and the forces which Nature gives freely for man's aid, in land and water, in air and light and heat.
- Land includes all the *gifts* of nature such as
  - (*a*) Surface or ground including soil and subsoil.
  - (*b*) Oceans and rivers.
  - (*c*) Minerals/ores under the surface of earth.
  - (*d*) Air, heat, light, climate conditions, rainfall, winds etc.
- Land possesses following *characteristics.*
  - (*i*) Land is a gift of nature and cannot be produced. Land is a saleable item.
  - (*ii*) The value of land is determined by its location. For example, land in the city is costlier than in a village.
  - (*iii*) Land is fixed in quantity and cannot be increased.
  - (*iv*) Land itself does not act in the production process. It is a passive factor. Land is acted upon by men and machines.

Production is not possible without land, because, for housing raw material, machinery and finished goods and for the men to work, land and building are must.

(*ii*) **Labour**

Definition

- By labour is meant the human effort employed in production.
- Labour implies the economic work of man, whether with the hand or the head (mind).
- Labour is classed as economic when it is undergone partly or wholly with a view to attain objectives of the organization such as to earn an economic reward.

Characteristics of Labour

- Labour is absolutely indispensable to all forms of production.
- Labour differs from land and capital in that it is supplied by human beings, and because of that, ethical and moral conditions must be taken into account when dealing with it.
- Labour is perishable. If a worker does not work on a particular day, the labour of that day is lost for ever and cannot be regained.
- Money can be invested in labour for the acquisition of skill and education.
- Labour cannot be easily transferred from one occupation to another or from one place to another.

Classification of labour

(*i*) Skilled and unskilled labour :

A Skilled labour requires some special skill or training in its performance. The work is such that the worker without special skill cannot do it. For example, operating a turret lathe requires special skill on the part of the worker.

Unskilled labour can be performed without any sort of special skill or training. For example, the labour of a helper in workshop is unskilled.

(*ii*) Mental and manual labour :

Though purely mental or purely manual labour is seldom there, even then it may be said that

the labour of a philosopher is mostly mental whereas that of a helper in workshop is mostly manual.

Supply of labour

- The supply of labour may be taken to mean the total number of people—men, women and children—of working age.
- The supply of labour depends upon :
  - (*i*) The total population of the country.
  - (*ii*) The proportion of the population available for employment.
  - (*iii*) The mumber of hours worked by each person per year.

Efficiency of labour

- The term *efficiency* of labour signifies the capacity of the labourer to do more work or bettter work or both during a given period of time.
- Efficiency of labour depends upon the following factors :
  - (*i*) Willingness to work on the part of the labourer :
  - (*ii*) Ability to do a particular work.
  - (*iii*) Education and training of the worker.
  - (*iv*) Working conditions under which the worker has to work. Working conditions include ventilation, lighting, overcrowding, noise, heat, smoke etc.
  - (*v*) Wages. High wages may result in a high standard of efficiency.
  - (*vi*) Number of working hours. With increased hours of work, workers get more fatigue and consequently their efficiency lowers.

(*iii*) **Capital**

- Capital may be defined as wealth which is used for the purpose of producing further wealth.
- Capital has to be produced and some factors of production—land, labour and some capital itself, organised by the enterpreneur—has to be employed for this purpose.

Characteristics of capital

- (*i*) Capital is the result of saving.
- (*ii*) Capital wears out with the passage of time and need be replaced.

Functions of capital

- (*i*) Capital makes the workers to produce by providing them wages.
- (*ii*) Capital provides machinery, tools, raw material and other equipment required for production.
- (*iii*) Capital keeps production continued and increases productivity.

Efficiency of capital

The efficiency of capital depends upon

- (*i*) method of its application, for example, an untrained operator cannot make best use of a Computerized Numerically Controlled machine and hence the capital will remain inefficient in his hands.
- (ii) its fitness as a factor of production, for example, if a component can be fabricated using stick electrodes, capital should not be used for purchasing a MIG (Metal Inert Gas) welding set.

Capital Accumulation

- A country's *stock of capital* at any given period of time is the result of sacrifice by its people in the past, and any further increase in its stock of capital can be achieved only by forgoing the satisfaction of some present wants.

- Capital formation can take place only when the quantity of goods consumed in a period is less than the total produced.

  Capital formation = Production − Consumption.

- In all countries the early stages in capital accumulation are slow, but once having acquired some stock of capital, this in turn can be used to assist further capital accumulation – that is to say, the rate of accumulation proceeds with cumulative effect.
- The accumulation of capital depends upon
  - (*i*) The ability to save.
  - (*ii*) The willingness to save.

(*i*) Capital is saved if there is an excess of income over the expenditure, which can be achieved through increased production and more economical consumption. Efficiency of labour and capital help accumulation of capital.

(*ii*) Willingness to save comes from a number of considerations, a few of them being listed below ;

- (*a*) Money is saved as a provision against some contingency.
- (*b*) Capital brings respect and power in social circle.
- (*c*) Capital is accumulated to excel other business competitors.

For further details of capital please refer to article 35.7.

(*iv*) **Organization**

- Organisation (or enterprise) brings various factors of production (such as Land, Labour and Capital) into the most effective coordination/cooperation in order to achieve the desired objectives (*e.g.* production of a component).
- Organization is the keystone on which the entire structure of any business/production is based.
- Organization, only, bears the risks involved in production of a given item.

Functions of organization

(*i*) To coordinate various factors of production and to pay the wages.

(*ii*) To identify the talents of different persons and to entrust to them the work best suited to them.

(*iii*) To provide raw material, tools and machinery required for production.

(*iv*) To estimate sales forecast and hence the magnitude and rate of production.

Efficiency of organization

- Efficiency of organization may be defined as the capacity to manage production with greatest economy and highest profit.
- Efficiency of organization is influenced by
  - (*i*) Efficiency of other factors of production.
  - (*ii*) Organising ability of the organiser – which may include :
    - (*a*) Sound technical knowledge possessed by him.
    - (*b*) Foresight to estimate future product demands.
    - (*c*) Selection of right type of labour.
    - (*d*) Creation of an atmosphere of healthy competition etc.
- Some important problems faced by an organizer are
  - (*i*) Scale of production.
  - (*ii*) Division of labour including localisation of industry.

35.19 LARGE SCALE PRODUCTION-CHARACTERISTICS AND CAUSES

Concept of large scale production

- Large scale production or mass production means the production of items on large scale employing very specialized machines and processes.
- All specialized machines and processes are arranged in operation sequence to suit the product.
- A large scale production unit is no longer a single family or small group of persons working with few cheap, simple tools or small quantities of raw material, but a compact and closely organised mass labour composed of thousands of individuals, cooperating with large quantities of expensive and intricate machinery through which pass a continuous and mighty volume of raw material on its journey to the hands of the consuming public.

Characteristics of Large Scale Production

- Large scale production is carried with
  (a) Large quantities of raw material,
  (b) Very specialized machinery,
  (c) Huge capital,
  (d) Huge and highly trained labour force, and
  (e) Efficient and effective organization.

Causes of Large Scale Production

The following developments and causes led to the increased size of the business unit *i.e.* the large scale production.

(*i*) Specialization or division of labour.

(*ii*) Improvements in the means of transport. Without adequate transport facilities, large scale production would be impossible, for every increase in output requires an expansion of the market for the commodity and distribution over a wider field.

(*iii*) The development of the limited company too has been an important factor in making possible large-scale production involving huge amounts of capital.

(*iv*) There has been a great expansion in the demand for all kinds of things consequent on the rise in the standard of living that has taken place in recent times. This is another cause for large scale production.

(*v*) The prospect of greater profits was a definite incentive to the producer to expand his scale of production, for many economies were open only to the large firm, thereby giving it the great advantage of lower costs than to smaller competitors.

(*vi*) In some cases the hope of securing a measure of monopoly power as a means of keeping up prices may have been a further spur to expansion.

(*vii*) Producers frequently put back into their firms a large proportion of their profits and thus many large-scale production businesses were built up.

Economies of Large Scale Production

The advantages of large-scale production may be classified as External and Internal economies of production.

Internal Economies

- Economies which any single firm enjoys by virtue of its own individual policy is termed as *Internal Economies*. Such economies are related to the administrative, technical and commercial spheres of business.

- Some examples of internal economies are
  - (*i*) Economy affected in the purchase of raw material, machinery, tools etc.
  - (*ii*) Economy on shop-floor.
  - (*iii*) Economy in by-products.
  - (*iv*) Economy in packing department.
  - (*v*) Economy in factory offices.
  - (*vi*) Economy in using transport.
  - (*vii*) Economy in sales department etc.

External Economies

- Economies open to an industry as a whole (say automobile industry) are known as *External Economies*. Such economies are enjoyed by an *industry* as a whole when most of the firms comprising it are concentrated in one area. For example, external economies may apply to a number of units manufacturing Sports Goods and located in one industrial area.

  Examples of external economies enjoyed by various firms can be such as obtained by the establishment of a bank, post office, a pucca road, bridge or a railway line which enters straight in the locality *(i.e.industry)*.
- External economies are those economies in production which depend on increase in the output of the whole industry rather than on increases in the output of the individual firms.
- External economies occur where an increase in the size of an industry leads to lower costs for the individual firms composing the industry.

Disadvantges of Large-Scale Production

The large scale production suffers from the following disadvantages.

(*i*) *Loss of motive of self-interest*

The interests of the sole proprietor and his firm are one, with the result that there is less waste and greater efficiency. This is because all the profit goes in the pocket of the sole proprietor. It is but natural that the man who owns his business is often spurred on by a pride of achievement that is unlikely to influence the salaried manager of a large-scale production unit.

(*ii*) *Bureaucratic control*

The large firm is more impersonal than the small one.

In a large firm, in order to ensure the carrying out of the policies, rules and regulations are necessary and must be strictly adhered to. This is not the case with a small firm.

(*iii*) *Sluggish response to changes*

In a large firm, even to make changes for improvement, the manager will have to convince the Board of Directors to the soundness of the changes before he is allowed to make them; whereas, in a small firm changes in policy or organization can be introduced without delay by the proprietor.

(*iv*) *Difficulty in managing*

As the firm expands, it becomes difficult to coordinate and control the activities of large number of persons working therein.

35.20 LOCALIZATION OF INDUSTRIES

Concept of Localization

- An industry concentrated in a certain locality is commonly described as a localized industry. For example, woollen carpet industry is localized in and around Mirzapur, brasswork is being carried out in Moradabad, textile industry has been localized in Bombay and Ahmedabad etc.

- The localization of industry gradually prepares the way for many of the modern developments of division of labour in the mechanical arts and in the task of business management. Even now we find industries of a primitive fashion localized in some villages of central Europe, and sending their simple wares even to the busiest haunts of modern industry.
- Another example of localization of industry can be found in Russia, where over 500 villages are devoted to various branches of wood-work, every village carrying on only one branch of production. One village makes nothing but spokes for the wheels of vehicles, another nothing but bodies and so on.

Causes of Localization of Industries

(1) *Physical conditions*

The chief cause of the localization of industries has been the physical conditions : such as the character of the *climate* and the *soil* or within easy access by *land or water*. Thus, textile industry has been located near coastal areas (*e.g.* Bombay)

(2) *Market*

It has been seen that Industries are attracted to big cities where they easily find a big market. A number of manufactures of Television sets have localized their industries in and around Delhi. Even cloth mills have been started in our country into the interior (away from the coastal areas) where the actual demand exists. A number of such industries can be seen in Delhi and Faridabad.

(3) *Raw material and fuel*

Industries have been localized in the neighbourhood of mines and quarries. Metallic industries (such as those of iron and steel, copper, aluminium etc.) have generally been either near mines or in places where fuel (*e.g.* coal) was cheap. The iron industries in England first sought those districts in which charcoal was plentiful and afterwards they went to the neighbourhood of collieries. Iron industries developed in Bihar (India) because of iron and coal mines being together.

(4) *Labour*

Cheap, efficient and specially trained labour has been another important cause of localization of industry. Availability of labour is the major cause for the manufacture of woollen carpets at Mirzapur.

(5) *Imitation*

Sometimes a person sets up an industry in a locality and it starts enjoying high profits. Others watch and thus many more similar industries come up and congregate in that area resulting in the localization of industries. An example of such type is the location of a number of firms manufacturing drawing instruments at Roorkee (U.P.).

Advantages of Localization

(*i*) When an industry is highly concentrated in an area, the principle of division of labour can be extended to a whole industry. Different firms which constitute the whole industry and are close together can specialize in particular varieties of a commodity. For example, in wool textile industry, fine worsteds can be made by one firm, heavy woollens by another firm and so on.

(*ii*) Localization of industry brings into being a reservoir of skilled labour for new firms which intend to set up in that area.

(*iii*) When an industry is highly localized, subsidiary industries grow up to cater for the needs of the major industry.

(*iv*) Localization of industry often leads to the establishment of highly organized markets.

Products of localized industry enjoy goodwill and find a good market. Moreover, localization creates a local market for that skill.

(*v*) Localization encourages the use of specialized machinery and offers great opportunities for

Research and Development, inventions and improvements in machinery.

(*vi*) Localization attracts banks and other financial agencies and thus increases the supply of capital by affording a profitable field for investment.

Disadvantages of Localization

(*i*) If a highly localized industry declines due to drop in the product demand, mass unemployment may result in that area.

(*ii*) Another disadvantage of extreme localization is the growth of great conurbations, where one town merges into another, with consequent overcrowding, lack of open spaces and traffic congestions.

(*iii*) Localization causes the economic dependence of one part of the country over another and in times of hostilities, great difficulties arise to both the consumers and manufacturers.

(*iv*) Localization narrows the intelligence and skill of mind as only one type of labour is required.

(*v*) In some cases heavy costs of transport may out weigh the advantages of localization.

35.21 DECENTRALIZATION OF INDUSTRY

- Considering the disadvantages of localization of industry, it is sometimes thought to establish different types of industries in one particular area. This is decentralization of industry. Decentralization is opposite to localization.
- Decentralization has the following advantages :
  - (*i*) Even if the product demand of one or two firms declines, mass unemployment (as in localization) will never result.
  - (*ii*) Economic dependence of one part of the country over another will not be much.
  - (*iii*) All types of workers will be developed and be available in a particular area.

35.22 LAWS OF RETURNS

Introduction

- Laws of Returns occupy a central position in production.
- It has been seen that an entrepreneur increases the quantity of various factors of production in order to increase the output of his factory so as to earn higher profits.
- The returns due to these additions in the factors of production are not always fixed. Sometimes *returns increase* due to increase in factors of production and this is known as the *Law of Increasing Returns* and it encourages the entrepreneur to expand his business.
- In some cases, even when the factors of production are increased, the return diminishes. This is known as the *Law of Diminishing Returns* and it prohibits the entrepreneur from expanding his business.
- In other cases, the return due to each successive increase in the factors of production remains almost constant. This is known as the *law of Constant Returns*.

  Fig 35.10 shows the optimum production and the laws of Returns.
- Table 35.7 shows that there are three firms namely *X*, *Y* and *Z* having their factors of production combined in the same proportion, but *Y* is larger than *X* and *Z* larger than *Y*. It may be that to expand the firm from size *X* to *Y* will yield *increasing returns* : firm *Y* has all production factors 5 times than of *X*, but its output is more than 5 times that of *X*. If the firm expands from size *Y* to size *Z*, diminishing returns set in, because, *Z* has all production factors 2 times that of *Y* whereas its output is less than twice that of *Y*.

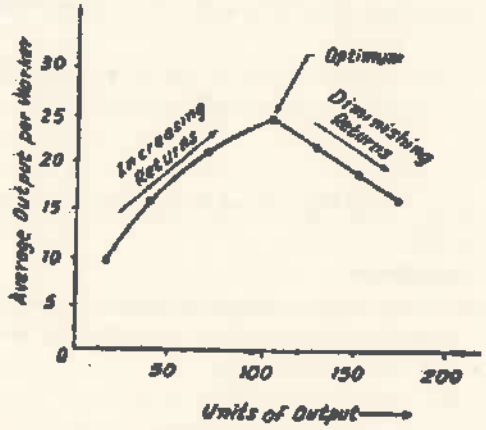


Fig. 35.10. Laws of Returns.

TABLE 35.7

Firm	*Area of land*	*Number of men*	*Units of capital*	*Output units*	*Additions to output units*
X	1	20	8	10	–
Y	5	100	40	55	45
Z	10	200	80	95	40

(A) The Law of Increasing Returns

– The *law of Increasing Returns* states that :

"An increase of labour and capital leads generally to improved organization, which increases the efficiency of the work of labour and capital and thus each successive dose (*i.e.* increase in the factors of production) results in a more than proportionate increase in the output."

The law is graphically shown in Fig. 35.10 and is evident from Tables 35.7 and 35.8.

TABLE 35.8

Number of workers (land and capital fixed)	*Output units*	*Average output per worker*
1	10	10
2	30	15
3	60	20
4	100	25

The increase in efficiency as shown in TABLE 35.8 and which results in larger output may be because of the following reasons :

(*i*) If a few more workers and extra machines are provided the production will naturally go up. The overheads will remain more or less constant. This will result in a drop in the per piece cost.

(*ii*) The efficiency of the organisation can also be improved through specialization. Special purpose

machines, technical experts and trained labour will result in increase in production and fall in the per piece cost.

(*iii*) It has been shown at (*i*) and (*ii*) above that cost per piece may fall due to *Internal Economies*. *External Economies* such as means of communication and transport, Bank and post office facilities etc, also help reduce cost per piece.

- Increasing returns according to the Law of Increasing Returns, appear to be due to varying the proportions between the factors of production, though obviously this can be achieved only by increasing the size of the firm.

(B) The Law of Diminishing Returns

- Returns (*e.g.* increase in output) do not continue increasing indefinitely as a firm grows in size. A time comes when an attempt to increase the output after the fixed factors of production are fully worked, will meet with diminishing returns.
- Thus, the *law of Diminishing Returns* states that :

  "With a fixed amount of anyone factor of production, successive increase in other (variable) factors (of production) will after a point, yield a diminishing increment in output".
- The *Law of Diminishing Returns* as applied to land states that

  "After a certain point, successive applications of equal amounts of resources to a given area of land produces a less than proportionate return". If this were not so, there would be no limit to the yield from one small area of land.
- Table 35.9 explains diminishing returns with labour as the variable factor.

TABLE 35.9

Number of workers	*Fixed amount of capital units*	*Output units*	*Average output per worker*
2	10	32	16
3	10	60	20
4	10	100	25
5	10	115	23
6	10	126	21
7	10	133	19

The table shows that after more than 4 workers are employed, though the output units increase, the average output per worker reduces and so illustrates the law of Diminishing Returns with reference to labour.

- The cause for decline in the average output per worker, after more than a definite number of workers/capital are employed can be explained as follows :

  In the case of multi-storey building construction, the higher the building, the larger will be the proportional expenditure on constructing upper storeys because more labour and capital is required in taking building material from ground floor to upper storeys. On the other hand, rental return of the upper storeys goes on diminishing.
- The law of Diminishing Return finds the following applications :

  (*i*) Agriculture

  (*ii*) Building of houses.

(*iii*) Manufacture

(*iv*) Fisheries

(*v*) Mines and quarries.

(C) The Law of Constant Returns

- If the actions of the laws of increasing and diminishing returns neutralize each other or are balanced we have the law of Constant Returns. An increased produce is obtained by labour and sacrific increased just in proportion.
- When the application of fresh dose of factors of production results in an equal return due to each successive dose, the law of constant returns is said to apply.

  Table 35.10 explains the law of Constant Returns. Upto two workers, the return increases, whereas with the further increase in the number of workers, the averge output per worker remains constant (*i.e.*, 20).

TABLE 35.10.

Number of workers	*Fixed amount of capital*	*Output units*	*Average output per worker*
1	7	10	10
2	7	30	15
3	7	60	20
4	7	80	20
5	7	100	20

- For the Law of Constant Returns to hold good, raw material should be availabe in bulk so that its price does not rise. *Secondly* the increase in size of the industry should not lead to greater division of labour. *Thirdly*, increasing and Decreasing Returns should counterbalance so that production is at constant cost. Such a situation may be visualized in an industry which manufactures raw material also for itself.

35.23 DISTRIBUTION

- The sharing out of the net national income (total output less depreciation) among the owners of the various factors responsible for production (land, labour, capital and entrepreneur) is termed as *distribution*.
- Factors such as capital and land by themselves cannot produce anything. Labour, with the help of capital and land produces wealth; this wealth being more than necessary for its own sustenance and reproduction. The surplus wealth thus obtained may be distributed either as additional wages or it may be

  (*i*) saved, in order to accumulate capital to assist further production,

  (*ii*) used to raise the standard of living,

  (*iii*) retained by the owners of the essential aids to production (land, capital etc.), who in turn save and reinvest a portion.
- The broad groups of factors of production are land, labour, capital and entrepreneur. All these factors of production have *prices* in the form of rent, wages, interest and profits respectively.

In the past, ideas about the determination of the prices of factors of production were often referred to as the **Theory of Distribution.** Nineteenth century economists were extremely interested in the problem of how much of the receipts of industry and agriculture went to the various factors of production. Now-

a-days, in pure economic analysis at least, the centre of interest has shifted. Economic theory is more concerned with what determines the prices of the factors of production than,with what determines their respective shares of the national income.

35.24 RENT

Introduction

- The word *rent* can refer to any periodic payment made regularly for the hire of a good e.g. a house, a flat, a shop etc.
- Rent is the share of the national income that goes to the owners of land. Mineral royalties are a form of rent.
- The amount of *economic rent* is determined by the richness of the *land or mine*, since the greater the value that a given amount of labour can produce, the greater the surplus from which rent can be paid. Economic rent is in fact the difference between the yield of land and the cost of producing the yield.
- In common use *rent* means the hire price of land or building. When a person hires a house, he is said to rent it and the periodic payment is termed rent. In ordinary sense rent is simply a price for the use of the services of a factor of production, land or land together with buildings, paid by the tenant to the owner. Rent, as the hire price of land, however also includes interest on capital.
- Rent is the surplus received by any factor of production above its opportunity cost-that is, any surplus over and above what was necessary to keep that factor in its present employment. Rents can therefore be received by labour, capital or the entrepreneur, as well as by land.

The Ricardian Theory of Rent

- One of the earliest explanation of the nature of rent, and one which is still regarded as coming very near the truth, was provided by David Ricardo in the early years of the nineteenth century.
- Ricardo defined rent in what he called in the strict sense as that portion of the produce of the earth which is paid to the landlord for the use of the original and indestructible powers of the soil.
- Ricardo had two main intentions
  - (*i*) Rent is a return for the use of the original and indestructible powers of the soil.
  - (*ii*) High rents are not a sign of the bounty of nature, on the contrary, they are an indication of the niggardliness of nature.

Ricardo lived at a time when high rents were causing great anxiety. He saw only too clearly that these high rents were caused by the scarcity of agricultural land and its produce and not by their abundance. It is scarcity and high prices which cause high rents, not bountiful plenty.

- Rent, according to Ricardo, arises like this. If a country has an abundance of rich and fertile land, there will be no rent, for no one will be willing to pay for the use of land if there is a greater supply of it than is required for all purposes. Rich and fertile land, however is not unlimited in quantity in any country, nor is land uniform in quality. It is because of this that rent arises, for says Ricardo, "When land of the second degree is taken into cultivation, rent immediately commences on that of the first quality and the amount of that rent will depend on the difference in the quality of these two portions of land. More fertile land will yield a greater return, and value of this excess yield over that of land at the margin of cultivation is its rent.

Not unnaturally, perhaps, in view of his definition, Ricardo restricted rent to land. As it is defined by modern economists, rent becomes a much more useful concept, since it can apply to any of the factors of production.

Scarcity Rent

- Scarcity rent results from the scarcity of homogeneous land.

- The essential feature of pure scarcity rent is this. Whilst a rise in the prices of other factors of production will often cause an increase in their supply, a rise in rent cannot increase the supply of land. It is the fixity of its supply which distinguishes homogeneous land and its scarcity rent from other factors of production and their prices. Scarcity rent is essentially the result of the fact that, in the real world, land is in inflexible supply.

Differential Rent

The model which is assumed to discuss the problem of scarcity rent considers that land is both homogeneous and scarce. This is not, however, a very realistic model. Because all land is never of the same quality. It is reasonable to assume that a particular stretch of land will not be so fertile as the rest of that. This type of situation leads to *differential rent* i.e. rent will be *different* on each grade of land. Differences between the fertilities of different types of lands will cause differences in their rents. Rent will be lower on the less fertile land and higher on the more fertile land. However, rent is caused solely by the fact that land is scarce.

Quasi-Rent

- Following Marshall, the term quasi-rent was used to describe all rents received by factors other than land.
- Quasi rents tend to be temporary, received by the factors concerned in the short period only until supply catches up with damand.
- In Marshall's words the supply of *Machines and other appliances made by man* is elastic in the long run but inelastic in the short run. They are not in fixed supply like land, so the earnings from their use cannot be called rent in the economic sense.

  Marshall attached great importance to the analysis of these earnings from machines and coined a special term for them, namely *Quasi-rent.*
- The quasi-rent of a machine is its total short-run receipts less the total costs of hiring the variable factors used with it and of keeping the machine in running order in the short run. In long run equilibrium, quasi-rent will become equal to the (constant) normal earnings of the machine.

  Quasi-rent, in other words, will be at its *normal* long run level, where it is just equal to the cost of keeping the machine in continued existence.

35.25 INTEREST

- Interest is the share of national income that goes to the owners of the capital. *Interest* differs from *profit* in the sense that interest is sometimes considerd as a fixed payment, while profits are variable, but economically, there is no difference between them.
- The term *interest* implies payment for the use of capital. Interest is the payment made by the borrower of the capital to lender. The borrower pays interest to the owner of the capital because capital contributes to production of wealth and has productivity. 'A' borrows Rs. 10,000/- from 'B' and buys a machine to produce certain components. Since Rs 10,000/- will generate further wealth, 'A' will pay interest to 'B' on this loan of Rs 10,000/-. The revenue product of the machine, however, must at least equal its cost, plus interest at the market rate.
- The payment of interest has become respectable only in recent times, otherwise, in the early days, persons charging interest were looked down upon. The reason for this could be that earlier, money was generally borrowed at the time of want, misery and distress; but now it is also taken for productive purposes.
- Borrowing and lending are indispensable activities in an advanced economic system. At the present day the chief lenders are:
  - *(a) Commercial banks* which lend to businessmen and Government.
  - *(b) Building societies* which help people to purchase house or business property.

(c) *Finance companies* whose main business is to finance hire-purchase transactions.

(d) *Money lenders* who lend to private individuals.

– *Net and Gross interest.* Gross interest is the total payment which the borrower actually makes to the capitalist for the use of his capital. This payment, besides *net interest*, (a payment exclusively for use of capital) may include any or all the items such as :

(*i*) Insurance against risk; the borrower may not return the money which he has taken.

(*ii*) Payment on account of inconveniences *i.e.,* borrower may repay to lender at a time when it is not possible for the lender to reinvest it.

(*iii*) Salaries for the Manager and other persons keeping record etc., of the money given on loan.

Due to factors (*i*), (*ii*) and (*iii*) above, the gross interest differs widely but the net interest tends to be equal throughout the country.

Theories of Interest

Interest is one of the most controversial subject in Economics. A number of theories have been put forward to explain it:

(i) The Demand and Supply Theory

The rate of interest is the price of loans and is determined by the demand for loans, on the one hand, and the supply of loanable funds, on the other, so that the equilibrium rate (or natural rate) is the rate that equates demand and supply.

(ii) Time Preference Theory

– The supply of loanable funds come from saving. As with other things, more funds will generally be supplied, the higher the price, thus a high rate of interest will increase the supply of loanable funds.

– Time preference theories, including that of Bohm-Bawerk, stress the idea that the supply of loans depend on the fact that most people prefer to have a certain sum of money now than at some future time.

Interest therefore arises because one person prefers Rs. 1000/- now, to (say) Rs. 1050/- a year hence, while another prefers Rs. 1050/- a year hence to Rs. 1000/- now, lending and borrowing being possible only because the satisfaction of immediate wants occupies a higher place on the borrower's than on the lender's scale of preferences.

35.26 PROFIT

Introduction

– Like *Interest, Profit* is also the share of national income that goes to owners of capital.

– Profit is sometimes considered as the return to the *entrepreneur*—the person responsible for initiating production as distinguished from the *rentier* who is passive and merely lends capital.

– The profits of an entrepreneur is partly a true profit—payment for ownership-partly the wages of management. The national income is distributed either in payment for work or in payment for ownership : it goes either to labour or to capital.

– Profits is sometimes considered as a reward for bearing risk.

– Over all business in the long run, profit is simply a payment demanded by owners of capital from those who use the capital for production.

– Profit is the surplus, remaining after all the expenses of production, including wages of management, have been met. Profit goes to the owners of the business, who risk holding assets in that form.

– Variations in the rate of profit reflect variations in the size of the surplus produced by different industries and indicate the direction in which there is a demand for new capital.

If profits are high in certain industries that indicates high surplus production relative to labour

costs, so that capital is attracted into such industries, expanding production and lowering price.

Gross Profit & Net Profit

- After paying all the expenses of production, residue left with entrepreneur is named as *Gross Profit.*
- Gross profit contains one or more of the following elements :
  (*a*) Rent of Land/factory building.
  (*b*) Interest on capital used.
  (*c*) Wages for the workers.
  (*d*) Salaries of Managers and other indirect workers.
- Deduction for depreciation (of machinery *etc.*) and insurance charges have to be made from the gross profit to arrive at the net profit.
- *Pure or net profit* is a purely personal differential gain which accrues to the entrepreneur by reason of his enterprise and organising ability. It is the reward for two main functions *viz,* the *Risk taking function* and *superior bargaining skill* and is the balance of gross profit which is left after deducting the above terms.

Profit per annum and profit on the turnover

- When the rate of profit is calculated every time the capital of the business is turned over *i.e,* every time when the sales of the business are equal to the capital invested, we get *the rate of profit on the turnover.*
- When the rate of profit is calculated annually on the amount of capital invested in any particular trade, it is known as the *rate of profit per annum.*
- Profits per annum are generally high in the trades in which the work of management is difficult and risky.
- The rate of profit on the *turnover* varies much more widely than the *annual* rate of profits on capital.

35.27 WAGES

Introduction

- Wage may be defined as payment for the use of labour. It is the price of labour hired and employed by an entrepreneur.
- Wage is the share of the national *dividend* which accrues to labour, including all kinds of workers *e.g.* skilled, unskilled etc.
- In ordinary speech a distinction is frequently made between *wages and salaries* though economically there is no clear line of demarcation between them. Some people would demarcate wages from salaries like this :

Wages	Salaries
1. Wages are payments for manual work.	1. Salaries are payments for non manual work.
2. Wages are Paid weekly or so.	2. Salaries are paid at longer intervals *e.g.,* a month.
3. Wages are paid for a definite amount of work, as measured by time or piece, so that if less than a full week is worked a proportionate deduction from the weekly wage will be made.	3. Salaried workers suffer no such deductions.
4. Wages are a variable cost, varying with output.	4. In the short period, salaries are a fixed cost and so do not vary with output.
5. Wages are included in the Trading Account, drawn up to enable gross profit to be calculated.	5. Salaries are included in the Profit and Loss Account, as one of the expenses to be deducted from gross profit in order to arrive at net profit.

Nominal and Real Wages

- When wages are paid in term of money, they are called *Nominal wages.*
- The *real wages* consist in the amount of necessaries, comforts and luxuries which can be bought by nominal wages and other advantages which are offered by an occupation.

Wage Theories

(*a*) Subsistence Theory.

(*b*) Wage Fund Theory.

(*c*) Marginal Productivity Theory.

(*d*) The Bargaining Theory of wages.

(a) Subsistence Theory

- It states that wages tend to keep to a level that will provide the workers only with bare subsistance. If wages for a time rise above this level, it inevitably leads, it is said, to an increase in the population, and increased competition among workers for employment, causing wages to fal again. If wages fall below subsistence level, fewer children are born and malnutrition raises the death-rate, so that competition for employment is reduced and wages tend to rise.

(b) Wage Fund Theory

- At the time when the wage fund theory was developed it was thought that a fund of capital had to be accumulated in advance before wages could be paid. Thus the size of the fund limited the total amount available for payment of wages.
- Though the theory did not specifically say so, it appeared to imply that if one group of workers obtained a rise in wages it could be only at the expense of other workers, whose share of fund was thereby reduced.

  The theory ignored the fact that total output could increase and the wage-earners might also be able to benefit at the expense of capital.

(c) Marginal Productivity Theory

- According to this theory, the higher the wage, the smaller the amount of labour the entrepreneur will employ.
- Additional labour will be employed till the last addition to the total value of the product is only just covered by the wages paid to the marginal or the last worker taken on, without leaving any profit.
- Apparently, an employer cannot afford to pay more than the wealth produced by the labourer.
- As the number of labourers incoases, the productivity of each successive worker goes on decreasing. Ultimately a stage is reached where the productivity of the last or the marginal labourer is just equal to the wages paid to him. His contribution to production is known as *Marginal Productivity.* He is just on the margin of being employed or dismissed. It may be said that the maxium limit beyond which rates of wages cannot be paid to a labourer, is determined by its marginal productivity to the employer.

(d) The Bargaining Theory of Wages

- Earlier theories of wages have been rendered invalid or atleast inadequate, as a result of collective bargaining by trade unions.
- Collective bargaining provides an example of what is sometimes called bi-lateral monopoly, the trade union being the monopolist supplier and the employer's association, the monopolist buyer of a particular kind of labour.
- Level of wages in an industry depends on the bargaining strength of the trade union concerned.

The power of a trade union depends on the size of its membership, the size of its fighting fund and the extent of the dislocation to the national economy it can cause by a strike. In times of full employment, the union will be in a strong position, in a depression they will be weaker.

N.B. For more details refer chapter no.30.

35.28 INTRODUCTION TO BANKS AND BANKING

- A bank (German word) means a joint stock fund.
- A bank denotes a financial institution dealing in money.
- A bank is an institution that is prepared to accept deposits of money and repay the same on demand.
- The system of banking is very old and the same was prevalent in Greece, India and Rome.
- A banker (*i.e.* person or a corporation) deals in credit and money *i.e.* it accepts deposits from those who want to commit their wealth to *safety and earn interest* thereon, and lends money to the needy through cheques and advances and loans of various sorts.

35.29 FUNCTIONS OF BANK

A bank performs the following functions :

(a) It *accepts deposits* from the customers, who can take back their money at will. A saving bank also pays interest to customers on their deposits and is popular with small savers.

Customers can leave their cash with the bank as *Saving Account, Current Account or a Fixed Deposit Account.*

Customers deposit their money in *Saving Bank Account* to save a part of their current incomes to meet their future needs and also intend to earn an income from their savings (bank interest). For the depositor, the number of withdrawals over a period of time and the total amount of one or more withdrawals on any date, are however limited.

A *Current Account* on the other hand is running account which may be operated upon any number of times during a working day. There is no restriction on the number and amount of withdrawls. The bank does not pay any interst, rather it takes incidental charges from the depositor on such accounts in some cases.

In a *Fixed Deposit Account,* the deposits are made for a fixed period (say 36 months) and a higher rate of interst is paid to the depositor.

(b) A *bank lends money* to needy people at a certain interest rate. Banks give loan to agriculturists, industrialists and businessman who invest it in their ventures to their own profit and to the economic advancement of the country.

(c) A *bank issues notes* and creates other inexpensive media of exchange-a note or a cheque. The issue of notes is entrusted to the Reserve Bank of the country.

Credit instruments such a bank note, bank drafts, cheques and letters of credit are created by Banks. These things economise the use of metallic money and make the transmission of money over long distances cheap and convenient.

(d) The deposits may be created by the bank itself by giving loans to its customers, in which case the borrower is credited with a deposit account withdrawalable when needed. The money borrowed from the bank is usually deposited in the same bank by the borrowers either because the bank insists on it or because of the advantages of current account deposit. Such deposits are known as Credit Deposits.

(e) Other functions of a bank are :

(*i*) The collection of cheques drawn on other banks.

(*ii*) The acceptance and collection of bills of exchange.

(*iii*) Dealing in foreign exchange to assist the settlement of overseas debts.

(*iv*) Stock Exchange trustee and executor business.

(*v*) Safe deposit facilities.

(*vi*) Making standing order payments.

(*vii*) Supplying change and assisting the central bank/Reserve bank in keeping the note issue in good condition.

35.30 TYPES OF BANKS

The Indian Banking System consists of :

(*a*) The indigenous Banking System.

(*b*) The Modern Banking System :

(*i*) Commercial Banks

(*ii*) State Bank of India

(*iii*) Exchange Banks

(*iv*) Land Mortgage Banks

(*v*) Saving Banks

(*vi*) Cooperative Banks

(*vii*) The Reserve Bank of India.

35.31 THE INDIGENOUS BANKING SYSTEM

- The indigenous bankers are usually a family concern.
- Their main functions are

  To advance loans against ornaments, land etc.

  To deal in Hundies.

  To receive deposits.

35.32 COMMERCIAL BANKS

- Most of the banks in India are Commercial banks, *e.g.* Punjab National Bank, Allahabad Bank, United Commercial Bank etc.
- Such banks deal in short-term credit. They collect the surplus balances of the individuals and finance the temporary needs of commercial transactions.
- A commercial bank borrows money from individuals by accepting deposits on *current account saving account, fixed deposits and miscellaneous deposits* and then it lends money to Industrialists and Traders.
- As a *principle*, the commercial bank

(*a*) Supplies circulation capital rather than fixed capital,

(*b*) gives loans for short period only,

(*c*) does not involve itself too much with one industry only, because if that industry fails, the bank's assets may become frozen.

35.33 THE STATE BANK OF INDIA

- The Imperial Bank of India established on January 27,1921 was renamed as the State Bank of India on July 1, 1955 after passing of the State Bank of India Act, 1955.
- The State Bank of India has its central office in Bombay and seven loal head offices in Calcutta, Madras, Bombay, Delhi, Hyderabad, Kanpur and Ahmedabad.

- The *main functions* of the State Bank of India are :
  - (*i*) The bank borrows money from public by accepting deposits.
  - (*ii*) It lends money to industrialists, farmers and Traders for short periods.
  - (*iii*) It provides financial assistance to importers and exporters.
  - (*iv*) It undertakes foreign exchange business.
  - (*v*) It collects cheques, drafts, bill of exchange, dividends, interest, salaries and pension on behalf of customers.
  - (*vi*) It maintains safe deposit vaults.

35.34 EXCHANGE BANKS

- Whereas commercial banks finance the internal trade of the country, the Exchange banks finance its foreign trade.
- Exchange banks of our country will have their headoffice located outside India.
- *The functions of Exchange banks are* :
  - (*i*) To supply finance for imports and exports.
  - (*ii*) To purchase and discount bills of exchange drawn by Indian exporters and also collect on maturity the proceeds of bills drawn on Indian Importers for goods purchased by them.
  - (*iii*) To act as refrees, collecting and supplying information about the foreign customers, etc.
- A few foreign exchange banks in India are :
  - (*i*) The National and Grindlay Bank.
  - (*ii*) Lloyds Bank.
  - (*iii*) The Mercantile Bank.

If an exporter in Bangalore requires finance to move goods from Bangalore to Bombay port and from there to New York, he may enter into agreement with an exchange bank for financing the movement of his goods.

35.35. CENTRAL BANKS

- Central Bank of a country is an apex monetary and banking institution that controls the supply of currency in that country.
- Central bank is entrusted with the duty of regulating the volume of currency and credit in the country.
- Central bank controls the banking structure of country.
- Central bank controls and regulates the monetary, banking and credit policies of the country.
- Central bank determines the quantum of money which should be circulated in the country.
- Central bank performs general banking and agency services for the Government.
- All the banks keep reserves with the Central Bank and banking policies in the country are framed by it.
- Whereas the object of a commercial bank is to earn profit, a central bank stimulates growth of the country.
- Whereas a commercial bank deals with public directly, a central bank deals with commercial banks and other institutions and the government of the country.
- The central bank is the custodian of the foreign exchange reserves of the country.
- The central bank controls and regulates credit and currency with a view to stabilize prices in the country.

- The central bank pumps in more money when the market is short of cash and pumps out money when there is an excess of credit.

35.36. THE RESERVE BANK OF INDIA

- *Reserve Bank* of India was established as the *central bank* of the country on April 1,1935, though the idea existed since 1836.
- As the Central bank of the country, the Reserve Bank is the banker to the banks also.
- The Reserve Bank regulates the entire banking system of the country.
- It regulates the issue of bank notes and the keeping of reserves with a view to secure monetary stability in India and generally to operate the currency and credit system of the country to its advantage.
- It has also been given the power to pursue on appropriate credit policy. It has control over the cash reserves of the commercial banks.
- The Reserve Bank has also been given the power to issue licence to the banking companies in the country.
- The Reserve Bank is required to remove structural instability of the banking system and to provide leadership to the money market.
- The Reserve Bank was nationalised with the passing of an act in 1948 . The entire share capital of the bank was acquired by the Central Government w.e.f. Jan 1, 1949 and the Reserve Bank started functioning as a state-owned and state-controlled institution.
- The affairs of Reserve Bank are controlled by the Central Board of Directors consisting of twenty members. There are one Governor, four deputy governors, fourteen Directors and one Government offical nominated by the Central Goverment.
- For performing its function, the Reserve Bank consists of the following departments :

(i) *Issue department.* It has the sole right of note issue which must be backed by gold and sterling securities to the extent of 40%.

(ii) *Banking department.* It is authorized to accept money on deposit without interest, to purchase, sell and rediscount trade bills and bills against Government securities maturing within 90 days and bills against agricultural crops maturing within 9 months; to purchase and sell to member banks, sterling and to regulate credit in the interest of trade and industry.

(iii) *Exchange control department.* It controls foreign exchange transaction and maintains a stable rate of exchange.

(iv) *Department of Banking Operations and Development* extends banking facilities to semi-urban areas and keeps solving the problems of rural finance.

(v) *Industrial Finance Department* has been entrusted with all matters pertaining to industrial finance including the activities of state financial corporations.

(vi) *Research and Statistics Department* acts as an agency for the collection and dissemination of financial information and statistics in India and abroad.

(vii) *Legal Department* gives legal advice on various matters referred to it by other departments of the bank.

(viii) *Departments of Financial Companies* regulates the acceptance of deposits by non-banking companies.

(ix) *Department of Accounts and Expenditure* maintains and supervises Reserve Bank's accounts in the Issue and Banking Department.

(x) *Inspection Department* carries out periodic internal inspection of different offices and departments of the Reserve Bank.

(xi) *Department of Administration and Personnel deals* with general administration, training of staff and employer-employee relations.

(xii) *Secretary's Department* deals with policy matters relating to open market operations, floatation of Government loans and treasury bills and the Reserve Bank's dealings with international financial organisations.

35.37. MONEY MARKET

– Money market is in effect the mechanism through which the financial institutions come into contact with each other to borrow or to lend. To explain further, *money market* is a mechanism through which short-term funds are loaned and borrowed and through which a large part of financial transactions of particular country or of the world are cleared.

Various kinds of banks, discount houses, private bankers, bill brokers etc., all are taken as the constituents of a money market.

– *The functions of a money market are* :

(i) To supply capital and credit to the manufacturers, industrialists and traders for the purpose of production and exchange dealings.

(ii) To supply currency in accordance with business requirements of the country.

(iii) To maintain the relative stability of the purchasing power of the monetary standards.

– *The constituents of money market are* :

(i) *The lenders i.e.,*	Indigenous Bankers,
	Commercial Bankers
	Reserve and State Banks,
	Foreign Exchange Banks,
(ii) *The Borrower i.e.,*	Industrialists
	Traders
	Agriculturists, etc.

35.38 CREDIT

Concept of Credit

– *Cash transaction* is one in which cash is paid at the time of purchase of a commodity or service.

A *credit transaction* means that the buyer will pay for the commodity to the seller at a futre date. Thus *credit* implies the postponement of payment or deferring of a payment.

– Credit involves :

(i) Transfer of a commodity from one party to another,

(ii) postponement of its payment to a future date.

The seller must have confidence in the buyer that the buyer has the intention to pay and he will pay the price of the commodity at a later date as promised by him.

– In modern industrial economy, the whole economic structure is built with the *credit mortar*. The manufacturer gives his production to wholesaler on credit, the wholesaler sells it to retailer on credit and the consumer buys it from the retailer wholly or partially on credit.

– Credit is organised through the credit institutions and instruments.

Advantages of Credit System

(1) Credit encourages saving instinct and the formation of capital.

(2) Credit encourages production by allowing to flow the capital, formed by collecting small personal savings, into the hands of entrepreneurs to carry on their business.

(3) Credit enables to tide over temporary financial difficulties.

(4) A good credit policy minimises fluctuation in prices.

(5) Credit gives rise to credit instruments which economise the use of metallic money and thus substitute a cheap medium of exchange for a more expensive one.

Disadvantages of Credit System

(*i*) Credit enables a man of doubtful ability to start a speculative business and thus ruin himself and those who have given credit to him.

(*ii*) Credit may lead to extravagance and indebtedness endangering the smooth progress of society.

(*iii*) The greatest danger of credit is the liability of cretit to be over-issued.

Mechanisms of Operating Credit

(*a*) *Credit Instruments :*
(They are written evidences of indebtedness, issued by Govt./ Corporation/Individual, Containing a promise to pay money at a future date).

- Cheques
  - Bearer cheques
  - Order cheques
  - Crossed cheques
- Bank notes and currency notes
- Bill of exchange
- Promissory notes
- Bank draft
- Book credits

(*b*) *Credit Institutions*
(They consist of Banks with clearing houses).

- A **cheque** is a credit instrument so long as it is not presented for encashment. A cheque is a written order on a specified bank made by the depositor to pay a certain amount to a person who possesses the cheque or in whose name the cheque has been cut.

A *bearer cheque* is made payble to the person who-so ever presents it at the Bank for encashment.

An *order cheque* is made payable to a certain person only in whose name cheque is. It is the responsibility of the Bank to see that the payment is made to the right person.

A *crossed cheque* cannot be encashed at the bank counter; it can only be deposited in the Bank account of the person in whose name the cheque is. Crossed cheques are highly safe.

- A **Bank note or a currency note** is a promise by the bank or government to pay a certain sum of money on demand to the bearer of the note. When issued by a bank it is known as a *Bank note* and when issued by Government it is known as a *Currency note.*
- A **bill of exchange** is an order from a creditor to the debtor to pay the stated amount of money to himself or to a specified person or to the bearer after a definite period of time. A bill of exchange differs a cheque in the sense that whereas cheques can be encashed on demand while bills are payable after a stated period of time.
- **A promissory Note** is a promise of the borrower to the lender to pay a certain sum of money only to the lender or to the bearer of the promissory note, after stated period of time (Fig. 35.11). A promissory note is perhaps supported by the guarantee of some third person in whom the lender may have confidence.
- **A Bank Draft** is a kind of cheque. It is an order to pay money, drawn by one office of a bank upon another office of the same bank* for a sum of money payable to order on demand, inside or outside the country. A payment made by a cheque may dishonour but that made by a draft cannot, because the bank gives draft to a person only after it has received the amount (of draft) from that person.

* It can be drawn by one bank upon another bank also.

Rs. 10,000/-

Faridabad
Oct. 15, 1990

STAMP

Three months after sight of this bill, I promise to pay to M/s A.B.C. Traders, or order, the sum of Rupees Ten thousand only for value received.

Sd/- Raj Kumar

To

M/s. A.B.C. Traders
Faridabad

Guarantor
Sd/- Ram Swaroop

Fig. 35.11. A Promisory Note

- **Book Credit.** When a businessman sells on credit or a bank advances money, the transaction is entered into the account books of the businessman or of the bank and are legally recognised as evidences or credit.
- **Hundies** are indigenous credit instruments and are in use in Inda for a long time.

A hundi is more like a bill of exchange. It is accepted, endorsed and transferred just like a bill.

A hundi is usually written in a local language and regulated by local customs and traditions.

Hundies are issued by the borrower in the name of creditor with the promise to return his money on demand or after the stated period of time. The interest is paid to the creditor on the very day the money is borrowd at the rate mutually decided by the two parties. The commission is paid to the broker.

Important types of hundies are :

(i) Darshni hundies which are payble on demand.

(ii) Muddati hundies which are payble after the expiry of the term specified.

35.39. STOCK EXCHANGE

- Stock exchange is a place where dealings in stocks and shares take place, a market where those desiring to buy stocks and shares are brought into contact with those who want to sell. It is, therefore, primarily, mainly a market for existing securities.
- In simple words, the stock exchange is the market where securities, stocks, shares, debentures and bonds etc., are bought and sold freely.
- It is through the agency of stock exchange that people invest their money into joint stock companies. This money cannot be withdrawn from the company directly, but may be obtained back through its transfer. Shares, debentures etc., are transferable from one holder to another at rates existing in the market. If there were no stock exchanges, one could not have been able to dispose of his shares at the time of need, and thus very few people would have dared to invest their capital into loans floated by either the Government or other bodies.
- The price at which a security can be bought or sold on the stock exchange will depend, as in other markets, on the relative strength of the demand for and the supply of that particular security at a particular time. If business prospects are good, the prices of shares will generally be high; if prospects are poor, prices will be low. The publication of a company's balance sheet will affect the price of its shares favourably or adversely, as the case might be.
- The members of the Stock Exchanges are *Jobbers,* who deal on their own account, and *brokers,* who act as agents on commission between the public and jobbers.

A broker wishing to obtain stock or shares for a client will approach a jobber who deals in the required security and ask him to state a price, but without informing him whether he wishes to buy or sell. The jobber will quote two prices, the higher bring that at which he is prepared to sell, and the lower that at which he is prepared to buy. Thus, through the brokers and the jobbers buyers and sellers are brought into contact with one another.

- Since the exchange is a *perfect market* and since its deals are mainly for the settlement at the end or the fortnightly *Accounts*, its chief activity is *speculation*.

35.40 SPECULATION–BULL AND BEAR

Introduction

- Speculation may be defined as buying what you do not want, from someone who has not got it.
- There are two reasons why people buy stock exchange securities :
  - (*i*) Some people buy for the sake of investment, that is, with the intention of holding the securities in order to secure a regular income from their capital.
  - (*ii*) Other people pay little attention to the income to be obtained from securities, but are keenly interested to sell the securities when they believe prices are near the peak. These people are *speculators* and their aim is to take advantage of fluctuations in the prices of stocks and shares in order to make a profit for themselves. Such profits are known as capital gains.
- A speculator is neither a manufacturer nor a holder of goods. In fact, he deals in risks and not in goods. A speculator forsees a rise in prices in the future, he buys with the intention of selling afterwards at a profit and when he anticipates a fall in prices, he sells with a view to buy in future at lower prices.
- Those persons who buy securities hoping that their price will rise are known as *Bulls* and those who sell expecting prices to fall are known as *Bears*. If the market is keen to buy it is said to be *bullish* and if it is keen to sell, it is *bearish*.
- The existence of speculators in the market means that at all times it is possible to buy and sell. Speculation, therefore, helps to make securities more liquid.
- The activities of some speculators tend to steady prices, for they enter the market as buyers when most of the people desire to sell and so they prevent prices falling as much as they otherwise might; when others are wanting to buy they enter the market as sellers, and so prevent an undue rise in prices.

Advantages of Speculation

- (*i*) As explained above, speculation lessens price fluctuations.
- (*ii*) Speculation guides the investment of capital in securities.
- (*iii*) Speculation promotes the establishment of equilibrium between supply and demand and hence consumption becomes more steady.

Disadvantages of Speculation

- (*i*) Those indulging in speculation may attempt to influence prices by their own activities, trying to push prices down just before they buy or to raise prices before they sell.
- (*ii*) Speculation of an undesirable kind may therefore result in capital not being employed to the best advantage, and so lead to the misuse of real resources.
- (*iii*) Excessive speculation may lead to trade depressions.

Control of Speculation

The difficulty in controlling undesirable speculation is of distinguishing between speculative

dealings and genuine investment. The following suggestions may be put forward for restricting the activities of speculators on the securities market.

(*i*) Once securities are transferred to a new owner, he should not be permitted to dispose of them until a certain minimum period has elapsed.

(*ii*) Bank lending for speculative purposes might be restricted.

(*iii*) A capital-gains tax can be made to fall more heavily on short term capital gains.

35.41. PRINCIPLES OF TAXATION

– Taxation is required to cover Government expenditures such as cost of :

(*i*) Administration,

(*ii*) Defence from external aggression,

(*iii*) Police for the maintenance of law and order,

(*iv*) Judicial courts for administration of justice,

(*v*) Schools and colleges for giving education to people,

(*vi*) Hospitals for the preservation of health etc.

– The study of how the Government obtains its revenue and how it spends it, is known as **Public Finance.**

– The following *principles of taxation* are, however, generally accepted. These are *four canons* of Adam Smith laid down in his *Wealth of Nations.*

(*i*) Taxation should be *equal.*

(*ii*) Taxation should be *certain.*

(*iii*) Taxation should be *timely* and,

(*iv*) Taxation should be *economical to collect.*

– Adam Smith was of the view that the amounts people pay in taxes should be *equal*, by which in fact he meant proportional to their income. The people should be so taxed as to make them feel the burden of tax equally.

– There should be *certainty* with regard to the amount to be paid, for it should not be a tax-gatherer's business to squeeze as much as possible from the taxpayer. In other words, the form, quantity and manner of payment of the tax should be clear and plain to the contributor. There must be no confusion as to what, why and when he must pay.

– Tax should be paid in time, there should be convenience of payment and collection. The principle of *timeliness* or *convenience* is to the effect that taxes should be so selected and arranged in time and manner of collection as to disturb as little as possible both producer and consumer.

– *Economy* should be observed so that taxes should not be imposed of a kind where the cost of collection was excessive. The principle of economy in tax collection is generally conceded, for the State will benefit little if the tax is expensive to collect. A serious objection to bringing small incomes within the orbit of income tax is the heavy cost of collection. A tax may obstruct industry and cause unemployment, in which case it can hardly be considered economical.

35.42. DIRECT AND INDIRECT TAXES

– Taxes may be *Direct or Indirect.*

Direct tax

– It is borne by the persons on whom it is intended to be levied by the taxing authority. Direct tax is imposed on persons whom it is desired and intended should pay.

Examples of direct tax are :

Income Tax
Profits of companies (Corporation tax)
Capital gains tax, etc.

These are all taxes on different kinds of income, levied directly on the person receiving the income.

Direct taxes are usually collected at the very source and hence the cost of collection is comparatively very small and the chances of evasion are little.

The tax payer knows what to pay, why to pay and when to pay the direct tax.

Indirect tax

– An indirect tax is one, the burden of which is passed on by the person on whom it is imposed, to other persons. For example, import duties levied on foreign vehicles are collected from merchants importing them but ultimately this amount is realised (by them) from the customers, *i.e.*, the purchasers of the vehicles in the shape of increased prices of vehicles.

Indirect taxes are on goods and services, and so they are sometimes known as outlay taxes, since they are paid only when certain purchases are made.

How much a person pays indirect taxes depends on the extend to which he uses taxed goods or services.

Examples of indirect tax are :

Sales tax,

Excise duties etc.

Indirect taxation is the principal form of taxation on low incomes and is levied mainly on articles of wide consumption to ensure wide contribution. At the same time this form of taxation is the least equitable since it falls most heavily, in a relative sense, on the lowest incomes and has no relation to the capacity of the tax payer to bear the burden.

Luxury goods appear to be the things most suitable for indirect taxation but it is often very difficult to draw a sharp line of demarcation between luxuries and other things, and if luxury goods are rigidly defined, the total yield for taxing them is not likely to be very great.

The principle of indirect taxation is to spread taxation over as wide a range of goods and services as possible, so that people of all tastes are brought within the net.

Indirect taxes when levied on clothes, petrol, kerosen oil may agitate the public, but when applied on intoxicating liquors and drugs, do a distinct social service by restricting their consumption.

Indirect taxes make no distinction between rich and poor, and thus poor people have to make a bigger sacrifice. Indirect tax payers do not feel that they are paying tax and thus their civic consciousness remains unstimulated. Indirect taxes (such as custom duty) encourage smuggling of goods.

35.43. INCOME TAX

- It was first imposed by William Pitt in 1799 and since then income tax has become the most important direct tax.
- It is levied on annual incomes of both individuals and companies.
- Incomes below a certain minimum value are exempted from tax and as the income increases, the rate of charging the tax also increases.
- Income tax is deducted from salary and collected at the source by the employer who then deposits all the collection with the Government.
- Income tax rates are modified from time to time.

35.44. FREE TRADE AND PROTECTION

- **Free Trade** means freedom of international trade without any artificial restrictions on the course of trade that would naturally develop between different nations. As within a country, one can purchase in the cheapest market and can sell in the costlier one, similarly with free international trade, a country will buy in the cheaper market.
- **Protection** means safeguarding the domestic industries against foreign competition by Government regulation.

  It can be achieved by :

  (*a*) Imposing duties on foreign goods. Import duties aim at checking imports by making them dearer; import quotas more directly limit imports to certain predetermined amounts.

  (*b*) Giving grants and other facilities to the domestic industries during the period of infancy.

A lot can be said in favour of protection and against it. A few points in this connection are given below :

(*i*) Protection is required for the young and newly started industries of a country, otherwise such industries will never be able to establish themselves. However, a protective tariff for infant industries can be justified only if it is removed once the industry has become firmly established.

(*ii*) Protection, though helps industries in the country, the consumer suffers because he may be able to buy foreign goods at a cheap rate.

(*iii*) Curtailment of imports (by imposing duties on foreign goods) implies a decrease in exports too. If all the countries were to try for this object, none would gain.

(*iv*) In countries where the people enjoy high real wages, it is often felt that their standard of living will be undermined if cheap goods are imported from countries where wages are low.

(*v*) Protection equalises the cost of production of home and foreign countries. For example, if the internal cost of a coloured T.V. is **Rs.** 15,000 and that of a similar foreign T.V. is Rs. 13,000, then to equalise the prices, a duty of Rs. 2000 be levied on the imports.

35.45 FOREIGN EXCHANGE

- Foreign exchange is the name given to :

  (*i*) Either foreign currency, or to

  (*ii*) The means by which debts between foreign countries are settled.
- Money is essentially bank debts, therefore, it cannot physically move from one country to another, but debts in one country must be exchanged for debts in another.
- The process of making international payments is therefore one of exchanging the ownership of bank balances: an Englishman making a payment to India must obtain a bank balance in Rupees and give in exchange his bank balance in Sterling.

  The proceeds of Indian exports give merchants and banks in this country foreign currency which they use in payment for imports.

35.46. MECHANISM OF FOREIGN EXCHANGE

- Debts between two countries may be settled with the help of following mechanisms :

  (*i*) Bills of exchange,

  (*ii*) Cheques or drafts,

  (*iii*) Telegraphic transfer (T.T.),

  (*iv*) Mail transfers (M.T.).
- A *bill of exchange* is an order drawn by a person upon a bank or another person, asking the latter

to make certain payments to a third party. The exporters sell these to their banks, who get them collected in the foreign countries and credit to their accounts.

- For speedier payments *telegraphic transfers* (T.T.) are used : the Indian bank wires to the foreign bank with which it has an account to transfer the deposit at once to the account of a specified person.
- *Mail transfers* (M.T.) are similar to telegraphic transfers, except that they are sent by post.
- Both M.T.'s and T.T.'s are safer than drafts or cheques since there is no danger from loss.

35.47. FOREIGN EXCHANGE CONTROL

- Foreign exchange control is the child of economic difficulty born out of depression or war. The second World War brought about a great deal of exchange control in more or less all countries.
- In depression many countries found they could not meet all their overseas debts, *e.g.*, interest payments, on account of a big drop in the value of their exports, so in order to prevent heavy sales of their currency from depreciating it, they *blocked* the bank balances due to foreigners and merely refused to allow them to be offered in exchange from foreign currency.

  The problem of excess demand for foreign currency was solved by cutting off the demand at source ; the foreigners were left with their funds in the debtor country in which they had to spend their money themselves, since they were not allowed to exchange it for their own currencies.

  Exchange control coupled with the power to control imports is thus an alternative to a very heavy depreciation of the exchange value of a currency.
- Exchange control enables a country to control its foreign trade. All exporters are obliged to sell the foreign currency they receive, to the authorised Government Bank, where it is resold to the importers of such goods as the state desires to import. State authorises imports only upto the amount of foreign exchange available from exports. In India, the leading currencies can only be dealt in through the Reserve Bank which adjusts the proceeds of exports and imports in order of preference, the *rate of exchange* being determined by the Bank.
- The aim of exchange control is to keep exchange rates stable. The rate of exchange may be either higher or lower than the equilibrium rate of a free market. A country *pegging* the rate at a low level—that is under-valuing its currency—may do so to stimulate its export trade. New Zealand followed such a policy after 1933.

  A policy of over-valuation might be pursued in order to bolster up confidence in the currency at home, or to cheapen imports during time of war or preparation for war. Thus the German mark was over-valued in 1931.

35.48. INSURANCE, CONCEPT OF

- Insurance is a widely accepted method of safeguarding people against various hazards of life. It forms the foundation of the present day business. Without insurance, Banks may not finance business and without insurance many a businessman would become paupers through some unforeseen happenings beyond their control.
- Insurance is a contract under which a person(s) go on paying a sum of money (*i.e.*, premium) to an insurance company after regular intervals of time and in case the person suffers a loss on account of happening of some event, the insurance company pays to him so much money that the person is placed in the same position in which he was before the loss actually took place.
- Insurance does not actually avoid loss, rather it spreads the loss and protects the individuals from disaster. An insurance company collects the insurance premiums from all the persons insured and compensates the unfortunate sufferers and thus distributing the losses of unforeseen events on all.

- An insurance policy is the document embodying the contract between the insurer and the insured. Under such a contract a person or a company agrees, in consideration of receiving a series of payments called *premium*, to pay a lagrer sum if a certain event happens. The intention is to compensate the insured person for any damage suffered owing to the occurrence of the event insured against.
- Insurance enables a man to protect himself from loss from events beyond his control, and thus gives security in trade and is to public benefit.
- Almost any risk to which a man is liable may be insured against; but the three most common varities are :
  - (*i*) Life insurance,
  - (*ii*) Fire insurance,
  - (*iii*) Marine insurance.

35.49. LIFE ASSURANCE

- Life assurance guarantees the payment of a fixed sum of money to the dependents of the (person) assured at his death. In the case of an endowment policy, the payment to the dependents of the assured is either made on the death of the assured or at a fixed date.
- A life assurance policy may be taken out by a banker who has made advances to a borrower against securities which may prove of no value if the latter dies before the loan is repaid.
- To a businessman a life assurance policy is very useful. It may be used as a security for money advanced to the assured.
- Both the elements of *protection* and *saving* are present in case of life assurance. Systematic saving is possible because regular premiums are required to be compulsorily paid by the assured to the insurance company. This deposited premium cannot be withdrawn easily before the death of the assured or before the expiry of the term of the insurance policy.
- Life assurance fulfills the following needs of a person :
  - (*i*) Family needs
  - (*ii*) Old age needs
  - (*iii*) Need for education, marriage and settlement of children, etc.

35.50. FIRE INSURANCE

- Fire insurance is a method to compensate for the loss consequent upon destruction by fire. It relieves the insured from the horror of fire losses to which he is exposed.
- Fire causes huge losses every year. By taking fire insurance policy, the insured can get some compensation for the loss to him due to fire.
- The insurer or the insurance company acts as a middle man between all the persons who are exposed to fire risk on one hand and the members (*i.e.*, insured persons) who will be the actual victims of the fire losses, on the other. The insurance company charges the premium from all the insured members and makes good the losses when they occur to any of them.
- Fire insurance cannot avoid the break-out of fire, but it can compensate the insured and save him from a ruinous loss, at the cost of some others.
- The insured (person) cannot recover from the insurer any sum greater than that which represents the actual loss sustained.
- The *premium* required to insure a particular building or its contents, depends on the probability of fire, into which many factors enter, such as :

(*i*) The situation, (*ii*) Material of Construction,
(*iii*) Condition of electric wiring, (*iv*) Nature of business,
(*v*) Use of approved preventive appliances, *e.g.*, fire alarms, sprinklers, fire extinguishers, etc.

- Usually, before accepting a fire insurance risk, the company has the premises inspected by its surveyor.
- It is safest to take the insurable value as the cost of replacement or the market value.
- Separate policies should be taken for

Buildings	Fixtures	Machinery
Stock	Materials	Accessories etc.

35.51. MACHINERY INSURANCE

- Every class of

Boilers	Steam turbines	Machinery
Electric generators	Engines	Lifts, hoists and cranes, etc.

may be insured against breakdown.

- The advantages of machinery insurance are to minimize sudden and unexpected breakdowns, inefficiency in the operation of machinery and financial loss, therein.
- The machinery insurance premium covers loss or damage, including injuries, repairs or replacements, and periodic inspection and reports by engineer surveyors.

35.52. MARINE INSURANCE

- In marine insurance, the insurer undertakes to indemnify the insured in a manner and to the interest thereby agreed, against marine losses incident to marine adventure. Marine insurance covers the risks incidental to the transport of goods by sea when in transit.
- The rate of premium of marine insurance varies in accordance with the class of goods, their packing, nature of journey, vessel and port facilities.
- In a contract of marine insurance, the insurer agrees to compensate the owner of a ship or cargo for complete or partial loss at sea, or, in more legal language, it is a contract for indemnity against loss accruing to ship, cargo, freight etc, during a voyage.
- Given below is the *classification* of marine insurance :
  (*i*) *Hull insurance.* Insurance of vessel and its equipments.
  (*ii*) *Cargo insurance.* Insurance of wares, merchandise, property, goods etc.
  (*iii*) *Freight insurance.* Freight is to be payable for the carriage of cargoes. The carrier is unable to earn freight if the goods are not safely transported.
  (*iv*) *Liability hazards.* Marine insurance policy may include liability hazards such as collision or running down.
- Given below are the different *elements* of marine insurance act:
  (*i*) Features of general contract.
  (*ii*) Insurable interest
  (*iii*) Utmost good faith.
  (*iv*) Doctrine of indemnity.
  (*v*) Subrogation : Insured should not get more than the actual loss.
  (*vi*) Warranties.
  (*vii*) Proximate cause.
  (*viii*) Assignment and nomination of policy.
  (*ix*) Return of premium.

36

Computers

36.1. INTRODUCTION

- The advent of modernization turned the life of man more and more complex. So when his limited abilities surrendered before the mighty requirements, he realised the need of a *device* which was transcendently efficient and the solution was right in front of him – *A Computer.*
- A *computer* is an electronic device capable of performing a number of complex operations within no time. It has internal storage (for the program and the data being operated on), a stored program and program modification capabilities.
- A *computer* is basically an automatic information convertor. It can transfer raw and unusable data into a meaningful information.
- A *computer* is utilized for *processing* a set of information.
- A *computer* is a *data processor* that can perform substantial computation, including numerous arithmetic and logic operations without intervention of a human operator during the run.
- The main *characteristics* of the computer are :

  (*i*) Speed (*ii*) Accuracy (*iii*) Storage
  (*iv*) Versatility (*v*) Automation (*vi*) Diligence.
- Today **computer is used** by Government, public and private enterprise, and its technical and commercial applications reach ever further into the needs of modern communities.

In one role the computer will carry out routine tasks such as the preparation of *company payroll, invoicing*, or the *auditing* and *monitoring of warehouse* stocks, at another level it becomes a basic *research instrument* which is able to investigate, assess and isolate statistical information, or carry out engineering and scientific designs and calculations ; and in yet a third role it is a means of stabilising and controlling complex chemical plants and other industrial processes such as power stations and smelting furnaces etc.

Coupled with a capacity to store data in **memory banks**, and to make any segment of this data instantly accessible to the user, computer systems are now an essential feature of social administration and provide *industrial managements*, in particular, with a powerful and important tool.

36.2. HISTORY OF COMPUTERS

- The use of *fingers* was the first method of counting.
- The *Stone-age man* used *pebbles* for counting.
- Having found that fingers or the quantity of pebbles were not able to cope with increased requirements of computation, the man employed other methods for computation such as scratches on stones, trees etc.
- The process required further perfection and a sort of adding machine called ABACUS was invented in *China* about 400 B.C.

An *abacus* consists of a rectangular wooden frame with wires, which carry similar round beads. Counting is performed by shifting the beads from one side to the other (Fig. 36.1).

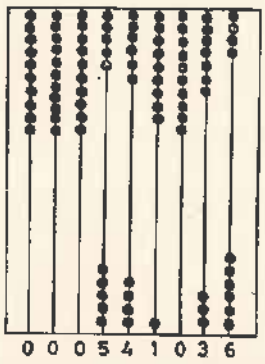


Fig. 36.1. A Russian Abacus reading the number 541036.

– In 1617, a Scots mathematician **Napier** invented *Computing rods* which are called *Napier's Bones.*

There are a set of eleven rods having four faces, with numbers marked on them in such a way that by simply placing the rods side by side, products and quotients of large numbers can be obtained.

Napier also invented **logarithm,** which is still used by some students to do complex arithmetical calculations.

– *Napier's* invention of logarithms led to the development of the **Slide Rule** in the year 1632 by English Mathematician **William Oughtred.** Slide rules were used extensively for doing calculations (until the electronic calculators were introduced).

– You would have seen some mechanical calculators being used in some offices, provision shops or super markets to add or subtract numbers and prepare bills for the customers. These machines were first invented by **Blaise Pascal** in 1642. The machine invented by *Pascal* was limited to *addition* and *subtraction.*

– **Gottfried Liebniz** (1646-1716) later improved upon *Pascal's* machine to do multiplication and division.

Incidentally Liebniz was the first to recognize the true potential of the *Binary System.*

– **Joseph Marie Jacquard** in 1801 invented the first *punched-card machine.* The pattern woven by the *loom* was determined by the placement of *holes* in a control *card* ; only those *threads* whose guiding hook encountered a hole in the card could enter the pattern.

– In 1822 **Charles Babbage** of England known as the father of Computers, invented a machine which he named as **Difference Engine,** in order to automatically perform simple computations needed for trigonometric and logarithmic tables.

Inspired by *automatic Jacquard looms*, Babbage *proposed* an **Analytical Engine** which had four components :

(*i*) Storage device (*iii*) Control unit

(*ii*) Arithmetic unit (*iv*) Input-output device.

This concept is still used in our modern computers.

Due to the limited technology available at those times, Babbage was not in a position to build *Analytical Engine.*

– In 1855, **George Scheutz,** a Swede, made a machine based on Babbage's principles and drawings.

– In 1889, **Dr. Herman Hollerith** of America developed the idea given by *Jacquard* and introduced the world with the *punching of cards as a means of coding.* Numbers and alphabets were punched

on the cards by holes. These cards were mounted on machines which after reading these cards, operated accordingly.

In 1896, *Hollerith* formed his own company, The *Tabulation Machine Company* which, however, he sold in 1911. It merged with two other companies to form the *Tabulation Recording Company by 1924*, this company became the *International Business Machines* (IBM), the largest manufacturer, even today, of *computers*.

- During the years between 1920 and 1930 the *punched card system* developed steadily not only in USA but also in Britain and other parts of Europe.
- During *second world war* (early forties) development in computer science took place at a faster rate. Computers were used to understand the code of enemy and for designing aircrafts. *Computerised radars* were also made.
- In 1944, an American **Howard Aiken** developed a computer, which he called as **Mark-I**. This computer was based on the principles of electronics. It was capable of performing five basic operations—addition, subtraction, division, multiplication and table reference. It was extremely slow by present day standard. It was very noisy, bulky and its size was 15 m×0.6 m×2.4 m ($l \times w \times h$). Present day fourth generation micro computer can be mounted on a table measuring 1.2 m×0.7 m. In *Mark-I* the input and output were by punched cards and paper tapes.

  Soon after Mark-I, *Aiken* himself introduced the world by Mark-II, Mark-III and Mark-IV computers which were some improved versions of their predecessors.
- In 1946, *University of Pennsylvania* developed *Electronic Numerical Integrator And Calculator* (ENIAC) which was the first electronic computer of the world.

  ENIAC weighed about 27 tons, occupied a room 15 m×9 m, contained 18000 vacuum tubes, 1500 relays and consumed 150 kW of electricity. It could perform 5000 additions in one second. The addition of two numbers was achieved in 200 microseconds and multiplication in 2800 micro-seconds.

  The internal operations of this machine were conducted by electronic impulses generated at a rate of 100,000 per second.
- Neumann was the first to introduce the *stored program concept* in the computer.
- Based on *Neumann's* idea, between 1947-1950, the Moore School personnel and the Ballistics Research Laboratory of U.S. Army built the computer EDVAC (Electronic Discrete Variable Automatic Computer).

Another Computer using internal storage, called EDSAC *(Electronic Delay Storage Automatic Computer)* was completed in 1949 at the *University of Manchester (England)*. EDSAC was of some significance since it was the first computer to contain a changeable program of instructions within its own memory.

36.3. GENERATIONS OF COMPUTERS

The growth of computer is studied in five distinct phases (or age groups). These age groups are called *generations of Computer*. The different generations are characterized by their technology of basic Computing elements. The different elements are :

(*i*) Valve.

(*ii*) Transistor.

(*iii*) Integrated circuit.

(*iv*) Micro-processor chips or VLSI Chips.

(*v*) Large Scale Inference Systems.

Generation	*Electronic Component*	*Advantages*	*Disadvantages*	*Comments*
Ist generation 1940–52	Vacuum Tubes	Vacuum tubes were the only electronic components available	Large size and space needed Generated heat Air conditioning required, unreliable, slow, constant maintenance, cost-crores of rupees	Manual assembly of individual components into a functioning unit
2nd generation 1952–64	Transistors	Smaller size, Less heat generated, More reliable, faster, accurate, Less power consumption	Air conditioning required Maintenance	As above
3rd generation 1964–71	Integrated circuits	Even smaller size, even less heat generation, less power required, Even more reliable, faster still.	Initially problems with manufacture	Less human labour at assembly stage
4th generation since 1971	Large scale integrated circuits (LSI)	No A.C. reqd Min. Maintenance High component density, cheapest		As above
5th generation yet to come	Ultra large scale Integration circuits (ULSI)	Artificial Intelligence		

(*i*) **First Generation Computers (1940–1954)**

– The first generation computers used diodes or triode valves (or vacuum tubes) for the electronic components and the copper wire for connecting different components of a Computer. It used either electrostatic tubes (CRT) or mercury delay lines for storage.

– *Computers of first generation are*

1. ENIAC was the beginning of the first generation computers. There were 18000 vacuum tubes, 70,000 resistors, 10,000 capacitors and 60,000 switches in it. It consumed 150 kW of electricity.
2. EDSAC built by M.V. Wilkes at Cambridge University in 1949.
3. EDVAC built at Pennsylvania University in 1950.
4. Lyons Electronic Office (LEO), the first Commercial Computer produced by M.V. Wilkes in 1951.
5. Universal Accounting Company-1 (UNIVAC-1) produced in 1951 by Universal Accounting Company set up by Eckert and Mauchly.

6. IBM-701 and IBM-650, were introduced in 1953 and 1954 respectively by International Business Machines Corporation (I.B.M.). The IBM -650 was the first modern digital computer produced on the mass scale.

(*ii*) Second Generation Computers (1952-64)

- The second generation machines were initially marked by either magnetic drum or magnetic core storage and, later, by the use of the *Transistor* in place of vacuum tubes.
- Because transistors were much smaller in size, the Computer became compact and consumed less power.
- In place of copper wire connections, the components were fixed on printed circuit boards. As a result computers
  became smaller in size,
  cost came down,
  the speed increased manifold, and the emission of heat was greatly reduced.
- Second generation computers were used for scientific and mathematical applications as also for business type *applications.*
- By 1960, U.S.A. alone had more than 5000 computers.
- Some of the second generation computers are :-

Model	*Size*	*Application*
IBM-1620	Small	Scientific
IBM-1401	Small to medium	Business
IBM-7094	Large	Scientific and business
CDC-1604	Medium to large	Scientific
CDC-3600	Large	Scientific
RCA-501	Medium	Business
UNIVAC-1108	Large	Scientific and business

IBM-1401 was the most popular of second generation computers.

(*iii*) Third Generation Computer (1964-1971)

- Computers of third generation were made still smaller with larger capacity, by using small ceramic plates on which the integrated circuits were produced.
- These computers were characterized by integrated circuits, improved secondary storage devices and new input-output devices like-visual display units (V.D.U.) and high speed printers.
- These computers were called *Mini Computers.* The solid state discrete components (*e.g.*, instead of having one *transistor** of its own, several transistors could be integrated with the other components) were packed into integrated circuits (IC). The IC was invented by Jack Kiby at Texas Instruments in year 1958. These computers used integrated circuits built on wafer-thin-stices of extremely purified silicon crystal popularly known as *chip.*
- These computers used integrated circuits. The technology used was *Large Scale Integration.* Each I.C. incorporated hundreds of Transistors.
- In addition to computers main memory, secondary or auxiliary better storage devices were developed. These devices made multi-purpose and multi-programming possible.
- Improved input/output devices such as VDU's, and High speed printers were used.
- Third generation Computers were of small size, low cost and large memory.
- Some of such computers are

Model	*Application*
IBM-360 Series	Scientific and Business
IBM-370/168	Scientific and Business
ICL-2903	Education, affairs of local government, and small business

*A transistor is a bistable logic element. It can be on, allowing current to flow through it, or it can be off, denying current flow.

(*iv*) Fourth Generation Computers (Since 1971)

- With the development of *Micro-processor chips** or large scale integrated circuits (LSIC) and very large scale Integrated Circuits (VLSIC) in 1971 by Intel Corporation of USA, another breed of computers known as *Micro Computers* came into existence in 1974 and became popular as *fourth generation of computers.*
- *Altair* was the first Micro-Computer designed by Ed. Roberts, President of MITS.
- In 1970, an Englishman Clive from Cambridge designed the smallest and cheapest computer available at that time—called *Personal Computer Sinclairs ZX-80.* It could be linked with a TV set for visual display.
- The first pocket computer Sharp PC 1211 was sold by Japan in year 1980.
- The *Apple* series of micro-computers was developed by Steve Wozniak and Steve Jobs in 1976. This used 8 bit++ *micro processor* chip. The chip enabled to put together a complete computer, a key board for input, a processor and few thousand characters in memory and screen ; all in a small box.
- Fourth generation computers are of small size. They can occupy an office Table only with all its *peripherals* (external parts of a computer).
- The capacity of such computers is unimaginably large due to ultra high capacity storage devices. These computers have
  Excellent speed
  Reliability, and
  Low cost.
- Some of fourth generation Computers are :-
  Intel 4004
  Apple I and II
  DCM Spectrum-7
  ZX-Spectrum
  BBC's Accorn
  IBM Compatibles etc.
  Sinclairs ZX-81

(*v*) Fifth Generation Computers

- The fifth generation is the story of the new super-breed of computers now being planned by the Japanese. Research is going on using Ultra Large Scale Integration (ULSI) technology. The result of this technology is a super chip.
- The fifth generation computers will

1. Have ability to understand normal human speech.
2. Be able to conduct a dialogue with users by means of synthesized speech.
3. Have ability to perform intelligently to human queries.
4. Have ability to learn from experience of the past.

- *Artificial intelligence* (A.I.) is the main charm for these computers.
- The fifth generation computers, once developed, will have three sub-systems.

(*a*) External interface of basic software system,

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* When an entire Central Processing Unit (CPU) is placed on a single micro-chip, then it is called as micro- processor. Micro-chips are also used for storing information. The product of VLSI is micro chip which is an integration of thousands of transistors.

++ The digits 0 and 1 are called BITS.

(*b*) Basic software system

- Problem solving
- Knowledge base,
- Intelligent interface

(*c*) Hardware system.

36.4. DIFFERENCE BETWEEN A CALCULATOR AND A COMPUTER

(1) A computer can perform the job of a calculator, but a calculator is not competent of performing the job of a computer. For example, if one has to arrange 5000 numbers in increasing or decreasing order of magnitude, it will not be possible on a calculator. On the other hand, a computer would follow the concerned programme and arrange the given numbers in order of magnitude in a very short time.

(2) A calculator requires *Manual* attention at every stage of operation and has no provision for storing the programme and data. Since a computer can store both programme and data, it is also referred as a Stored Programme Device.

(3) *Computers* differentiate them from *calculators* in features such as high *speed* of operation, internal *memory* and stored *program.*

36.5. CHARACTERISTICS OF COMPUTERS

The main characteristics of the computer are :

(i) **Speed**

Electrical pulses travel at incredible speeds and, because the computer is electronic (and not tied down to mechanical movements, turning of wheels, slipping of clutches and gears), its internal speed is virtually instantaneous.

We do not talk in terms of seconds or even, today, of milliseconds (thousandths of a second). Our units of speed are the *microsecond* (millionths), the *nenosecond* (thousand-millionths) and even the *picosecond* (million millionths).

(ii) **Storage**

As a human brain retains important things in its memory and relegates unimportant details to the back of the mind, the computer also stores certain amount of information in the internal memory of CPU (Central Processing Unit) and other data can be stored outside the memory of the CPU, on *auxiliary* or *secondary* storage devices, usually magnetic *tape* or *disk.*

(iii) **Accuracy**

The accuracy of Computers is consistently high. Almost without exception, the errors in computing are due to human rather than to technological weaknesses.

(iv) **Versatility**

- Computers seem capable of performing almost any task, provided that the task can be reduced to a series of logical steps.
- The computer actually performs the following four basic operations and many daily activities can be reduced to an interplay between these functions.

1. It exchanges information with the outside world *via* input/output devices.
2. It transfers data internally within the CPU.
3. It performs the basic arithmetical operations.
4. It performs operations of comparison.

(v) **Automation**

A computer is automatic (unlike a calculator which requires human operators to press the necessary keys for the operations to be performed).

In computer once the process has begun, it would continue without the need for human intervention until completion.

(vi) **Diligence**

Computer, being a machine, does not suffer from the human traits of tiredness and lack of concentration. If 4 million calculations have to be performed, it will perform the 4 millionth calculation with *exactly* the same accuracy and speed as the first.

36.6. LIMITATIONS OF COMPUTERS

(*i*) Computer finds itself helpless in the areas involving *creative thoughts* and the development of *original ideas*. The computers upto 4th generation do not have any *thinking* and *decision* taking ability.

(*ii*) Computer parts require regular *checking* and *maintenance* in order to give correct results.

(*iii*) Computer needs a *dust* and *traffic* free place of installation.

(*iv*) Due to very fast working, some parts of Computer get heated up. They are required to be kept cool, otherwise they may stop functioning. This needs the workplace to be *air-conditioned.*

(*v*) The output of the computer depends upon the skill of the programmer. The mode in which the computer has to perform and the sequence in which the data is to be processed to solve a particular problem are the things that are decided by human brain.

(*vi*) Computer is a costly item beyond the reach of every user.

36.7. CLASSIFICATION OF COMPUTERS

Computers in general are of three types based on their *function* (the way they work *i.e.*, operations) :

1. *Digital Computers*
   - Super computer
   - Main frame computer
   - Mini Computer
   - Micro computer
   - Personal computer
2. *Analogue Computers*
3. *Hybrid Computers.*

36.8. DIGITAL COMPUTERS

- A computer which operates essentially on *digits* and *numbers* is known as digital computer.
- Digital computer accepts data in the form of *digits*, subjects the data to mathematical processing, and finally presents the *user* with a *result* based on these operations.
- Digital computers represent *numbers* by *discrete* coded pattern (*e.g.* digital data), such as perforations in card or presence of pulses.
- Mathematical expressions are finally represented by *Binary digits* (0 and 1) and all operations are done using these digits at very high rate.
- A digital computer operates on *inputs* that are *on-off* or incrementally-stepped quantities which are represented by numerical digits.
- The digital computer incorporates an electronic memory. This is, in fact, an information store which may be activated at any point to influence or modify the calculations in hand.
- Digital computers have vast *applications* and are the most popular. They are useful for evaluating

arithmetical expressions, such as solution of quadratic equations or simultaneous equations, preparation of budgets, bills, payrolls etc. Generally the digital computer is applied to the processing of business and administrative data.

Digital computers can be further classified in accordance with their *memory-size* as follows :-

(*a*) Desk Top (Personal Computer) ..... 32 kb

(*b*) Micro-Computers ..... Upto 256 kb

(*c*) Mini--Computers ..... 256 Kb to 12 Mb.

(*d*) Super-Mini Computers ..... 1Mb to 80 Mb.

(*e*) Mini Main Frame Computer ..... 2 Mb to 128 Mb

(*f*) Maxi or Super Computer ..... 8 Mb to 256 Mb

Each information which is to be stored in the Computer's memory is coded into some special combinations of zeros and ones.

The digits 0 and 1 are called BITS (a contracted combination of BInary and digiTS). Every BIT is represented by electronic switches where *on* switch represents 1 and *off* switch 0.

1 Byte (b) = 8 or 2^3 BITS.

1 Kilobyte (Kb) = 1024 or 2^{10} BITS.

1 Megabyte (Mb) = 1024 or 2^{10} Kilobytes.

WORD is a group of BITS, the length of which varies from computer to computer, but it is predetermined for each computer machine. The *WORD-length* may be as long as 60 BITS or as short as 8 BITS.

Main Frame Computer

- Main frame computer occupies a large airconditioned roomful space. Since all its peripherals are mounted in large cabinet type of *frames*, it is called *Main frame computer.*
- This computer can be used by 128 users simultaneously in time sharing mode. The main memory size of this computer is upto 128 Mb.
- In respect of storage and processing capacity, main frame computer is the strongest one.
- It is used when very voluminous computations are to be carried out in a very short time.
- Computations regarding the flight of artificial satellites cannot be taken up on a micro or mini computer.
- All the first to third generation computers which work with the speed of 5 to 100 million instructions per second fall under this group.
- Some of the examples of main frame computers are :

  IBM 308-580 series

  IBM 4300,4381

  DEC 1090

  UNIVAC 1100/70

  ACOS 100

- **Super Computer** is a main frame computer. Super computers are generally used as Net-work Computers, *e.g.*, accounts in a branch bank can be controlled by a Super Computer in head office, World-wide Airlines reservations can be controlled etc.

Mini-Computers

- A mini Computer is in between the main frame computer and the micro computer.
- The storing and processing capacities of mini-computer are greater than that of micro-computer.

- Mini Computers are at least 5 times more faster than micro-computers having CPU speed of approximately 500 kilo instructions per second.
- In comparison with main frame computer, the capacity of mini-computer is smaller.
- The *bytes* used in mini-computer comprise of 16 bits. Some mini computers also have bytes of 32 bits.
- In mini-computer, there is also provision of a key-board for insertion of data and program. The final results are displayed on the screen of mini computer.
- Some of the mini computers are :-

  TDC-316, 332

  IBM-9370.

Micro-Computers

- A micro-computer is called so because of two reasons : one, because it is miniature in size and another because it uses micro processor.
- A micro-computer does not occupy much space, its maintenance is easy and it is less costly than the mini or main frame computers.
- The entire CPU of micro computer is contained in a single silicon micro-chip of thumb nail size called microprocessor. A micro-processor unit is not a complete micro-computer, because a micro-processor does not contain memory unit, input unit and output unit. Therefore when equipped with memory and input/output control circuits the micro-processor is known as micro-computer.

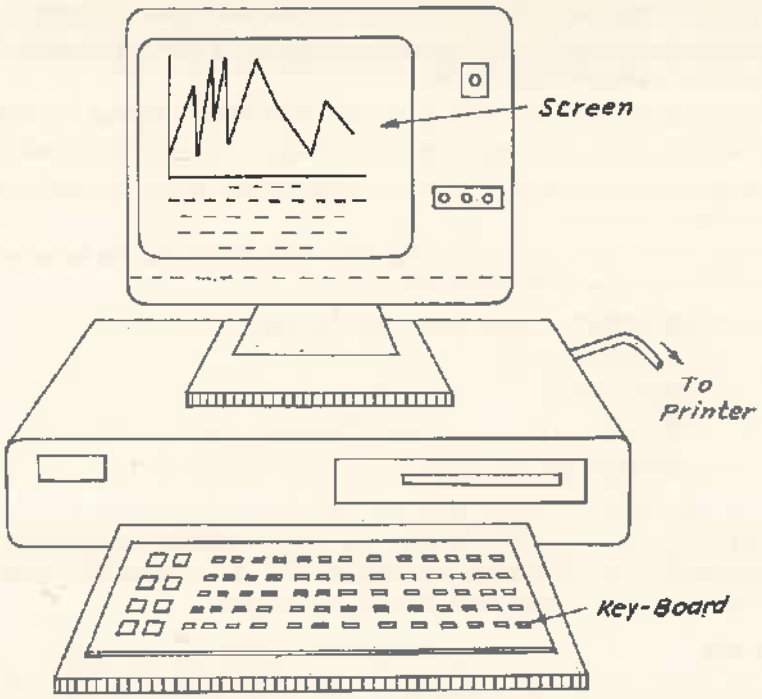


Fig. 36.2. Micro-computer.

- In some micro-computers, even the memory, and the input/output unit are also contained in the same chip. This further reduces the size of the micro-computer.
- Early micro-computers had a word length of 8 BITS but currently 16 BITS micro are available..
- The speed of the micro-computer is of the order of 100 Kips (Kilo Instructions per second).
- Micro-computers are suitable for a medium sized organisation, colleges etc. They have generally a visual display unit, key board, one or two floppy disk drives and printer (Fig. 36.2).
- Some of the micro-computers are Z X 81, BBC Acron etc.

36.9. ANALOG COMPUTERS

- An *analog computer* is one which solves the problems by preparing *analogue models* of mathematical equations of physical phenomenon. Analogue or *Analog means* establishing similarities between two quantities.

In analog computers, similarities are established in form of current or voltage signals. Analog computers use electronic circuitry to represent physical processes, with changes in electric current representing the behaviour of the system being studied.

- *Analog* computers operate by *measuring*, whereas *digital* computers operate by *counting*.
- Whereas digital computers work on discrete (digital) quantities, analog computers work on continuous quantities such as length of rods, voltage across terminals, forces in springs etc.
- While using an analog computer, a physical system is first converted into equations which are then further converted into analogue electrical signals.

The arithmetical operations are performed electrically using small signal amplifier blocks. The results so obtained are then decoded into mathematical form or in the form of graphs.

- An analog computer is used in the investigation of physical systems and simulates—*i.e.* creates an analogue of the elements of these systems, by means of synonymous electrical voltages.

Permutations of these voltages represent changes in the system and hence can be manipulated to reproduce the variety of situations under study.

The analog computer, therefore, accepts and processes data in the form of *continuously variable physical quantities.*

- An analog computer,

(*a*) sets up analogy of problem,

(*b*) represents physical variable by continuous measurement of analogous quantity (*e.g.* voltage, shaft rotation etc),

(*c*) is best suited to represent *measurable* quantities and simulate response of physical systems by mathematical analogies,

(*d*) does not have good accuracy.

- By analog computer method, it is easy to get graphical results directly.
- They can solve differential equations, can find not only real roots but complex roots also of a polynomial.
- The analog computer, because it has only a limited memory facility and is restricted in the type of calculations it can perform. can only be used for certain specialised engineering and scientific applications.

36.10. HYBRID COMPUTERS

- Design features of Analog and Digital Computers can be combined to create a *Hybrid Computer.*
- In this form of computers, a single machine is equipped with both Analogue and Digital capacity.

- In hybrid computers, some calculations are done in analog portion of computer and some are done on digital portion of the same computer. Then it utilizes the services of the devices which convert analog signals into digital, and digital signals into analog wherever necessary.
- Hybrid computers are specialised machines intended for *special-purpose* applications and, as such, are not generally encountered by the public.
- Hybrid computers are most expensive computers and are used in most sophisticated areas such as space flight, dropping of bombs on the targets, monitoring of the space activities etc.
- Some hybrid computers are

  Apple II

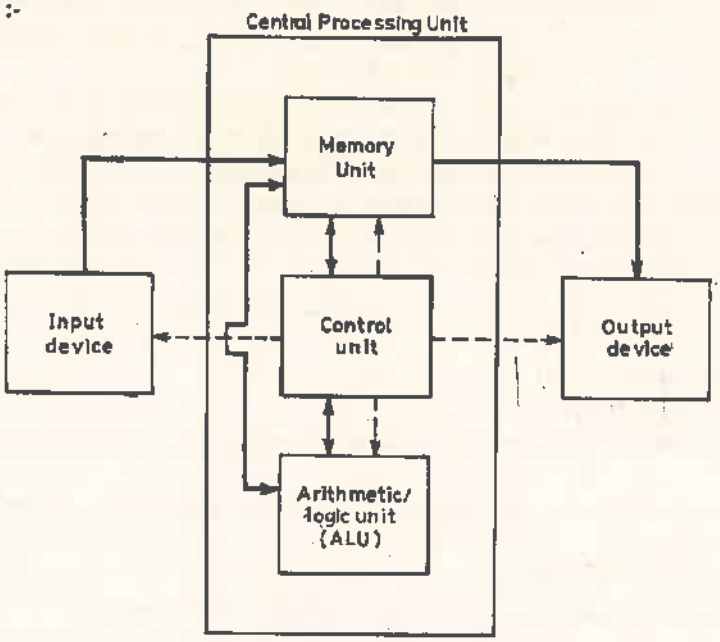
  TDC-3000

  BBC series

Most Modern Computers are digital computers and it is usually digital computers that are referred to when the word *Computer* is used. Digital computer is the *everyday unit* to be found in modern commercial and industrial undertaking–which is described in the following pages.

36.11. COMPUTER STRUCTURE (OR ANATOMY)

- A computer essentially consists of the following functional elements/constituents/basic components :-



——Data flow, - - - - -control of events

Fig. 36.3. Computer structure.

(1) *Input Units/systems/devices* — Program, Raw data, Key board

(2) *Central Processing Unit (CPU)* — Memory unit, Control unit, Arithmetic/Logic Unit (ALU)

(3) *Output unit/devices* — Final Results; Printer

The parts of the computing machine which are involved in the transfer of data to and from the outside world are known as **peripheral devices** *e.g.*, (1) and (3) above.

1. Input Unit and Devices

- If a person has to use the Computer to solve his problem, he will have to make computer understand his problem in the *language* which the computer can understand.
- The *input unit* (a) accepts the data or the program of instructions given by the user and

(b) It converts the data/instructions from man readable form to machine (computer) readable code.

- *Input devices* are used to transfer the information *into* the computing machine.
- The most commonly used *input device* is the *punched card reader* . The *input medium* in this case is *punched card.*

Paper tape readers are used as input device when input data has been placed on punched paper tape.

Magnetic character readers are used mainly in banks for cheque processing.

Optical scanners are becoming more popular, especially for reading ticket-type data, such as gasoline charge tickets and air line tickets.

- To conclude, the *function of the input unit* is to feed the data and program to the *memory unit* of C.P.U. Actually, *input* and *output units* are meant for creating communication between the user (man) and computer.

(2) Central Processing Unit (CPU)

- CPU is popularly called as the *Heart* (memory unit), *Brain* (ALU) and *Nervous System* (control unit) of the computer.
- It provides *central control* of the functions of the whole computing machine.
- It is the *computer* part of the computer system.
- *Functions of a CPU are :-*

(*i*) To store data as well as program (instructions).

(*ii*) To control the sequence of operations as per the stored instructions.

(*iii*) To issue commands to all parts of the computer system.

(*iv*) To carry out *data processing* and send results to *output unit.* Data processing implies the processing of information (specially business type information) by computer.

- *CPU contains :-*

(*i*) A memory unit,

(*ii*) A Control unit,

(*iii*) An Arithmetic and Logic Unit (ALU)

(*i*) Memory Unit

- Memory unit of the CPU is a place where the Computer *Program** and *data*+ are stored during processing. It is a random access storage device, consisting of a number of storage locations, each storage location being identified by a unique number, called as its *address.*

* The program is the set of "instructions" which the computer is to carry out.

+ The data is the "information" on which these instructions are to operate.

– The data that are to be stored in the memory unit for processing are fixed by the computer program, and the particular storage locations which are to receive these data are assigned when the program is loaded into the memory.

Normally, each data item called as a *field* is assigned to a particular storage location so that the item may be directly accessed, by means of the address of the storage location.

– The *Main or Internal Memory* (called *Primary storage* also) usually contains the program being executed and the data required by that program.

– The commonly used *devices* of main storage memory are :-

(*a*) Magnetic core memory

(*b*) Thin film memory

(*c*) Thin rod memory

(*d*) Plated wire memory

– *Main memory stores the following :-*

(*a*) Instructions waiting to be obeyed by other components of the CPU

(*b*) Instructions currently being obeyed.

(*c*) Data awaiting processing.

(*d*) Data currently being processed.

(*e*) Processed data awaiting output.

– The information required by the computer for its immediate needs is stored in the *Internal Memory* while the rest of the information is stored on *Secondary storage* devices.

– *Secondary storage* also called *Auxiliary storage* is supplementary to the primary (Internal) storage associated with the CPU.

Secondary storage is used to hold programs and data file and has large capacity storage relative to the internal memory. When a data record or program is to be used in processing, it is copied from the secondary storage into the primary storage. After processing, the updated record is stored back in its storage position in the secondary storage.

Punched cards can be used for secondary storage, but *magnetically encoded storage media* is usually more desirable, because data once written on them, after being used, can be erased and new data can be recorded in place of old one as in a home tape recorder. The *most popular* magnetic storage media are *magnetic tape* and *magnetic disk.*

– The *storing capacity* of main (internal) memory unit of computer is *limited* but the capacity of secondary stage is practically *unlimited*. The data which are to be used rarely and are voluminous in size are kept in secondary storage.

(ii) **The Control Unit**

– The control unit directs all operations inside the computer. It is known as the nerve centre of the computer because it controls and co-ordinates all hardware operations.

– Referring to Fig. 36.3 the *program* (instructions) and *data* are transferred, *under the direction of the control unit,* from the input device into the memory.

During program execution, each instruction is retrieved in turn (proper sequence) from the memory and interpreted.

Control unit informs the (Arithmetic/Logic Unit) ALU of the precise operation to be performed and directs the transfer to the ALU of any item of data which is needed for the operation. *The ALU then executes all calculations and comparisons.*

Results destined for output are then passed to memory where they are held in storage temporarily, prior to presentation by the output device. This procedure also takes place under the direction of the control unit.

- The control unit may be a *hardwired control* or a *microprogrammed control.*
- *To summarize,*

The control unit is designed to coordinate the representation, storage and internal movement of instructions and data, as well as the interpretation and subsequent execution of those instructions, and it then has to pass on the results.

(iii) **The Arithmetic /Logic Unit (ALU)**

- The ALU comprises of a number of *accumulators** and *registers+*.
- The ALU derives all the data from the main (internal) memory as directed by control unit based on program given to it. This *data* gets loaded into accumulators in the ALU.
- The ALU *operates* on the *data* available in the main memory and sends it back after *processing*, once again to main memory for onward transmission to output unit/device.
- ALU is that part of CPU where all the arithmetical and logical operations are performed. Constructed from high speed electronic components, ALU is a sophisticated piece of circuitry which will perform some specified operation on the data presented to its inputs. Typical of the operations that an ALU is able to perform are :

(1) It carries out *arithmetical* operations such as addition, subtraction, multiplication and division.

(2) It performs certain *logical* operations based on AND, OR, EXCLUSIVE, OR.

(3) Manipulation operations such as SHIFT, TEST.

(3) Output Unit and Devices

- The *function* of the output devices is to get (results) information *out* of the CPU.
- The output unit (Fig.36.3) receives the *results* of processed data from the main memory unit. These results are in binary signals. Therefore provision is made in the output unit so that the results, given in binary units, may be translated into understandable language.
- **Various Output devices** are

Line Printers	Visual Display Unit (VDU)
Punched cards	Punched tape
Magnetic tape unit	Magnetic disk unit etc.

36.12. COMPUTER SYSTEM

- A computer with all its *peripherals*** is called a system. *Data processing*++ is done by this system.
- Elements of a computer (processing) system are :

(*a*) Hardware

(*b*) Software

(*c*) Humanware

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* Accumulator—A register and associated equipment in the arithmetic unit of the computer where arithmetic and logical operations are performed.

+ Register—A hardware device for holding data (usually a computer word) to be operated upon.

** Peripheral devices—the input, output and storage devices normally operated under computer control.

++ Data Processing – To collect all items of Data together to produce meaningful information is known as data processing. The system is called 'Manual', when processing is performed by human beings and 'Automatic' when machines are used. When computers are used for data processing, the system is called E.D.P.

(*d*) User Programs

(*e*) Procedures.

(*a*) **Hardware**

– *Hardware* refers to the *physical units i.e.,* the electronic devices etc., which make up a computer system.

– There are three basic hardware components of a general-purpose digital Computer :

(1) Input section

(2) Central Processing Unit (CPU)

(3) Output section.

– In other words, hardware involves *equipment* which can perform the following functions :-

(*i*) Data preparation (example : card punch)

(*ii*) Input to computer (example : card reader)

(*iii*) Processing (CPU)

(*iv*) Secondary storage (example : disk, tape), and

(*v*) Output from computer (example : printer)

– Hardware is the jargon term given to the machinery itself and to the various individual pieces of equipment.

When the hardware is linked together to form an effective working unit we have a *Computer Installation.* (Fig. 36.4).

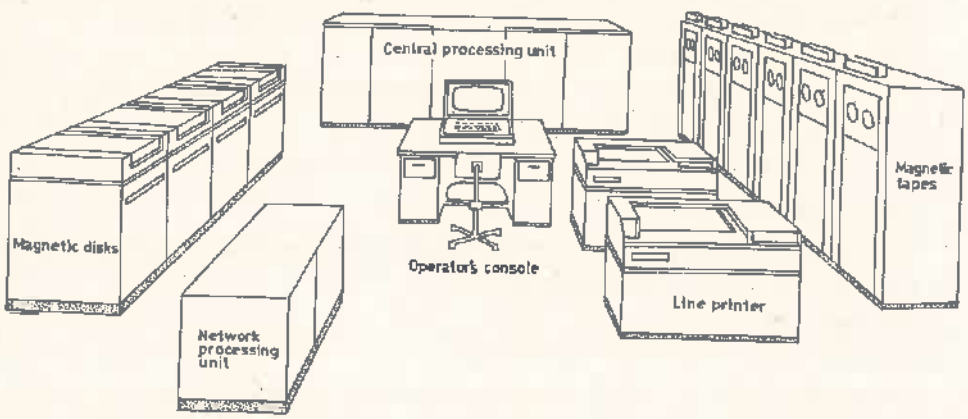


Fig. 36.4. A Computer Installation.

– However, you can do nothing useful with the computer hardware on its own. It has to be driven by certain utility programs, called *Software,* which are input and stored permanently in the computer system.

(*b*) Software

- Any problem before it is fed into a computer should be programmed. That is, the necessary operations to be done should be written in a systematic manner. These instructions/program as a whole are called *software.* These programs are written in a language which the computer can read and interpret.
- All the forms of *programs* associated with computer which *command* the computer to work are called *softwares.*
- *Software* consists of non-hardware *aids,* namely computer programs and computer routines which facilitate the operation of the computer by the user installation.

These *aids* consist of computer programs for standard tasks such as

(1) Sorting data records,

(2) Organizing and maintaining files,

(3) Translating programs written in a symbolic language into machine language instructions, and

(4) Scheduling jobs through computer.

- *Software* are a collection of programs written to bring the hardware of a computer system into operation and to best advantage.
- *Software* includes programs, languages, procedures, rules and associated documentation used in the operation of a data processing system.
- The term software can include user programs, but more commonly refers only to general programming and operating programs which are made available from the hardware manufacturer. Software is as vital to effective use of a computer as the hardware.
- *Common software aids are :*

(1) *Assemblers* provide a means of converting *symbolic language* programs into the *machine language* instructions required by the computer on a *one for one* basis.

(2) The *Compiler* is the link which translates a *symbolic language* (COBOL, FORTRAN etc.) into the form suitable for specific makes of computer and also performs the function of an assembler.

- *Software* are *grouped* into two classes :-

  System software

  Applications software

(*c*) Humanware

- All the persons associated with computer in any way may be called *humanware, e.g.*

(1) *Systems analyst,* who studies information and processing requirements. Designs the flow of operations and prepares other specifications for the processing system.

(2) *Programmer,* who has a skill in writing computer instructions.

(3) *Computer operator,* who operaters the computer.

(4) Hardware maintenance engineer etc.

(*d*) User Programs

- A program consists of a set of instructions to the computer to perform operations which accomplish processing task.

A data processing job may require a number of programs.

The user normally writes his own programs for applications unique to his installations. However, generalized applications programs can be purchased or leased from software organizations.

The terms *Routine* and *Program* are somewhat synonymous. *Routine* refers to a set of instructions to perform a particular process. A *program* may consist of one or more routines—for example, an input routine, a processing routine and an output routine.

(e) Procedures

– The operation of a data processing system requires procedures for use :

(1) In obtaining and preparing data,

(2) For operating the computer,

(3) For distributing output from processing,

(4) For initiating new programs etc.

– These *procedures* include control steps such as actions to be taken in the event of errors (or actions) if there is a malfunctioning of the equipment.

36.13. ORGANISATION OF DIGITAL COMPUTER

– Fig. 36.5 shows the basic arrangement for computer organisation.

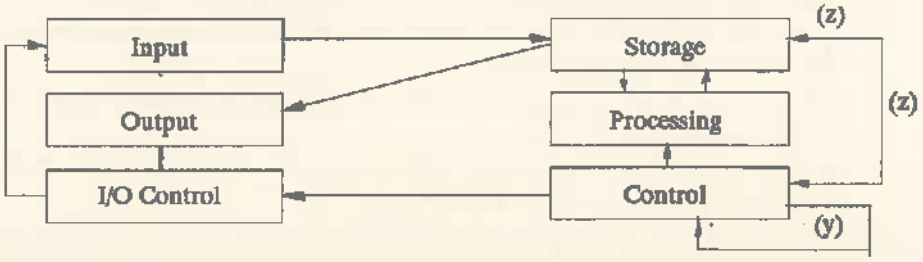


Fig. 36.5. Computer organisation.

– The main features of this organisation structure are :-

1. Input and output units are directly connected to storage (memory). This will free the processing unit from the necessity of waiting while input and output data move through them.
2. An additional subsidiary (I/O) control unit has been provided to work under the direction of (main) control unit and to assist it.
3. The control unit has the power to change the sequence of instructions it gives to different units of the computer organisation. This is achieved by adding a further line of communication (y) in the circuit (Fig 36.5).
4. The control has been provided with direct access with storage, using the line of communication (z). Thus, the control will have added ability for READ and REMEMBER information it is processing. This (arrangement) may be called *stored programme arrangement.*

– The present day computers are mostly arranged in the manner as explained above differing only in details.

36.14. COMPUTER PERIPHERALS

– The parts of the computing machine which are involved in the transfer of data to and from the outside world are known as *peripheral devices* and can be categorized as follows :-

(1) *Input* devices used to transfer information *into* the computing machine.

(2) *Output* devices used to transfer information *out* from the computing machine to the outside world.

(3) *Input/Output* (I/O) devices which can be used for both the input or the output of data. Such devices are capable of communicating in both modes.

(4) *Television Technology* these are currently available methods of data transmission based on television.

(5) *Specific transducers* devices which will sense such things as pressure, temperature etc., and pass information directly into the computer.

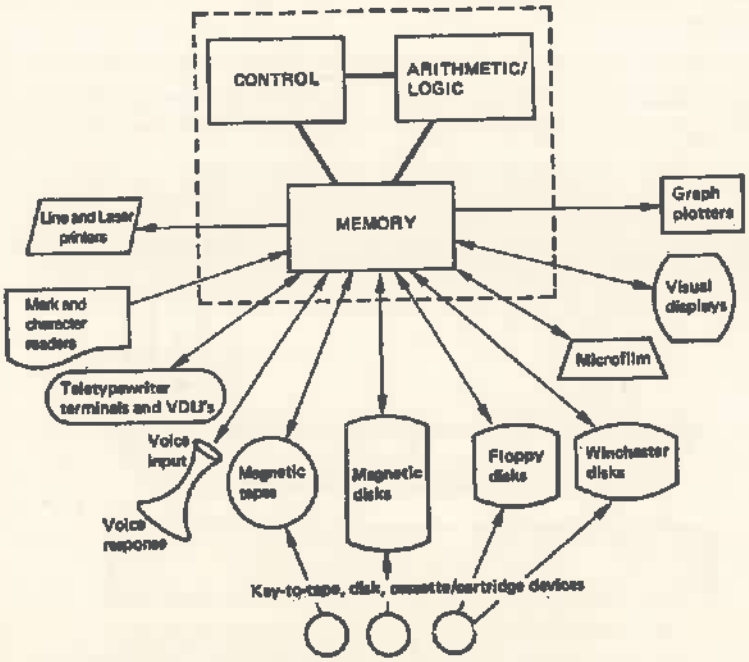


Fig. 36.6. CPU and the peripheral devices.

36.15. INPUT DEVICES

- The *input unit* is meant to receive the *data* from the programmer.
- The *data* is prepared on an *input medium* (*e.g.* punched cards) in the *coded form* understandable to the computer.
- This *coded data* is fed to an *input device* (*e.g.* punched card reader) and is translated by it automatically in a form which is recognized by the computer machine. In other words, *input devices* are basically meant for presenting the information to computer machine in a readable form.
- The *input unit* may consist of one or several input devices.
- Some of the *input medium* and *devices* have been explained below.

Input medium	*Input devices*
Punched Card	Punch card reader
Paper tape	Paper tape reader
Magnetic tape	Magnetic tape reader
Magnetic tape or Cassette/cartridge	Key-to-tape
Magnetic disk or Floppy disk	Key-to-disk
Cards or special forms	Mark-reader
Documents	Optical character reader
Documents (mainly cheque)	Magnetic ink character reader
Key board or CRT screen	Terminal
Light pen on C.R.T. Device	CRT (Cathode Ray Tube) screen
Audible Signal Receiver	NB : Direct entry via spoken words.

(1) Punched Cards Input

– The standard present day *punched card* is a piece of thin card board measuring $7\frac{3}{8}$ inches $\times 3\frac{1}{4}$ inches. It is divided horizontally into 12 rows and vertically into 80 columns. A particular character is represented by a unique pattern of holes punched into one column (Fig. 36.7).

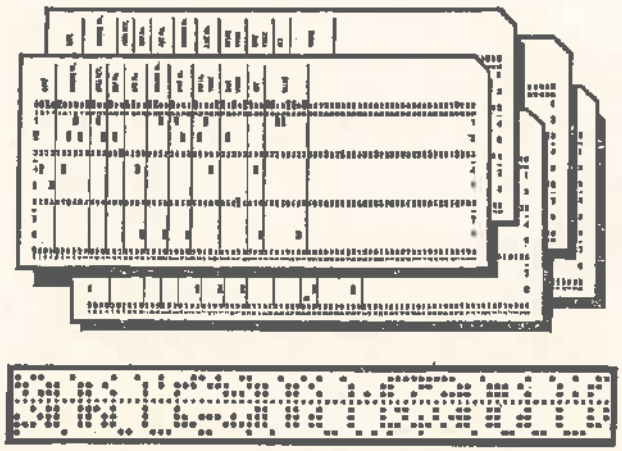


Fig. 36.7. *(Above)* 80-column punched cards : read into the computer *via* the card reader. *(Below)* 7-channel punched paper tape for computer input.

– Cards are prepared by a person typing on the keyboard of a machine known as a *Card punch.*

– The deck of cards thus prepared (and then verified) can be read into the computer by a peripheral device known as a *card reader* at speeds of up to 30 cards per second.

Advantages

1. Card codes are universal.
2. A card may be easily added to, inserted, removed or replaced from a *deck* of cards.
3. Cards may be processed off-line (that is on machines not connected to the computer) *e.g.* sorted, merged, collated, reproduced.

Disadvantages

1. Rarely all card columns are used.
2. A card reader is a relatively slow input device.
3. Require verification–additional equipment.
4. It is relatively expensive.

(2) Paper Tape Input

– Information is represented in a machine readable form as a pattern of holes across the width of a strip of paper tape (Fig. 36.7 and 36.8).

– The tape itself is typically one inch wide, successive characters being represented by a pattern of up to eight holes at a spacing of ten characters to the inch.

– The tape is prepared on the keybord of a machine known as a *paper tape punch.* When all the tape has been prepared (and this usually involves a *verification* process to check that the correct data has been punched) the information on the tape can be read by *a paper-tape reader* operating with the help of light beam and photo electric cells. The light passing through the hole in the tape activates the photoelectric cell.

Paper tape reader reads the data quickly upto speeds of 2000 characters per second.

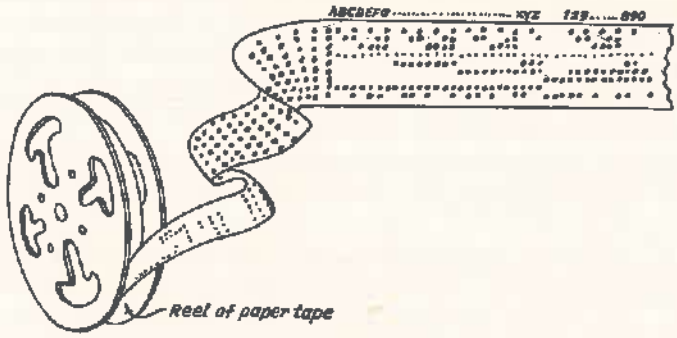


Fig. 36.8. Paper Tape.

- Paper tape can be thought of as being a *Continuous* punched card. This presents *advantages* such as the fact that no individual record can be lost or put out of sequence because (unlike punched cards) all are on the continuous tape. However, paper tape is more difficult to correct and is less flexible for sorting etc.

  The paper tape punch is *less expensive* than a card punch.
- The *paper tape input* is frequently transcribed to magnetic tape in a paper tape to magnetic tape run before further processing is performed on the data.

(3) Magnetic Tape

- Magnetic tape consists of a plastic base coated with an iron oxide coating. Tape measuring 1/2" wide is most common (Fig. 36.9).
- Magnetic tape is very effective and inexpensive storage and very widely used.
- The recording of data on magnetic tape is similar in concept to a home tape recorder.

Writing (recording) on the tape destroys the previous contents; *reading* may be repeated, since it does not alter the contents.

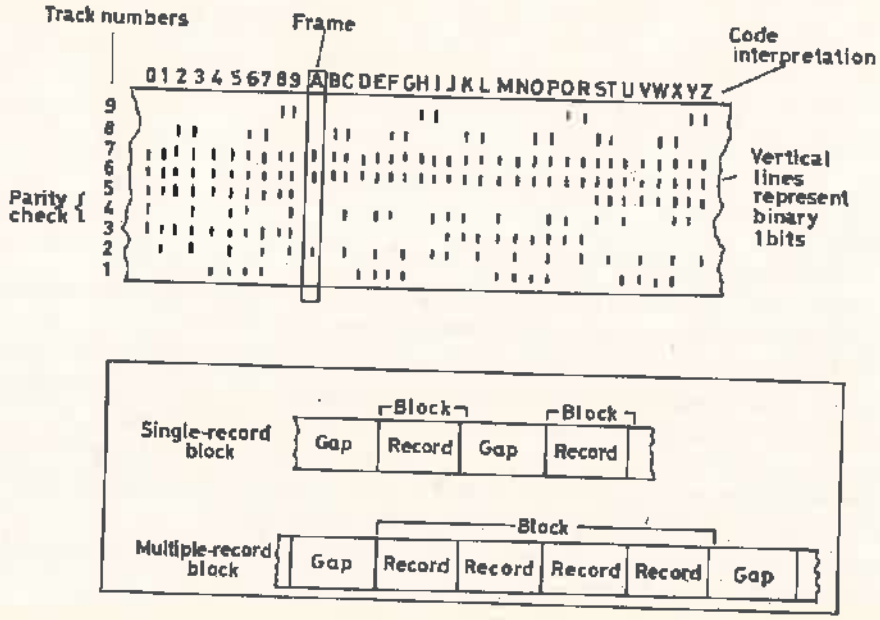


Fig. 36.9. Nine-track magnetic tape.

- The information is retained on the tape in the form of magnetized and non-magnetized spots (representing 1s and 0s) which are arranged in tracks, normally nine, running the length of the tape. To represent a character in tracks, special codes are needed. Data is physically stored on the tape in *blocks*. The blocks are separated by an interblock gap.
- A parity bit is included on the tape for checking purposes.
- Several methods, all quite similar, are used to drive the *tape* past the *read-write* heads and to permit the tape to be started and stopped quickly. A vacuum operated tape unit is shown in Fig. 36.10.
- As shown in Fig. 36.10 the tape runs from a supply reel to a take-up reel *via* two vacuum chambers and the read-write head. The two vacuum chambers are designed to take up slack tape, acting as buffers to prevent the tape from snapping or stretching when starting from a stationary position or slowing down from full speed.
- In addition, magnetic tape is widely used to back-up information on *magnetic disk*. The use of *cartridge tape* for this purpose is associated particularly with microcomputer systems.

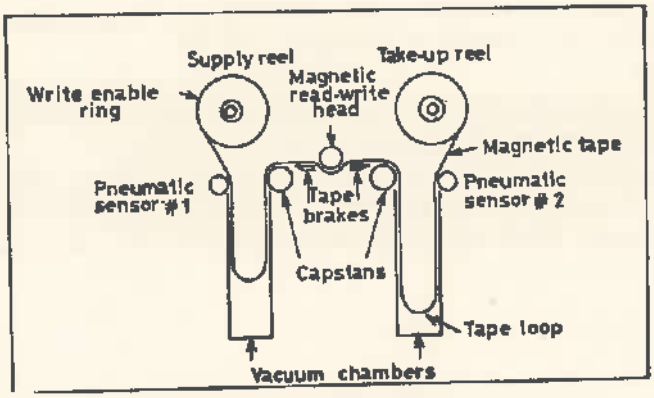


Fig. 36.10. Vacuum-operated magnetic tape drive.

(4) Magnetic disk

- In shape a magnetic disk resembles an LP record.
- A *disk pack* consists of six or more disks mounted about ½" apart on a central hub which rotates, spinning the disks at speeds of 60 or more revolutions per second.
- Information is recorded on both sides of each disk as a series of magnetized or non-magnetized spots. As with magnetic tape, the information on magnetic disk can be accessed again and again and when fresh data is recorded it simply replaces the existing information.
- On a magnetic disk, information is stored on *tracks* arranged in concentric circles (Fig. 36.11) with each character represented by a pattern of *bits* in sequence on one track. Although varying in length, each track contains the same number of characters.
- Each *track* is normally subdivided into *sectors* and information is accessed by track and sector address (80 ; 4, that is 80th track and 4th sector).

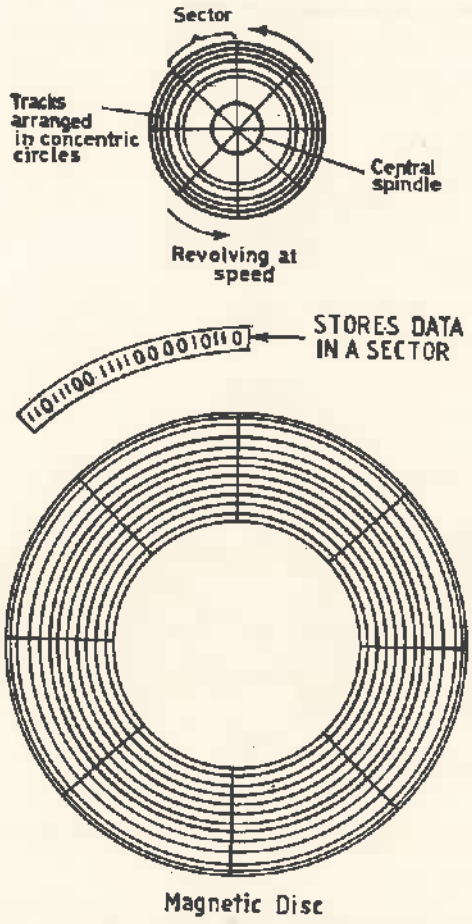


Fig. 36.11. Tracks and sectors of a disk.

- The diameter of the magnetic disk is 14" and there may be several hundred tracks per surface (400- 1600) each with a storage capacity of thousands of characters. Disk packs are potentially very high capacity storage devices typically in the range of 20 to 1000 megabytes.
- There are two types of *read/write head units* for magnetic disk devices—a *moving head unit* and a *fixed head unit* (Fig. 36.12).
- In the *moving head unit,* the head moves horizontally across the surface of the disk so that it is able to *access* each track individually. There is head for each surface and all the heads move in unison. Exchangeable disk packs are only associated with moving head units.
- A *fixed-head unit* has one read/write head for each track, as a result of which, no head movement is needed and information is therfore traced more quickly.
- The heads do not have direct contact with the disc surface but *rest* on a cushion of air. The air movement caused by the revolving disk forces the head to *fly* about 1/400th of an inch from the surface.

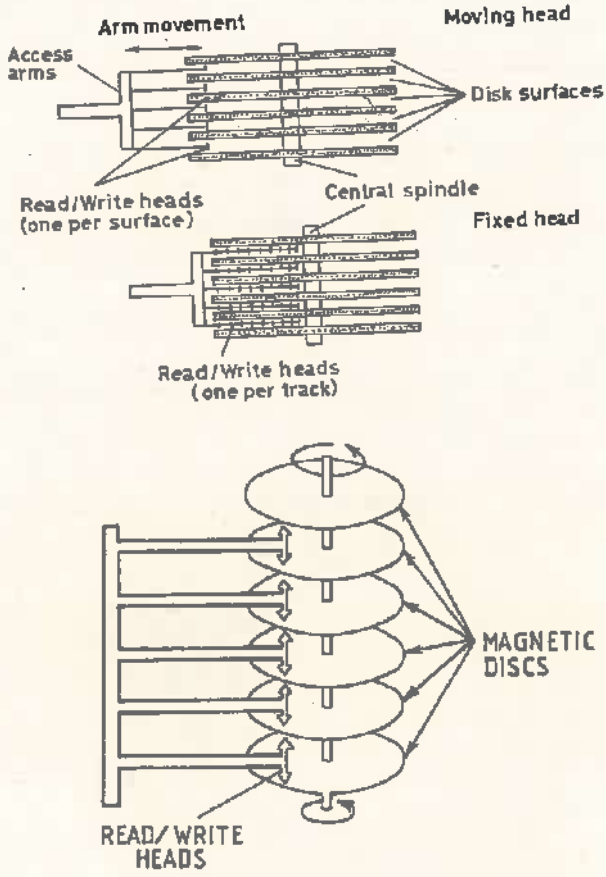


Fig. 36.12. Read-write head units for magnetic disk packs.

(5) Disc Systems (Floppy)

- **Disc systems** take many forms which are commonly categorized as :-

  (a) Floppy *(b) Hard*

  (c) Fixed *(d) Exchangeable*

- **Floppy** and **hard** relate to the nature of the base *material* upon which the magnetic material is coated. If it is constructed from *flexible plastic material* the term *floppy* is used. If the material is rigid the term *hard* is used.
- *Floppy* systems tend to be much cheaper, not be so critical in their manufacturing tolerances but also have a much *slower* data transfer rate and smaller data capacity than *hard disc* systems.
- Floppy disks tend to predominate in micro-computer systems where the requirement for large, fast disk storage is not necessary.
- The floppy disc was developed in the early 70's as a cheap and fast alternative to storage on magnetic tape.
- The disc is made of flexible plastic and coated in magnetic oxide. There are two recognized standard sizes, 8" and 5¼", frequently referred to as *diskette* and *mini-floppy* respectively. A more recent developemt is the 3½" size.

- The capacity of an 8" diskette is typically between 250 Kb and 1.5 Mb and that of 5¼" mini floppy is between 125 Kb and 500 Kb.
- For protection, the floppy disk is normally contained within a plastic or cardboard sleeve, often referred to as a *cartridge* (Fig. 36.13). The cartridge is readily loaded into and unloaded from a *drive* unit.

  Unlike the moving-head read/write mechanism on magnetic disk drives, the heads on a floppy disc unit make contact with the rotating disc surface, when reading or writing and disks therefore get worn with constant use.
- The floppy disc is a low cost device particularly *suited* to supporting personal computer systems and for use with small business and word processing systems.
- A **fixed disc system** is one in which it is not possible to remove the disk(s) from the drive mechanism.
- An **exchangeable disc system** is one in which the disk can be removed and replaced by a different disk. An exchangeable system allows for unlimited storage but only a part of the total can be accessed at any one time.

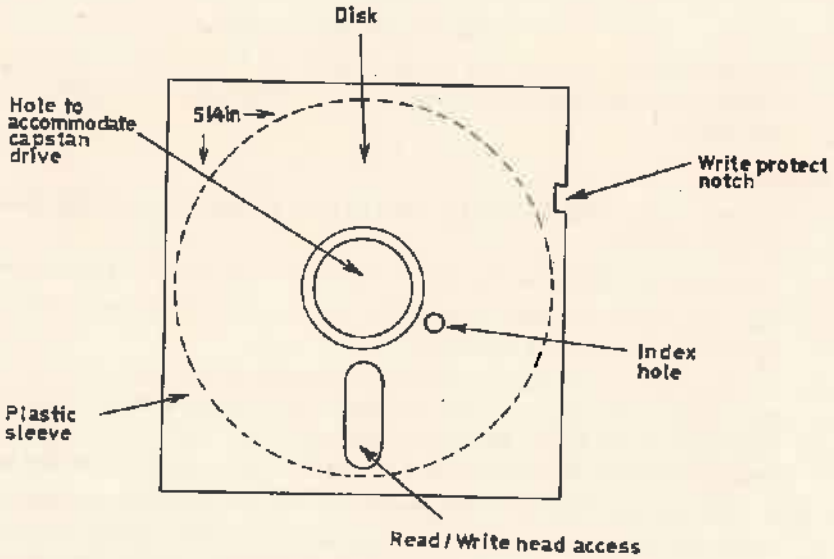


Fig. 36.13. A floppy disk.

(6) Winchester disk

- Winchester disks are used to support mini-computers and micro-computers and they compete with floppies in the rapidly expanding areas of personal computing, word processing and business applications.
- Winchester disks are hermetically sealed units, in which the read/write heads are designed to take off and land on the disc surface (Fig. 36.14). The disc is coated with a special lubricant which reduces the friction when the heads land and the sealed chamber prevents contamination from dust etc.
- Winchester disks are available in 5¼", 8" and 14" sizes, but 8 inch is the most common. Storage capacities range from around 10 Mb to 456 Mb or more. There are also 3½" disks which can store 40 Mb or more.

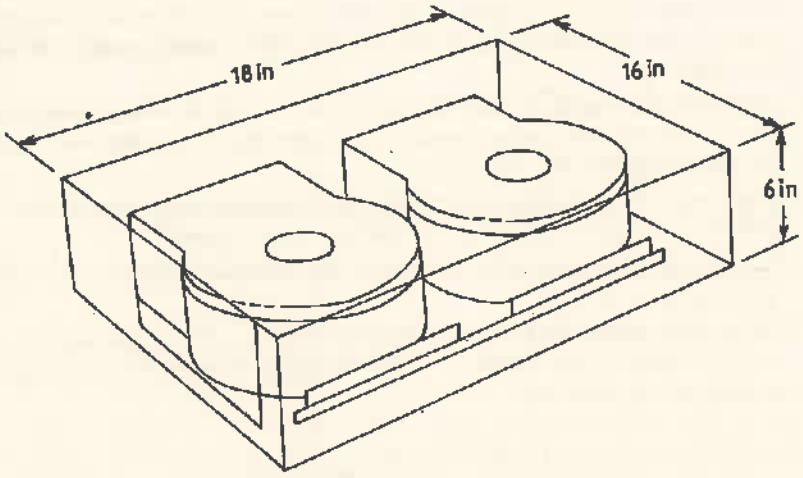


Fig. 36.14. A Winchester disk drive.

– Winchester discs are fast and highly reliable, yet low priced. There is greater precision of alignment, an increase in the number of tracks on the disk surface and a higher storage density per track.

(7) Keyboard

– Keyboard entry of data is now the main method of input. It is probably the most *user-friendly* of all input devices.

– The *keyboard* is similar to the face of a *typewriter*, but uses a TV-type screen instead of paper.

– All keyboards are not alike. Because they *talk* to a computer, some keyboards have extra *keys* to perform communication commands.

– The alphanumeric keyboard is used to enter commands, text and parameter values. To enable the key board to *talk* to the computer, a special code is employed. With IBM computers an EBCDIC (Extended Binary Coded Decimal Interchange Code) keyboard is used. Many other computer companies use an ASCII (American Standard Code for Information Interchange) keyboard.

N.B. There are two types of keyboards, the EBCDIC and ASCII as explained above.

– Along with the keyboard, a *programmable function box* is often used. Such unit contains from 16 to 32 function keys. When pressed, each key generates a unique code, providing two-way communication between the user and host program. Usually function keys are lighted, allowing the operator visual monitoring of what activity is taking place.

(8) Terminals

– A *teletype writer terminal*, sometimes called a teleprinter terminal or a *keyboard* /printer terminal, usually combines a keyboard for manual input of information, with a *printer* for outputting a *hard copy* (printed record) of the input, system information and program results.

– VDUs (Visual Display Units) are the most common form of terminal—the information is displayed on the screen as it is typed. (Fig. 36.15).

– Terminals may be connected to a computer in one of two *ways*. Some are connected *locally* by direct cable lines. This is known as *hard-wiring*. The second method is *via* a *remote* link, either by telegraph, telephone line, network or by micro waves.

Both these methods permit the simultaneous linking of several terminals in several locations to one computer, with each terminal making use of the computer in turn. This is known as *Time sharing.*

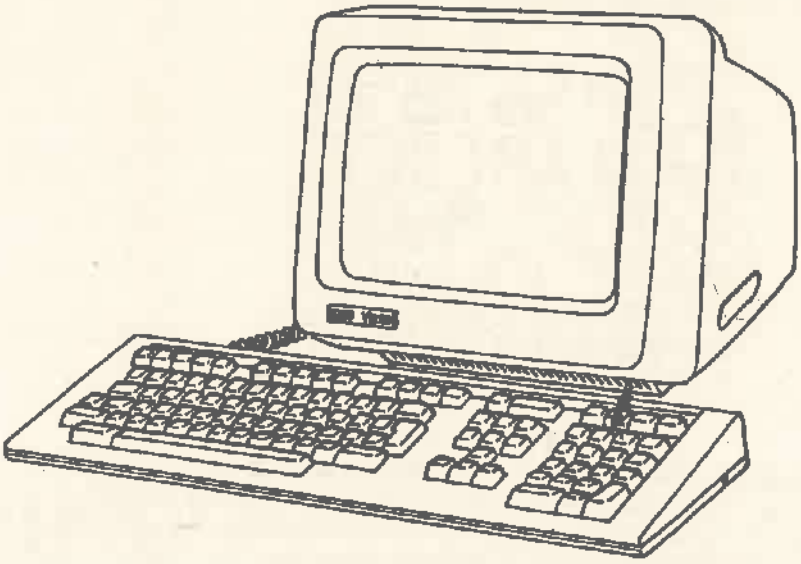
- Terminals are widely used for such tasks as stock control, entering orders, updating accounts and seat reservations.
- More recent developments are *hand-held terminal entry systems* and *hand print pads.*

(9) Mark and Character Recognition

- This method involves the recognition of marks or characters, *e.g.* from work dockets, cheques, sales order entry forms and even printed text.
- There are three types of *recognition :*

(*a*) Optical Mark Reading (OMR)
(*b*) Optical Character Recognition (OCR)
(*c*) Magnetic Ink Character Recognition (MICR)

These forms of recognitions facilitate the direct transfer of data from source document to the electronic form in which information is held in the computer. Where they are used, they eliminate the need for the laborious key- entry of data that is associated with *terminal* and *key-to disk* (magnetic disk) and *key-to-tape* (magnetic tape) systems.



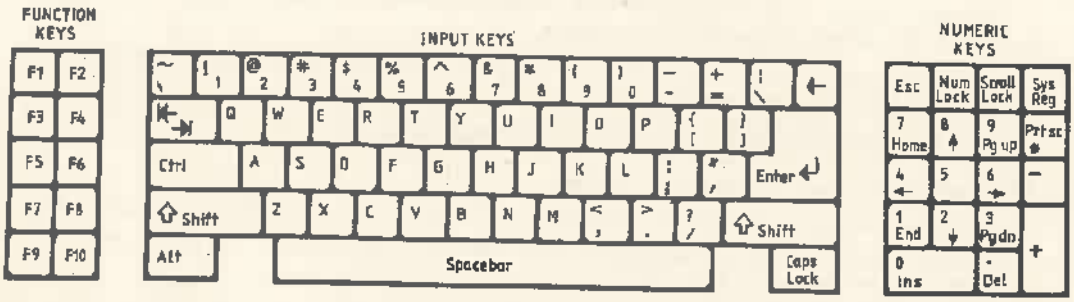


Fig. 36.15. Visual Display Unit (VDU) and Keyboard.

(10) Optical Mark Reading (OMR)

- Optical mark reader is used to identify the presence or absence of certain marks on the card or form, for example, the water and electricity meter readings.
- Optical mark readers are available to scan forms/cards completed in pen as well as in pencil.

  The card is passed under a light source and the presence of a mark is detected by measuring very accurately the infra-red light levels. A mark reader may be able to detect coloured marks.
- An earlier method known as *mark sense reading* relied on the conductivity of graphite to determine the presence of a portion *blackened* intentionally (using a soft pencil) as in the answer sheets of examinations involving exclusively objective type-multichoice questions. The examinee is asked to blacken the places on answersheet corresponding the answers which he feels to be correct (answers).

(11) Optical Character Recognition (OCR)

- Optical character reader is a device for reading the *documents.* It may be capable of reading whole pages or merely one or two lines only.
- An OCR is used for reading various *characters i.e.* letters, digits and symbols *optically.*
- Generally the characters to be read must be machine (typewriter/printer) printed and of a special character design or fount (Fig. 36.16).

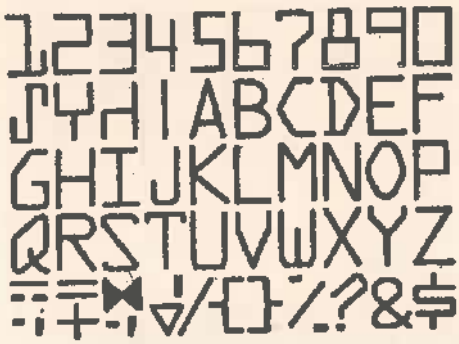


Fig. 36.16. OCR A' fount (U.S.A.).

- This is true that letters, digits and symbols are printed in variety of forms, shapes and sizes. But even then, there are certain characteristics which are peculiar and common to each character. The OCR recognizes each character as if it were made of a collection of minute spots, (Fig. 36.16). After scanning a character, the pattern is matched against a set of patterns stored in the computer, whichever pattern is identified or nearly identified is said to be read. Patterns which are not identifiable by the OCR are rejected.
- OCRs find *applications* such as credit card billing and reading of pin code numbers in large post offices to sort mail geographically.

  OCRs are also used in banks, insurance companies, airlines etc.

(12) Magnetic Ink Character Recognition (MICR)

- Magnetic ink character readers (MICR) are used to read *characters* inscribed on (Bank) documents with a special ink containing magnetizable particles of iron oxide. This system uses highly *stylized* character shapes (Fig. 36.17).



MICR E13B fount

Fig. 36.17. E 13 B fount.

- E 13 B is used principally for bank cheques. The code number of the bank, the customer's account number, and the cheque sequence number are all pre-printed in the magnetic ink. When such a cheque is submitted in the bank, the amount of the transaction is inscribed on it.
- The cheque is read by MICR that recognizes the particular *character* from the variation in *magnetic flux* which is induced by the shape of that particular character. The MICR after verifying the characters, sends the data directly to the computer or to magnetic tape or disk for later input to computer.
- MICR system has the advantage that the forgery is impeded, however the cheque requires special printing device.
- The speed of reading MICR is around 1200 documents a minute.

(13) CRT and Light Pen

- Data display devices use a cathode ray tube (CRT) to display data.
- Nearly all computer graphics terminals available today use the CRT as the display device.
- In CRT, a heated cathode emits a high speed electron beam onto a phosphor-coated glass screen. The electrons energize the phosphor coating, causing it to glow at the points where the beam makes contact. By focusing the electron beam, changing its intensity, and controlling its point of contact against the phosphor coating through the use of a deflector system, the beam can be made to generate a picture on the CRT screen.

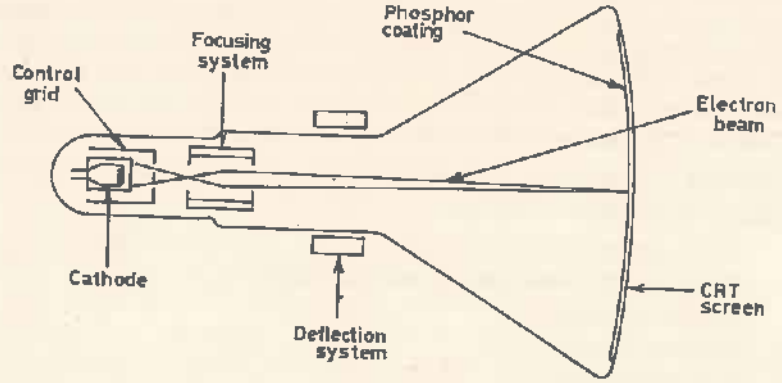


Fig 36.18. Diagram of Cathode Ray Tube (CRT).

- The advantage of the CRT display is that an entire record can be displayed instantly. A type writer device must type the record, a character at a time.
- CRT data displays are likely to be the dominant device in online systems having remote enquiry stations, as in Airlines.
- Data Display Devices may allow *input* via a *keyboard* or a *light pen.*
- If a permanent record is required of data displayed on the CRT, a command may be given to write the answer on the printer.

Light Pen

- A light pen is a graphic input device that allows an operator to interface directly with the CRT display.
- The hand-held light pen detects the light pattern of the picture on the CRT and sends an appropriate signal to the computer. If the operator modifies the picture by drawing on the tube with the pen, the computer will automatically carry out all consequential corrections and calculations and will present the result for observation.
- The light pen enables the operator to *pick* a point, character or vector on the CRT screen and to cause the system to take some action on the object picked.
- Repositioning or changing data on the screen is possible with the use of a light pen. The pen's tip *acts* on the area that is *touched* on the screen.

(14) Voice Data Entry (VDE)

- Voice data entry is rapidly becoming a desirable key *input* function for CAD/CAM systems. There is no need for the operator to move hands or eyes to different control panels or key boards to enter information. Data is input via a voice-intelligent terminal.
- VDE technology represents an attempt to simplify the human-machine interface.
- Under the proper circumstances, voice entry of information to the computer represents the easiest and quickest method of *input.*

  There is both, ease of use and efficiency, since a person can speak faster than he can type or write.
- A voice input system accepts spoken input. The system works by digitizing the waveform produced by a spoken word and storing the values as a *bit* pattern.
- The waveform created by the spoken input is analysed, patterns are extracted and matched against *prestored* patterns to identify the input. Once identified, the appropriate coding is generated for handling within the computer.
- Before a voice input system can be used, it must first be provided with a vocabulary. The words and phrases the system is to recognize are spoken with the system operating in a so called *training mode.* In this mode, the patterns are created and stored for future matching. A system may be trained to recognize both the voice of (one or more) operators and a given vocabulary for each operator, in which case, unwanted inputs or unauthorized speakers are rejected.
- The voice link to a system may be by microphone, telephone or radio communication.
- Examples of *applications* of VDE are

  Programming NC machine tools,
  Data input for manufacturing information systems,
  Quality inspection,
  Inventory control,
  Part identification,
  Shop floor control data collection.
- VDE has certain *limitations* also, for example,

(1) Most voice systems are *speaker dependent,* which means the system will not entertain input from everybody. It may not entertain even its actual user if his voice changes due to some temporary illness.

(2) A reasonable *vocabulary* is required to enter the data. Vocabularies are comparatively small, typically 100 to 300 words. In general as the size of a vocabulary increases, recognition reliability decreases.

(3) Each word spoken should be followed by a short break.

36.16. OUTPUT DEVICES

- It has been seen already that there are several paths by which humans can communicate with computers (*Input devices*). There are also several ways in which the computer can communicate with man (*Output devices*).
- The *purpose* of an output device (peripheral) is to transfer information from its internal character code as stored inside the computing machine to an appropriate real world representation. This real world representation may be a printed page (hard copy), a television tube, magnetic spots on plastic tape etc.
- *Various output devices are :-*
  1. Printers
  2. Visual Display Units (VDU).
  3. Plotters.
  4. Computer output microfilm (COM).
  5. Audio response units.

1. Printers

- Printers may be classified as:-
  (*a*) Impact printers
  (*b*) Non-impact printers.
  Also as :

(*i*) Serial printers or character printers — Daisywheel printer; Dot Matrix printer; Thermal Matrix Printer

(*ii*) Line printer

(*iii*) Laser Printer

- *Impact printers* make use of a system that strikes a ribbon to deposit ink or carbon onto paper, like a typewriter.
- *Non-impact printers* form an image by chemical or photographic means ; they may print characters by heat or ink jet also.
- *Comparison of impact and non-impact printers:*

  The *advantage* of impact printer is that multiple copies can usually be produced by using a number of papers interleaved with carbon as on a typewriter, but their *disadvantage* is that they can be relatively noisy.

  Non-impact printers on the other hand are usually very quiet but it is not usually possible to produce multiple copies.
- *Serial or character printers*, like a typewriter, print one character at a time working from left to right across a page.
- *Line Printers* are those which output a complete line at a time.
- A serial printer is much slower than a line printer, however it is much cheaper.
- Serial printers are suitable for applications producing low volume output and are frequently used as *output devices* for small, special purpose computer systems and micro computers.

Daisywheel Printer

- Daisywheel printer is so called because it uses a daisyshaped disk made of metal or plastic.
- The print mechanism of the daisywheel printer consists of a flat disk with petal like projections. At the end of each projection/arm is an embossed character which on impact with the paper will transfer the image of the character.
- The hub of the wheel rotates to bring the desired character into position and is then struck to form an image on the paper.
- Daisywheels come in several type founts that can be interchanged quickly to suit application needs.
- Typical printing speeds are 25 to 60 characters per second. Printing can be performed in either direction, paper can be fed up or down and the noise level is low.
- Daisywheel printers are noted for their high print quality and are often used with word processing systems.

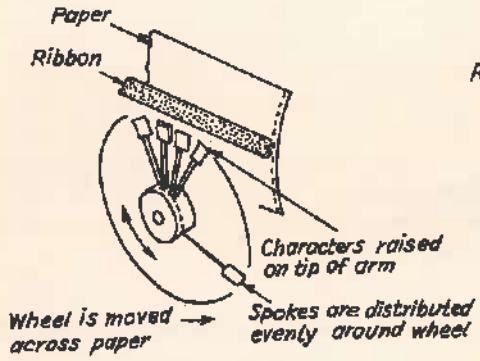
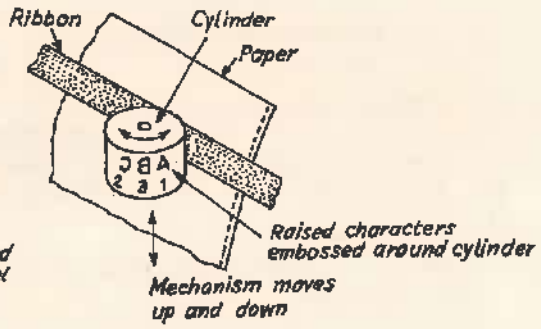


Fig. 36.19 (*a*) Daisywheel Printer Mechanism.



(*b*) Cylinder Head Print Mechanism.

Dot Matrix Printer

- The dot matrix printer is the most common type of serial printer in use. This is because of its speed, versatility and ruggedness. These qualities, combined with low cost, make the matrix printer particularly attractive to the personal computer market.
- The print head comprises a matrix of tiny needles which *hammers out* characters in the form of patterns of tiny dots. The shape of each *character*, *i.e.*, the dot pattern, is obtained from information held electronically.
- Standard characters are produced in a 5 × 7 (5 pins wide and 7 pins high) dot matrix via a single print head (a device containing a matrix of needle like hammers) by energizing the appropriate dots (needles). The print head moves across the paper. The needles strike the paper through an inked ribbon.
- Matrix printers are faster than daisywheel printers in the range 50 to 480 characters per second but in general the quality of print is inferior. Some higher (needle) density print heads (18 and 24 pin/needle) which can provide print quality roughly equal to that of a daisywheel printer though this is achieved at the expense of speed.

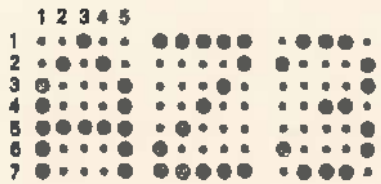


Fig. 36.20. A matrix 5 dots wide by 7 dots high (5×7).

Thermal Matrix Printers

- They are *serial printers* employing *non-impact* technique.
- Thermal printers have print heads that convert electricity to heat. Thus heated print elements (heated wires in the print head) create characters in dot matrix form on special heat-sensitive paper. There is no inked ribbon required since the images are created by heat.
- Thermal printer technology permits a smaller dot size than is attainable with *impact* dot matrix devices and hence offers higher print resolution, typically 200 dots per inch (dpi).
- Thermal printers are generally used where the volume of output is small because the heat-sensitive paper is relatively expensive. Speed is low because the heated wires of the print head must cool before moving to the next position.

  Thermal matrix printers are very quiet. The creation of multiple copies is not possible.

Ink Jet Printer

- The ink jet printer is another non-impact type.
- Ink droplets are squirted onto paper from nozzles to form *characters* using the dot matrix principle.
- The nozzles shoot stream of charged ink towards the paper. Before reaching it, the ink passes through an electrical field that arranges the charged ink particles into characters.
- Plain paper can be used and the print operation is very quiet. Although reasonably fast, they are relatively expensive.
- The range of devices is wide and the technology continues to improve. At the top of range there are machines capable of generating colour images of near photographic quality with resolution approaching 300 dpi, operable in letter quality or draft mode. These printers can print 200 characters per second.

Line Printers

- A common method of obtaining bulk output is *via* a device known as a line printer.
- A line printer prints a complete line at a time.
- The speeds of line printers range from 200 to 3000 lines per minute. The slowest line printer is thus 100 times faster than manual typing.
- Line printers print characters at a constant pitch, typically of 10 characters per inch with a total of 132 characters per line. They also facilitate multiple copies with pin feed for paper movement.
- Line printers of *chain, train* and *belt* type use several complete sets of *type* which move horizontally past the print line, and are separated from the paper by an inked ribbon.
- In the case of **chain printer** (Fig. 36.21), the type characters literally form a chain, like links of a bicycle chain.

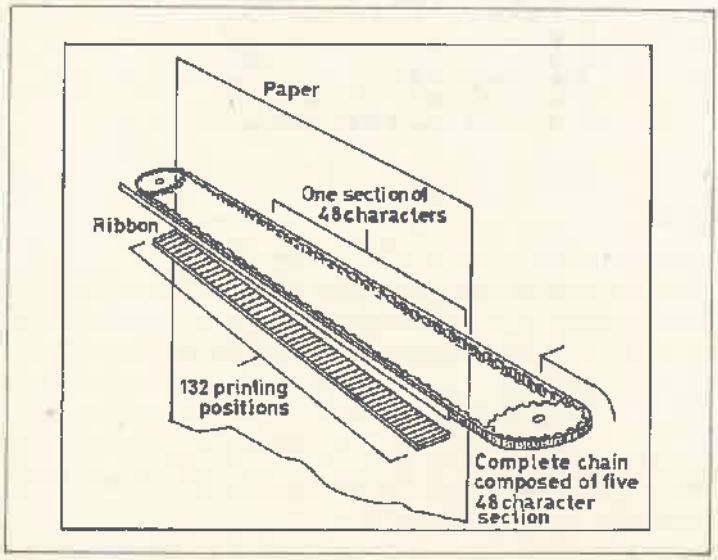


Fig. 36.21. Chain printer.

- The **train printer** is very similar to chain printer except that the type characters are not permanently joined together but can be individually attached to or removed from the train carrier. Hence the character set can be varied very easily.
- The **belt printer** has a series of slim metal uprights that are secured to a horizontal rotating belt, the type character being on the top of the upright.

  Depending upon the particular printing mechanism, chain, train and belt printers may be *character* printers or *line* printers.
- The **drum or barrel** printer has complete *character sets* wrapped around the circumference of the barrel at every print position. If the printer is a 132- character width printer then there are 132 complete sets of type wrapped round the barrel. There are also 132 hammers, one for each print position, with the inked ribbon and print paper sandwiched between the hammers and the barrel.

  As the barrel revolves and brings a particular character in line with the paper in every print position, the hammer(s) corresponding to that position in which the character is required strikes the paper. Consequently in one complete revolution of the barrel, all the characters will have passed the paper, and the complete line will have been printed.
- Commercial *applications* of the line printer include the production of tabulated information, invoices, payroll records and stock records etc., while scientific and technical applications give mathematical and similar print-out.

Laser Printers

- Laser printer is sometimes referred to as a *page or document printer.*
- Using a combination of laser and photocopier technology, these printers are capable of converting computer output into print, page by page.
- Laser printers produce very high quality images (graphics and text), generally offer a wide selection of character fonts (typically ten or more), are very quiet and operate very quickly. They are, however, costly.
- Laser printers can print from 8 to 300 pages per minute and a print resolution of 300 dpi is standard.

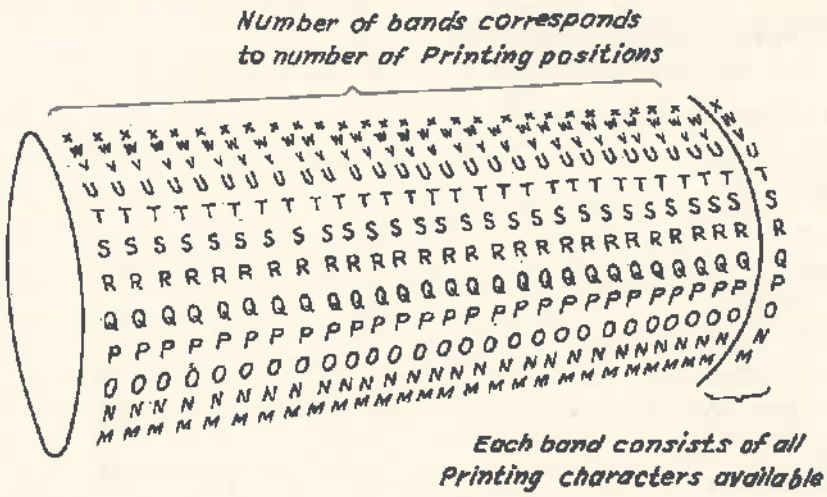


Fig. 36.22. Print drum.

2. Visual Display Units (VDU)

- Visual display devices were developed as an alternative to *printing* devices for situations in which it is not essential to have a printed copy. Their chief *advantages* are that they are virtually silent, and can, if desired, *display* information at far greater speeds than any printing device.
- The visual display device is essentially like a small television screen and displays information in a very similar manner to that of a TV set.
- The VDU is a type of *terminal*, with a keyboard for manual input of characters to the computer and a screen for character display of the input or output. The screen displays information to enable a visual check before the input is transferred to the computer.

  The VDU is extensively used for *keyboard* entry of data (Fig. 36.15).
- The most common display method is to generate characters from a *dot matrix*. A selected pattern of dots is illuminated to form a character (Fig. 36.20).
- Initially used in situations where information is required quickly, for example in airline seat reservations where speed is the essence in handling customer enquiries, VDUs are now widely used for general data entry and retrieval of stored information.
- Some VDUs are equipped with *touch sensitive screens* which allow data to be input by touching the screen with the finger tip.
- Fig. 36.15 shows a typical Visual Display Unit.

2 (b). The Keyboard

- The keyboard of a personal computer has the following set of keys on the keyboard (Fig. 36.15).

1. Function keys (Leftward)

F1, F2, F3, F4, F5, F6, F7, F8, F9, and F10.

2. Input keys (Centre position)

Containing 1, 2, 3--------, A, B, C, ----------X, Y, Z.

Control, shift, alter etc.

3. Number keys (Rightward position in Fig. 36.15)

0, 1, 2, 3, ------9, Esc, Num Lock, Del, etc.

1 (a). Function keys when BASIC in run

F1 –– List
F2 –– Run
F3 –– Load
F4 –– Save
F5 –– Continuity
F6 –– LPT 1 (Line Printer-1)
F7 –– TRON (Trace on).
F8 –– TROFT (Trace Off).
F9 –– KEY
F10 –– SCREEN

1 (b). Function keys with operating systems (MSDOS)**

F1	Redisplays previously entered line, a character at a time. F1 key must be hit for each character.
F2	Enter F2 followed by a character. Screen will redisplay all of the previously entered line upto the character you entered.
F3	Redisplays the whole previously entered line.
F4	Enter F4 followed by a character. Screen will skip all of the characters in the previously entered line up to the character you entered.
F5	Stores the currently displayed line for further editing.

F6, F7, F8, F9, F10 are vacant under MSDOS.

Ctrl	The CONTROL key is always used with another key to perform a command or to select a particular function.
Shift	The shift key changes lower case letters to capital or upper case.
Alt.	The ALTERNATE key is used with alpha typing keys to enter key words under BASIC.
Enter	The ENTER key is used to enter commands and/or responses into the system from the keyboard.
Caps Lock	This is toggle key. Hit the key once, and all letters typed will be in upper case (Capitals). When this key is depressed a red light will come. Hit this key again to return to lower case.
Esc.	The ESCAPE key deletes the last line that the cursor is on for corrections, but the line is not removed from the systems memory.
Scroll Lock	SCROLL LOCK/BREAK is used in conjunction with the control key.
Prt. Sc. *	PRINT SCREEN will print on 'Hit' simultaneously with the shift key, it will print all the data displayed on the screen as hardcopy printout from the printer.
Num Lock	The number lock is a toggle key. Hit the key once and the numeric key pad is activated. When the key is activated, a red light appears to indicate that the NUM LOCK is on. Hit the key again and numeric key pad is cancelled.

** MS-DOS–MICROSOFT DISC OPERATING SYSTEM

KEY	FUNCTION
1 - 9	With NUM LOCK activated, number ONE through NINE will be operative.
Del	DECIMAL POINT is used with numbers.
0	ZERO used with numbers
INS	MINUS is used with numbers.
+	PLUS is used with numbers.
	When the NUM LOCK key is pressed, it cancels the numeric key pad. These keys will become operative:
KEY	FUNCTION
9 PgUp	Moves the display screen up one page at a time as long as the key is pressed
8 ↑	Moves the cursor up .
7 Home	Moves the cursor back to the home position, which is the first character position located at the top left of the display screen.
6 →	Moves the cursor to the right.
5	No function
4 ←	Moves the cursor to the left.
3 Pg Dn	Moves the display screen down one page at a time as long as the key is depressed.
2 ↓	Moves the cursor down one line.
KEY	FUNCTION
1 END	Moves the cursor to the last character on the line.
Del	Deletes the character at the position where the cursor is located.
0 Ins	Insert sets the keyboard into a word processing correctional mode. Characters can be entered for correction at the cursor position and all data will move one cursor position to the right. By pressing the insert key again you can exit from the insert mode.
SYS	Internal register of CPU which stores the data temporarily.
Spacebar	The space bar is used to put a blank (a space) in a line you are typing. Often blanks are used to separate what you type into the computer just as we use them to separate words in typing or writing.

3. Plotters

- *Plotters* are devices that output line drawings on paper. These are slow compared with other forms of output, but the compensation is a very high degree of accuracy. In plotting, accuracy is more important than speed.
- Plotters consist of a pen which can either be touching the paper or lifted off it. It can be moved a short distance (*e.g.*, 1 mm) either horizontally or vertically or, by moving both horizontally and vertically at the same time, generate a line at 45 degrees.

- Plotter is able to produce bar charts, line graphs, engineering drawings, maps and many other two-or even three-dimensional illustrations, all fully annotated.
- The most common type of plotter is **flat bed type.** This plotter is by far the most simple : the paper is fixed in position on a flat surface, and the pens move on X-Y axis to draw the illustrations. The most significant advantage of the flat-bed plotter is the variety of media that can be used. The user can make drawings on vellum, acetate, or sheets of paper.
- In **drum plotter** the (plotting) paper (one end of which is wrapped round a drum) is fed round a drum which revolves in both directions (back and forth). The pen turret is suspended from a bar above the drum and moves only in a horizontal direction—left to right or right to left. Thus the paper and pen move relative to each other in X and Y directions.

  Generally, drum plotters use a roller, and, therefore, require a specific sprocket or some kind of feed mechanism.

  In a drum plotter, media size limitation is eliminated. Paper moves in a continuous output to produce a constant flow, which in turn produces larger graphics.
- A third type of the plotter is the **pinch roller plotter.** This actually is a hybrid of the flat-bed and drum plotters. It has a motor that drives the bed along the X-axis and a pen mount that moves along the Y-axis. Different companies manufacture this X-Y plotter with either a dc servo motor or a stepper motor.

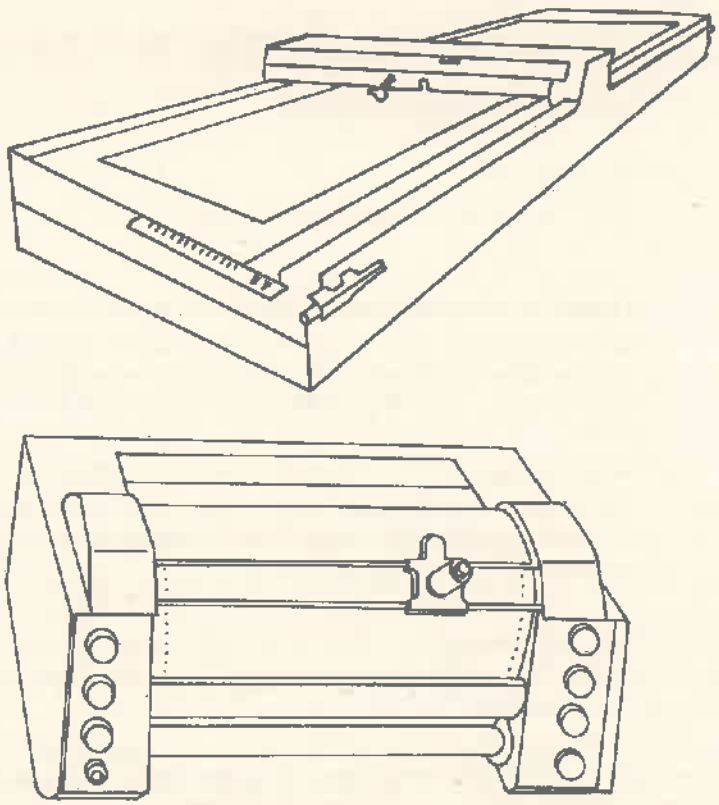


Fig. 36.23. (*a*) Flat-bed plotter. (*b*) Drum plotter.

- One feature that has been developed in some plotters is an *electromagnetic or mechanical-magnetic* pen pick-up. This permits clean, trouble-free pen pick-up compared to conventional mechanical pick-ups which can be a source of difficulty at times.
- A significant difference in plotters is the number of pens and pen (colour) choices they offer. Plotters are available that change pens automatically and on command. This permits the easy plotting of multicolour drawings, charts or graphs.

4. Computer-output-to-microfilm (COM) units

- COM units reproduce the drawings on *microfilm* rather than as normal size engineering drawings made on a plotter.
- Although microfilm media for data storage are available in several forms, the most common is called *microfiche*. Microfiche is a small card of microfilm with many small images as a grid pattern.

  Usually the output from the computer is written to magnetic tape. A special machine reads the tape and transfers the data to microfiche. Subsequently microfiche can be inserted into a simple reader which enlarges the image and projects it on to a screen for the user to read. It can also be duplicated, and the multiple hard copies can be printed from it if required.

Advantages of COM

1. Speed of output is many times faster than high speed line printers.
2. Very compact storage capability.
3. Cost of developing microfilm is low compared to traditional paper costs.

Disadvantages of COM

1. COM unit is an expensive piece of equipment.
2. User cannot write notes on the microfilm, as it is possible with a paper copy.
3. Requires special viewing equipment.
4. Enlargements of the microfilm onto paper, although adequate, are not of as high quality as the output from a pen plotter.

5. Audio Output

- The computer can be used to trigger verbal communications *via* an **audio response unit** and this could be an appropriate method to use if standard replies to requests for information are all that are required.
- Computer audio output or voice response units speak by arranging half-second records of voice sounds (phonemes) or pre-recorded words. Often they will be coupled with touch-tone terminals for data entry.
- Since only a limited vocabulary is available, they are used mainly in the banking industry to report customer account balances or in supermarkets to notify customers of the amount of each purchase.

36.17. INPUT/OUTPUT DEVICES

- These devices can be used for both the input or the output of data.
- There is some means whereby the user can input data (or commands) to the computer and there is also some means by which the computer can output information back to the user.
- These devices are particularly useful in situations which require a user to interact with the computer such as on a multiple terminal network system.
- It must be emphasized, however, that as far as the computer is concerned these are entirely

separate devices. One is an input device and other an output device. The fact that they may share the same cabinet is of no consequence to the computer.

- Two very common I/O devices are :

1. *Visual display unit* (VDU) and *keyboard* (refer page 36-35)
2. *Typewriter terminals*

These are very similar in principle to the device No. 1 above except that the output side of the device is a hard copy printer rather than a display screen. On this printer, which uses a moving, rotating or pivoting print head, the print device moves serially across the print line, the print head striking an ink ribbon which is between the print head and the paper.

36.18. STORAGE DEVICES

- The *memory unit* stores the instructions, data and intermediate results.
- It supplies as and when required, the stored information to the other units of computer.
- There are two memory units, namely
  1. Main memory (or Internal storage)
  2. Backing storage (or Auxiliary Memory Storage)
- The *main storage memory* forms the essential part of the CPU, is limited in size, is needed as a working space for the current program and only retains information on a temporary basis.

  However, computers may often work on vast amounts of data and *backing stores* are used to retain the data on a permanent basis. Information stored on these devices can be retrieved and transferred speedily to the CPU when it is required.

36.19. MAIN STORAGE DEVICES

- The commonly used devices of **main storage memory** are :

(1) Magnetic core memory.
(2) Thin-film memory.
(3) Plated wire memory.
(4) Semi-conductors.
(5) Magnetic bubble memory.
(6) Holographic memory.

There are many two-state devices which can be used to represent binary digits for computer storage; the most common storage device for main (primary) memory is the *ferrite core*. Other less used memories are thin film, plated wire and semi-conductors.

(1) Magnetic core memory

- A magnetic core is molded from a ferrite (iron) powder into a doughnut shape about the size of the head of a pin. The individual cores are stung on wires to form core planes. Several core planes stacked one on top of another form a core stack (Fig. 36.24).

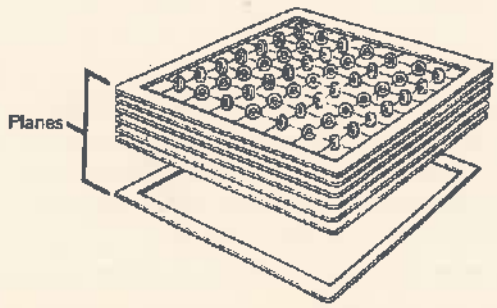


Fig. 36.24. Core stack.

- According to elementary physics, an iron bar can be magnetised in one of two directions : north-south or south-north.

  Similarly a ferrite core can be polarized in two directions. These two directions of polarity form the two states of the core.

  A core can be placed in either state by the application of a magnetising force. The direction of polarity will depend on the direction of magnetising current.

  The computer designer selects one direction to represent a 0-bit and the other to represent a 1-bit.

  Once, polarized in one direction, a core will retain that polarity until changed.

- Fig 36.25 shows a single wire being used to apply current to the core. The typical arrangement uses two wires strung through the core.

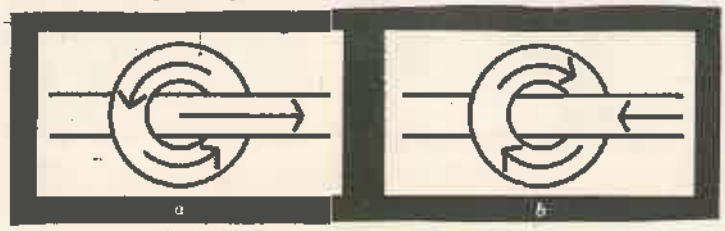


Fig. 36.25. Two-state representation with ferrite cores.

In Fig. 36.25 (*a*) current is applied in one direction to polarize '1', (*b*) current is reversed and polarity flips to the opposite direction to represent '0' (zero).

(2) Thin film memory

- Thin film memory is produced by depositing very thin *spots* of metallic (Ni-Fe) alloy on a ceramic or metal plate.
- This *spot* performs in the same manner as the core, except that only two wires are required.
- A typical thin film element consists of a *rectangle* about 0.625 mm by 1.25 mm with a thickness of about 0.00001 mm.
- This rectangle can be thought of as a bar magnet.
- Applying a current which causes the polarity to rotate but not to flip, induces a current which indicates whether a 1 (one) or 0 (zero) was stored (Fig. 36.26). After the sense field is removed, polarity is returned to its prior state by a digit pulse which *steers* the polarity back to a 1 or 0 state.

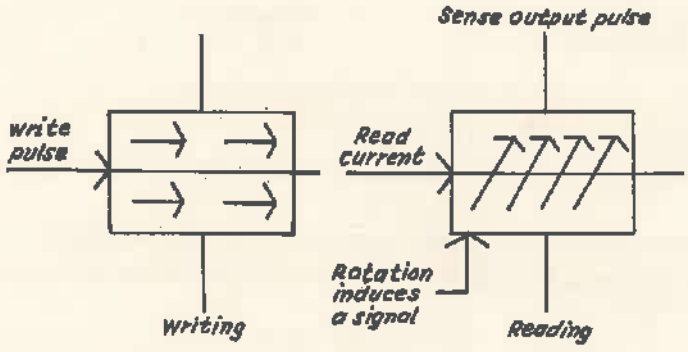


Fig. 36.26. Thin film memory

– An overlay of etched copper wires provides the circuitry necessary to connect the individual elements with the circuits which *read* and *write*. The magnetic properties of film elements allow much faster switching times than can be achieved with *cores*. This provides faster memory cycle speeds, but the technical difficulties of thin films have, upto now, discouraged their use.

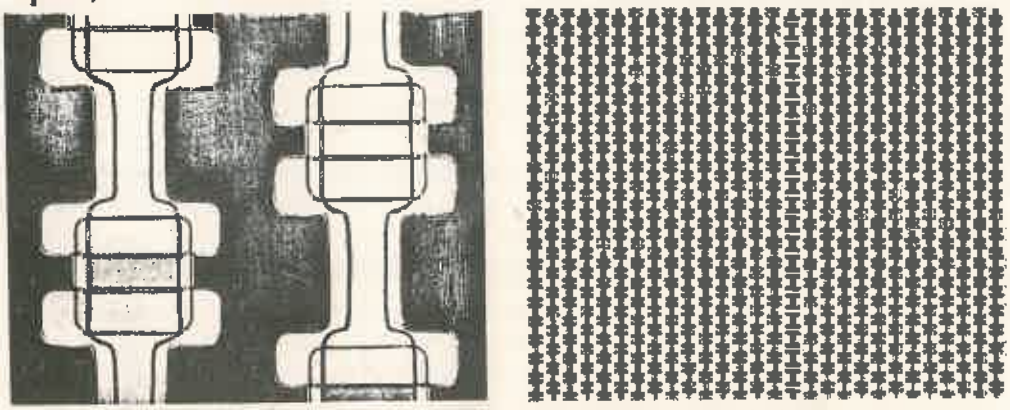


Fig. 36.27. (*a*) shows a 1024 bit mated film memory array 6.25 × 7.50 cm in size.
(*b*) A close-up through a microscope, of magnetic elements, H-shaped deposits magnetically coupled to deposited lines.

(3) Plated wire memory

– *Plated wire memory* or *woven wire memory* is a thin film which is deposited around a fine *wire*.
– This wire carries the write current during a write operation and is the sense line in a read operation.
– Insulated wires are woven across the plated wire in a fashion similar to weaving cloth.

The area where the insulated wires loop around the plate wire (Fig. 36.28) forms a bit storage location. Reading is non-destructive.

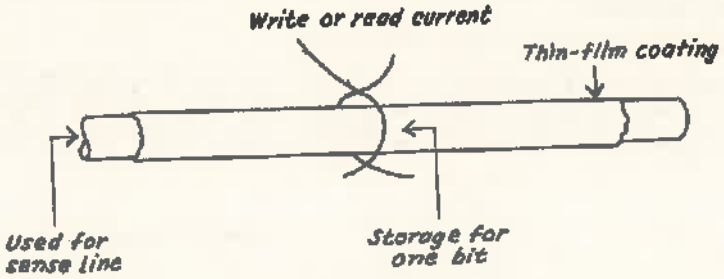


Fig. 36.28. Plated-wire memory.

(4) Semiconductor Memories

– Semiconductor memories consist of electronic devices etched on monolithic integrated circuit chips.
– A single silicon chip will contain many memory circuits plus support circuits.
– The advantages are increased speed of memory access and reduced memory size (reduction of 50% or more).

(5) Magnetic Bubble Memory

- A bubble memory is a magnetic device in which magnetic *bubbles* can be manipulated in such a way as to store data.
- The devices comprise a base plate upon which a pattern of electrical plates is arranged. An alternating current can be applied to each of the plates in turn so as to cause the movement of magnetic material from one place to the next. Upon the base plate a magnetic fluid (Fig. 36.29) is placed and kept in contact with the base plate by being encapsulated.
- The complete assembly is then held in a magnetic field which ensures that the fluid particles are all aligned in the same direction.
- Within the assembly, there is a means of causing a particle of the fluid to be magnetically reversed, thus forming a *bubble* of reverse magnetization to the majority of the fluid. There is also a mechanism by which it is possible to detect the magnetization of a particular bubble.
- The *operation* of the bubble memory is like this. Data is written to the memory by sending the *bit* pattern to the memory, whenever there is a *one* (1) *bit* the write assembly causes the current bubble to be inverted relative to the rest of the fluid. If there is a *zero* (0), then the bubble has the same orientation as the rest of the fluid. The applied alternating current then causes the bubble to move to the next plate and so on until the whole of the data has been encoded.
- This memory device, although cheap and small, is relatively slow.

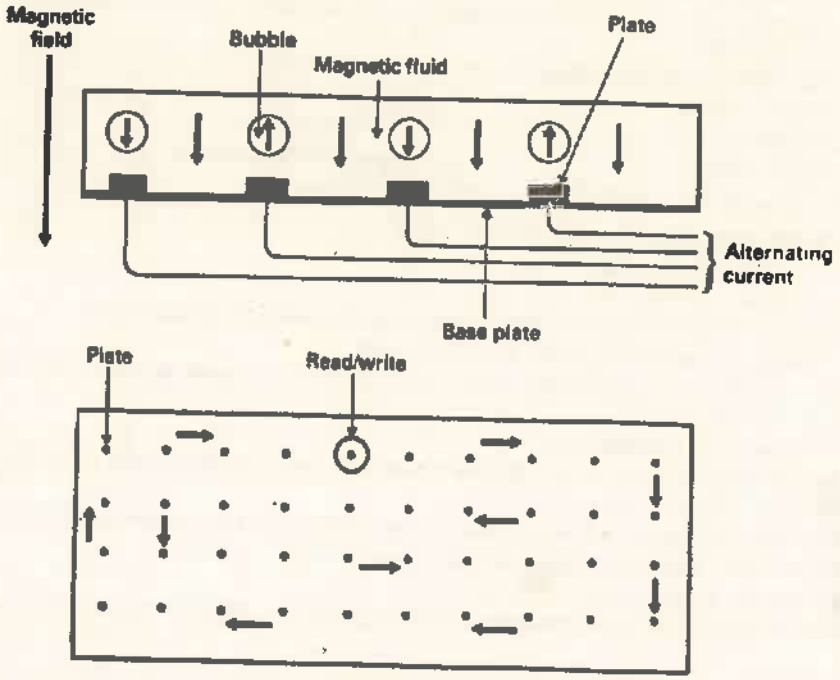


Fig. 36.29. Structure of bubble memory.

(6) Holographic Memory

- In the *mechanical type*, data bits are stored by a laser beam which permanently records the information by *burning* the coating on tape. By this way about two million bits can be stored per sq. cm. These spots can be read by a laser beam of lesser power.
- In the *optical holographic memory*, a laser beam is passed through an array of light valves to produce binary pattern of light and darkness. This is stored on light-sensitive material. The data thus stored is read by another laser beam.

36.20. BACKING STORAGE DEVICES

- The devices that hold the mass of information, which may be transferred for use during processing as and when required and for record purposes are known as *Backing Storage Devices.*
- Several different devices can provide this additional storage space, but the one selected will depend mainly on how the information needs to be *accessed.*
- *There are two methods of access :*
  1. Serial
  2. Direct
- Information on a **serial device** can only be considered in the same sequence in which it is stored. This would be suitable, for example, for dealing with a mailing list where each address needs to be accessed in turn.
  However, should an address be required out of order, it can only be retrieved by searching through all those addresses which are stored before it.
- More often, we need to access information in a more **direct manner** than serial devices allow. For example, at any given moment in a bank, some customer will be requesting details about his account. Backing storage devices exist which permit access to individual information in this more *direct* or immediate manner.
  Each item of information held on this type of store is associated with *location address,* in much the same way that information is held in the main memory. These **direct devices** are also called *random access devices* because the information is literally available at random, *i.e.*, it is available in any order.
- *The different backing storage devices are :-*

1. Magnetic tape
2. Magnetic disk
3. Floppy disk
4. Winchester disk
5. Optical disk
6. Magnetic bubble memory, etc.

These devices have been discussed earlier in this chapter.

36.21. PROBLEM SOLVING BY COMPUTER

The steps in using a computer are :-

(a) Analysis of a problem

Collect and decide what information is needed, frequency of processing etc.

(b) Design of a system to provide the information

Plan the system of processing using a system flowchart plus layouts (diagrams) of reports, documents, records, files etc.

(c) Planning the computer logic

Plan the program logic using a program flowchart and other methods of describing a diagram.

(d) Program preparation

Write the program of instructions and debug it to remove all textual or logic errors. Translate it into machine language. Prepare documentation.

(e) Input data preparation

Prepare input data by collecting or transcribing data into machine readable form such as punched cards.

(f) Running of program

Put program into computer memory.

Computer program reads data, processes it, and outputs the result.

(g) Use of the output

Use the output data for the desired purpose. (Refer Fig. 36.30)

36.22. NUMBER SYSTEMS

- A **number** is made up of individual *digits* (*e.g.* 905 consists of digits 9, 0, and 5). The value of each digit in a number is determined by three considerations :

(1) The digit itself
(2) The place of the digit in the number
(3) The base of the number system (where base is defined as the number of digits which can occur in any one *position*/place).

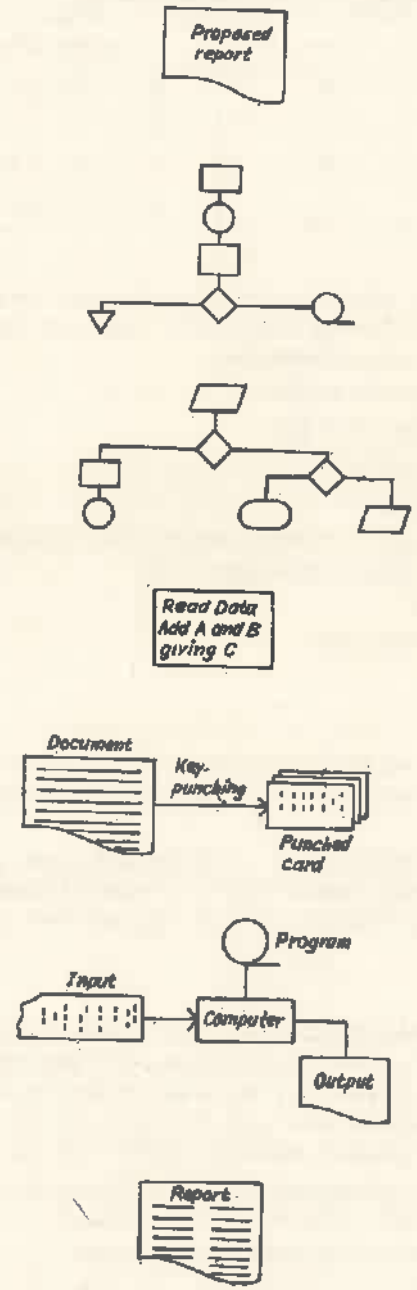


Fig. 36.30. Steps in using a computer.

– Various number systems are :-

(*i*) Decimal system

(*ii*) Binary system

(*iii*) Octal system

(*iv*) Hexadecimal system.

Comparison of Number Systems

System	*Base*	*Absolute values*
Decimal	10	0, 1, 2, 3, 4, 5, 6, 7, 8, 9
Binary	2	0, 1
Octal	8	0, 1, 2, 3, 4, 5, 6, 7
Hexadecimal	16	0, 1, 2, 3, 4, 5, 6, 7, 8, 9 and A, B, C, D, E, F

(*i*) Decimal System

– In decimal system the base (or radix) is 10, since any *position* can contain one of ten digits, refer (3) above. The system therefore has a carrying factor of 10 and each digit indicates a value which depends on the position it occupies, for example

In 6421 the digit 6 signifies 6×1000

In 4621 the digit 6 signifies 6×100

In 4261 the digit 6 signifies 6×10

and in 4216 the digit 6 signifies 6

– The decimal system uses *ten digits* to record the number. The ten digits are 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9 and any number (used) is based upon power of 10.

For example 5281 is made up of

$(5\times10^3) + (2\times10^2) + (8\times10^1) + (1\times10^0)$

$=5000+200+80+1=5281.$

(*ii*) Binary System

– Whereas *decimal system* uses *ten* digits to record the number, the *binary system* uses only two digits (for recording the number) that is 0 and 1, and its base is 2 (whereas that of decimal system is 10).

– Although in everyday life, people generally use the decimal number system for counting, it is more convenient to use the *binary* number *system* in a *computer* because electronic components are usually in one of two states, which can be used to represent 0 and 1, the two digits used in the binary system.

To elaborate it further

The computer does not have a large number of symbols for representing data. It has only two, 0 and 1 (called *binary digits* or *bits*). These correspond to the two electronic or magnetic states used in computer circuits and storage. For example if a *punched paper tape* is used in the computer, a *hole* in a tape may allow electrical contact to be made (ON) and the absence of a hole in the tape does not allow electrical contact to be made (OFF). Therefore a hole can represent 1 and no hole can represent 0.

– Binary system is more compact than the decimal system of coding as the latter will need large size of the storage medium and relative complexity of the reading device.

– Given next page is the *table* of construction of Binary numbers:

Binary Numbers				*Equivalent Decimal Number*	*Explanation*
2^3	2^2	2^1	2^0		
			1	1	$2^0 = 1$
		1	0	2	$2^1 + 0 = 2$
		1	1	3	$2^1 + 2^0 = 3$
	1	0	0	4	$2^2 + 0 + 0 = 4$
	1	0	1	5	$2^2 + 0 + 2^0 = 5$
	1	1	0	6	$2^2 + 2^1 + 0 = 6$
	1	1	1	7	$2^2 + 2^1 + 2^0 = 7$
1	0	0	0	8	$2^3 + 0 + 0 + 0 = 8$
1	0	0	1	9	$2^3 + 0 + 0 + 2^0 = 9$

Conversion of a binary number to the decimal equivalent

Binary Number (base 2)

1 0 1 0 1 0 1 1 0 1 1

$1\times2^{-3} = 1/8$
$1\times2^{-2} = ¼$
$0\times2^{-1} = 0$
$1\times2^{0} = 1$
$1\times2^{1} = 2$
$0\times2^{2} = 0$
$1\times2^{3} = 8$
$0\times2^{4} = 0$
$1\times2^{5} = 32$
$0\times2^{6} = 0$
$1\times2^{7} = 128$

$= 171\frac{3}{8}$

Conversion of a decimal number to binary equivalent

(*a*) Let the decimal number be 217. To find the binary equivalent proceed as follows :-

		Remainder
2	217	1
2	108	0
2	54	0
2	27	1
2	13	1
2	6	0
2	3	1
2	1	1
	0	

Start binary number with last digit. Therefore the binary equivalent of 217 is 11011001.

(b) Convert .8125 into binary number

	.8125
	×2
1	.6250
	×2
1	.2500
	×2
0	.5000
	×2
1	.0000

Decimal ∴ .8125 = Binary .1101

(c) Convert decimal number 217.8125 into binary number

From (*a*) and (*b*) above =

Decimal No.	*Binary No.*
$(217.8125)_{10}$	$(11011001.1101)_2$

Problem 36.1

Convert the following binary numbers into their decimal equivalents.

(*a*)	101.101	(*Ans.* 5.625)
(*b*)	11.011	(*Ans.* 3.375)
(*c*)	1010.1011	(*Ans.* 10.6875)
(*d*)	111.1111	(*Ans.* 9.9375)
(*e*)	101101	(*Ans.* 45)

Problem 36.2

Convert the following decimal numbers into their binary equivalents

(*a*)	11.125	(*Ans.* 1011.001)
(*b*)	26.25	(*Ans.* 11010.01)
(*c*)	39.625	(*Ans.* 100111.101)
(*d*)	74.1725	(*Ans.* 1001010.00101100..)
(*e*)	.375	(*Ans.* .011)

(*iii*) The Octal System

– The octal system (base 8) and hexadecimal system (base 16) are of importance because they can be used as a *shorthand* for binary numbers. This is because *three* binary digits can be represented by the numbers 0 to 7 *i.e.*, the octal range, while *four* binary digits can be represented by the numbers 0 to 9 and A to F.

Octal	761			365			6437101						
Binary	111	110	001	011	110	101	110	100	011	111	001	000	001

To illustrate :

Binary number 111 = $2^2+2^1+2^0 = 4+2+1 = 7$

Binary number 110 = $2^2+2^1+0 = 4+2+0 = 6$ and so on.

That is, 111 110 001 binary can be represented by only 761 in the octal system, therefore, octal system can be used as a shorthand for binary number.

TABLE 36.1

Octal Binary Conversion

Octal	*Binary*
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

(a) Conversion of Octal number into Decimal equivalent

Let octal number be $(235)_8$

2 3 5

$5\times8^0 = 5$

$3\times8^1 = 24$

$2\times8^2 = 128$

157

Hence $(235)_8 = (157)_{10}$

(b) Conversion of decimal number into octal equivalent

Let the decimal number be 692.625

Integral part *Fractional part*

Remainder

8	692	4
8	86	6
8	10	2
8	1	1
	0	

.625 ×8

5	.000

$\therefore (692)_{10} = (1264)_8$ $(.625)_{10} = (.5)_8$

$\therefore (692.625)_{10} = (1264.5)_8$

(c) Convert $(413.2)_8$ into Decimal equivalent

$$(413.2)_8 = [(4\times8^2)+(1\times8^1)+(3\times8^0)+(2\times8^{-1})]_{10}$$

$$= \left(256+8+3+\frac{2}{8}\right)_{10}$$

$$= \left(267+\frac{2}{8}\right)_{10} = (267.25)_{10} \text{ (Ans.)}$$

Problem 36.3

Convert the following decimal numbers in their octal equivalents

(1) 146.5 (*Ans.* 222.4)

(2) 267.25 (*Ans.* 413.2)

(3) 438.125 (*Ans.* 661.1)

Problem 36.4

Convert the following octal numbers in their decimal equivalents.

(1) 222.4 (*Ans.* 146.5)

(2) 661.1 (*Ans.* 438.125)

(3) 1264.5 (*Ans.* 692.625)

(iv) **The Hexadecimal System**

– The hexadecimal system has a base 16 and the digits 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 and letters A, B, C, D, E, F are used. The letters A, B, C, D, E and F represent the decimal numbers 10, 11, 12, 13, 14 and 15 respectively.

(a) Conversion of decimal number $(259.8125)_{10}$ into hexadecimal form

Integral part *Fractional part*

Remainder

16	259	3
16	16	0
16	1	1
	0	

.8125
×16

13	0000

Now $(259)_{10} = (103)_{16}$ and $(.8125)_{10} = (.D)_{16}$

Hence $(259.8125)_{10} = (103.D)_{16}$ (*Ans.*)

(b) Conversion of hexadecimal number B2F.5 into its Decimal equivalent.

$$(B2F.5)_{16} = [(B\times16^2) + (2\times16^1) + (F\times16^0) + (5\times16^{-1}]_{10}$$

$$= \left[(11\times256) + (2\times16) + (15\times1) + \left(5\times\frac{1}{16}\right)\right]_{10}$$

$$= \left(2863 + \frac{5}{16}\right)_{10} = (2863.3125)_{10} \qquad (Ans.)$$

Problem 36.5

Convert the following decimal numbers in the hexadecimal equivalent.

(1) 2863.3125 (*Ans.* B2 F.5)

(2) 2748.125 (*Ans.* ABC.2)

(3) 687.625 (*Ans.* 2AF.A)

Problem 36.6

Convert the following hexadecimal numbers in the Decimal equivalent.

(1) 103.D (*Ans.* 259.8125)

(2) 2AF.A (*Ans.* 687.625)

– When hexadecimal is used to represent a binary number, the individual hexadecimal digits represent successive groups of *four* binary digits starting at the point. This is similar to the conversion from binary to octal, in which each set of three bits is translated to an octal digit.

TABLE 36.2. Decimal, Hexadecimal and Binary Conversion

Decimal	*Hexadecimal*	*Binary*	*Decimal*	*Hexadecimal*	*Binary*
0	0	0000	10	A	1010
1	1	0001	11	B	1011
2	2	0010	12	C	1100
3	3	0011	13	D	1101
4	4	0100	14	E	1110
5	5	0101	15	F	1111
6	6	0110			
7	7	0111			
8	8	1000			
9	9	1001			

36.23. BINARY ARITHMETIC

- The computer user does not usually need to be able to perform binary arithmetic, but some understanding of binary arithmetic is a useful background for understanding computers.
- Here, in this article, the rules for each of the *four* basic arithmetic operations of *addition, subtraction, multiplication* and *division* will be explained and illustrated for the binary system.

(A) Binary addition

Rules for binary addition

1+1 = 0 and carry 1 to add to next column

1+0 = 1

0+1 = 1

0+0 = 0

Example 1

Binary	Decimal equivalent
1011	11
1001	9
10100	20

Example 2

Binary	Decimal equivalent
1110.01	14.25
11010.11	26.75
101001.00	41.00

Problem 36.7

Add 110101 to 101110 and give the answer in decimal form. (*Ans.* 99).

Problem 36.8

Find the sum of 29 and 17 using binary numbers.

(B) Binary Subtraction

Rules for binary subtraction

1−1=0

1−0=1

0−1=1 with a borrow from the next column of the minuend.

0−0=0

s	*Example 1*		*Example 2*	
	Binary	Decimal equivalent	Binary	Decimal equivalent
Minuend	10100	20	101001.00	41.00
Subtrahend	−01001	−9	−011010.11	−26.75
Remainder	01011	11	001110.01	14.25

In subtraction, the borrow reduces the remaining *minuend* by 1. A borrow will cause a 1 in the next column to the left in the minuend to become 0. If the next column contains a 0, it is changed to a 1, and the succeeding 0s in the minuend are changed to 1s until a 1 can be changed to 0, for example :-

Problem	Step 1	Step 2	Step 3	Step 4
	*1	**11	***011	011
1000	1000	1000	1000	1000
−0001	−0001	−0001	−0001	0001
	1	1	1	0111 (*Ans.*)

*Carry changes 0 to 1

**Continue changing 0s to 1s

***Until a 1 can be changed to a 0 then proceed with subtraction.

Binary subtraction can be carried out in another way also as explained below :

Taking the same problem as solved above.

Step 1

1000 (Minuend)
−0001 (Subtrahend)
?

Step 2

1000 (Minuend)
+1110 (After changing 0 to 1 and 1 to 0 in subtrahend)
1 ¦ 0110 (After adding minuend and subtrahend).

carry it to RHS and add (see step 3)

Step 3

0110
\+ 1
0111 (*Ans.*)

Problem 36.9 : *Subtract*

(1) 1001 from 101111 (*Ans.* 100110)
(2) 10101 from 111011 (*Ans.* 100110)
(3) 10011 from 110001 (*Ans.* 11110)

(c) **Binary Multiplication**

Rules for binary multiplication

Copy multiplicand when multiplier digit is 1; do not when it is 0.

Shift as in decimal multiplication.

Add the resulting binary numbers according to the binary addition.

Examples of binary multiplication

Example 1

Binary	*Decimal Equivalent*
1101	13
1100	×12
0	26
0	13
1101	156
1101	
10011100	

Example 2

Binary	*Decimal Equivalent*
101	5
111	×7
101	35
101	
101	
100011	

Example 3

		1	1	1 1
×	0	1	1	1 1
	1	1	1	1 1
	1	1	1	1
1	1	1	1	
1	1	0	1	0 1

Explanation

Column (3)

1 ┐
1 ┘ from problem
1
1 ┐ carry from col (2)

Sum 4

4 in binary numbers = 100

carry to col (5)

carry to col (4)

Remains in col (3)

Problem 36.10

(1) Multiply 111 by 1101 (*Ans.* 1011011)

(2) Multiply in binary numerals

(*a*) 10×127 (*Ans.* 10011110110)

(*b*) 127×65 (*Ans.* 10000000111111)

(*c*) 65×25 (*Ans.* 11001011001)

(D) Binary Division

Rules for binary division

- Start from the left on the dividend.
- Perform a series of subtractions in which the divisor is subtracted from the dividend.
- If subtraction is *possible*, put a 1 in the quotient and subtract the divisor from the corresponding digits in the dividend.

- If subtraction is *not possible* (divisor greater than remainder), record a 0 in the quotient.
- Bring down the next digit to add to the remainder digits.

Proceed as before in a manner similar to long division.

Example

Divide 100001 by 110

```
          0101.1  ———— quotient
Divisor-- 110 | 100001   0 —— Dividend
              110  ———————— Divisor greater than 100, so put 0 in quotient
              1000 ———————— Add digit (0) from dividend to group used above
               110 ———————— Subtraction possible, so put 1 in quotient
               100 ———————— Remainder from subtraction plus digit (0) from dividend
               110 ———————— Divisor greater, so put 0 in the quotient
              1001 ———————— Add digit (1) from dividend to group
               110 ———————— Subtraction possible, so put 1 in quotient
                110 ——————— Perform subtraction and add digit (0) from dividend to remainder
                110 ——————— Subtraction possible, so put 1 in quotient
                    ——————— No remainder, so stop.
```

Decimal equivalent : 33 divided by 6.

```
      5.5
   6 | 330
       30
      ---
       30
       30
      ---
```

Problem 36.11

1. 111 | 11100111
2. 101 | 1100010

Convert the above in decimal form, then divide to check the answers.

36.24. BIT, BYTE AND WORDS

(*i*) **Bit**

- The computer does not have a large number of symbols for representing data. It has only two, 0 and 1 (called **binary digits** or **bits**). These correspond to the two *electronic* or *magnetic* states used in computer circuits and storage.
- The smallest unit used for feeding data and program into computer is *bit.*
- Information is handled in the computer by electrical components such as *transistors, integrated circuits, semiconductors* and wires, all of which can only indicate two states or conditions. Transistors are either conducting or nonconducting ; magnetic materials are either magnetized or non-magnetized in one direction or in the opposite direction ; a pulse or voltage is present or not present. These two possible states can be expressed with the help of bits -0 and 1. For example, the presence of current pulse in a circuit in computer may be represented by the bit 1 and the absence of current pulse in a circuit may be represented by the bit 0.*

(*ii*) **Byte**

- A collection of some *bits* is called a *byte.*

* Nibble is a string of four bits. One Nibble is equivalent to half a byte. Examples of Nibble are 1010, 1111, 1000 etc.

- Byte is a group of adjacent bits (*binary digits*) operated upon as a unit.
- An *8 bit unit* is commonly called a *byte* and has become the standard unit for storing a single *character.*
- As mentioned above, in many computers, it is 8-bit set encoding one *alphanumeric character* or two decimal digits.
- *Alphanumeric* is a contraction for *alphabetic* (A, B, C, etc.) and *numeric*, (0, 1, 2, etc.).

  A set of alphanumeric characters will usually include special characters too such as dollar sign, comma etc.

(*iii*) **Words**

- Some memory units are not made up of *bytes* but of *words*. A computer word consists of the data which is stored or retrieved when a memory location is specified
- *Word* is a collection of bits treated as a single unit.
- Word is an ordered set of characters handled as a unit by the computer.
- The word may be *fixed* or *variable* in *length.*
- The *word length* depends upon the number of *bits* or *characters* in a word. The number of bits varies from 4, 8, 12, 16, 32 etc., upto 64 *i.e* the word may be as long as 64 bits or as short as 8 bits.
- In a *fixed* word-length computer, the number of characters in a word does not vary, and an *address* will typically refer to one set of characters.
- In a *variable* word-length computer, each character or *byte* has an address and the word utilized by the computer can include a variable number of characters.

  The length of the variable word is specified either by the instruction which calls for it or by a word-mark in storage.
- A *byte* is usually *shorter* than a word, typically consisting of 8 bits.
- In some computers the grouping of bits, bytes or words is flexible in design to meet the differing storage requirements of numbers, alphanumeric characters and instructions.

36.25. COMPUTER LANGUAGES

Introduction

- A *language* is a system of communications. It usually consists of all the verbal or written symbols and expressions that are used to exchange ideas and information.
- Humans communicate with each other through languages such as English, Hindi and so forth. They are highly developed so that we can express not only facts but also abstract ideas, as well as conveying shades of meaning or suggesting subtle feelings and sensations. But, in order to do so, a *large vocabulary* is required. In contrast, the *natural* language of the computer is far less exotic and has a comparatively *restricted vocabulary.* Moreover we can use natural languages *incorrectly* and still make ourselves understood. Computers, however, are not yet able to correct and deduce meaning from incorrect languages (*i.e.* instructions).

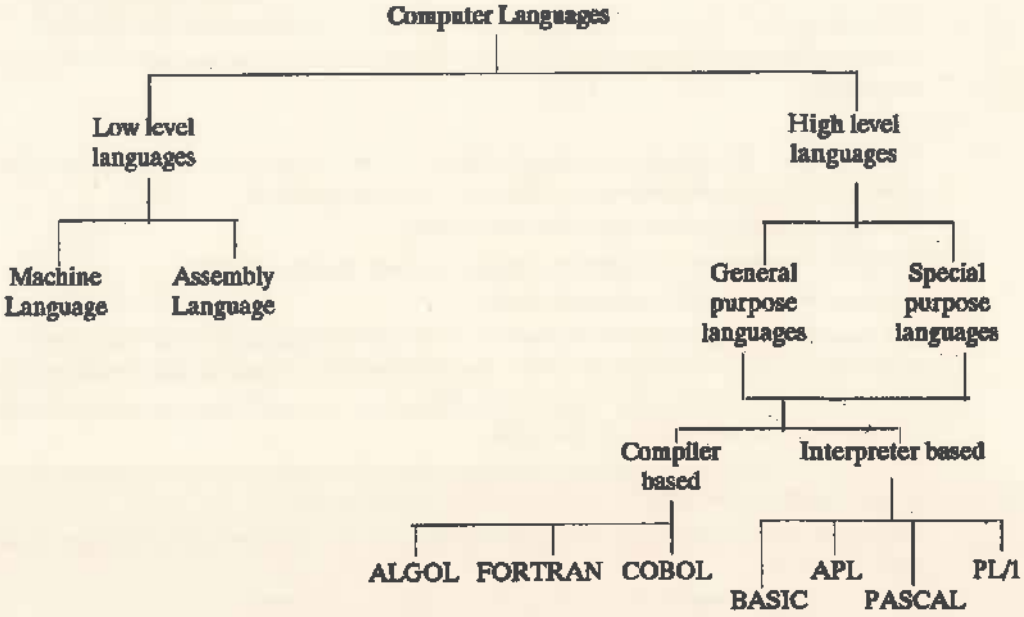
  Computer languages are smaller and simpler than natural languages but they have to be used with far greater precision. Unless a programmer adheres *exactly* to the *grammar* of a programming language, even down to the correct punctuation, the computer will not be able to execute the instructions.
- A *computer language* is a set of rules for creating instructions that either can be directly understood by a computer or can be translated into something that can be understood by a computer.

Types of Computer Languages

– There are *two* basic types of languages used in computers :

(i) Low level languages,

(ii) High level languages.



– *Low level languages* are more compatible with the hardware of the computer and consist of *binary* or *Mnemonic codes*. Thus, low level languages are understood by the computer in a better manner.

– *High level languages* look similar to the English language, and hence are better understood by the programmers rather than the computers.

– There is a *higher level* yet which includes packages, such as *word processing, data base management* and *spreadsheets*. These languages allow users to specify the information they want, in non-programming terms, and the package will produce the required results. These are closely related to Fourth Generation Languages (4GLs) where, again, the accent is on specifying *what* is wanted rather than specifying the steps (the procedure) involved in how it is done. These languages are *non-procedural*, therefore, as opposed to the conventional high level languages which are procedural since the programmer writes the steps (instructions) which specify how the task is to be solved.

– *Advantages of low-level languages :*

(*i*) They require far less space in memory,

(*ii*) They execute more quickly,

(*iii*) They permit the programmer to have more control over the internal working of the computer.

– *Disadvantages of low-level languages :*

They are more difficult to learn and use since the programmer requires quite extensive know[illegible] of the machine's architecture.

– The *high level languages* also known as *problem-oriented languages* have the following *advantages* :

(*i*) Easier to learn, to understand and to write.

(*ii*) Easier to correct and, in general, they are portable.

– There are many high-level languages, but they can be grouped into *four broad application areas* :

1. Scientific *e.g.* FORTRAN, ALGOL 60, FORTRANT 77
2. Commercial *e.g.* COBOL, RPG/2, COBOL 85
3. General purpose *e.g.* PL/1, PASCAL, ALGOL 86
4. Interactive *e.g.* APL, BASIC, LOGO, FORTH

– *Scientific* languages are used in engineering, scientific and mathematical applications where the emphasis is on *number crunching.*

– *Commercial* languages are used essentially for *data processing* applications where the emphasis is on *files of data* rather than numerical computation, *e.g.,* invoicing, stock control etc.

– *General purpose languages* are used for either commercial or scientific applications.

– *Interactive languages* are specially developed for terminal use rather than a batch processing environment.

– High level languages are either *Compiler based* or *Interpreter based.*

Compiler : a complex program which converts a program written in a high-level language into the machine language which a computer can recognize.

Interpreter : translates one source instruction into object code/program* and the computer immediately executes that instruction before moving on to translate the next instruction. This means that some instructions, such as repeated loops may be re-interpreted time and again. Interpreted programs tend to take longer to complete execution than compiled programs. However, an advantage of the interpreter is that if an error is made in a given instruction, the programmer knows exactly at which point the error occurred.

(*a*) **Machine Language**

– Machine language is the language which is directly understood by the computer.

– Machine language is the lowest form of computer language.

– When first generation computers were introduced, programs were written only in *binary* based machine level language. This is the only language actually understood by the computer.

– Since *human* programmers are more familiar with the *decimal* system (rather than the binary system), most of them preferred to write instructions in decimal and leave the *input device* to convert these to binary.

– To understand the *structure* of a *machine code* or *machine language* two facts need to be understood.

The *first*, is that a machine instruction has a two-part format (Fig. 36.31).

The *second* point is that both parts are represented internally in the machine's store as a string of binary digits.

OPERATION (Code)	ADDRESS (Location)

Fig. 36.31. Two-part format.

– Thus, a machine language instruction may look like 563603 where 56 is, for example, the operation code for *addition* and 3603 is the address of the memory location where the number

* Object program : The program in machine language after translation from high level language/assembly language.

to be added is stored. The instruction is, of course, stored in a memory location in a binary representation.

- The main *difficulty* in utilising machine language lies in the fact that one has to memorise the codes for all sorts of *operations* as well as the *location* numbers and addresses of all *memory* boxes. The stupendous task can well be imagined by the fact that a program may consist of more than 100 different operations (instructions) and also hundreds or thousands of locations in memory.

(*b*) Assembly Language

- *Assembly language* is also known as *Symbolic language*. Like machine language, it also being oriented towards the basic design of computers, is called *low level language.*
- Considering the *difficulties* encountered with the machine language, the assembly languages were developed in 1950's and were introduced in the second generation computers.
- In Assembly language, the idea of *mnemonics* (or memory aids) was introduced.

  The human mind can more easily identify with mnemonics or abbreviated words such as MULT for multiply, DIV for division etc., *than* (a series of digits, for example, a computer may be designed to interpret) the machine code 1001 (binary) or 09 (decimal) as the *operation-multiply.*
- This, though, made the life easier for the programmer, it made things more involved for the computer.
- The abbreviated words such as MULT, DIV, SUB, ADD, STO (store) etc. have to be translated into the *binary* pattern before the computer can *understand* the operation intended.

  This act of translating is carried out by a special pre-stored program called an *assembler.*

  In other words, the *software aid* that translates the *symbolic language* program into a *machine language-object program* is called the *assembler program* or *assembler.*

  Assembler translates the program written by the programmer into that version which the computer/machine recognizes and responds to, and *assembles* it in the main memory, ready for execution.
- The assembly language program prepared by the *user* is called *source program.* This source program acts as an input to the *assembler*, which is loaded to the computer's memory. Then the assembler performs the translation and generates the equivalent machine code, which is called as the *object program* or *object code.*

  In a typical computer system, the assembler program is stored on paper tape, magnetic tape or a disk. When it is needed, the assembler is called up from secondary storage and loaded into RAM (Random Access Memory, usually on a chip). The source program is then entered by the user *via* the terminal and is also stored in RAM. The assembler translates the source program into object code and stores it in another portion of RAM. The object code or program is then stored on some external media. In this way, the program can be retrieved and executed again and again when needed.

(*c*) FORTRAN

- The commercial viability and wider use of computers led by the mid-1950s, to the necessity for, and development of *higher level languages.*
- Higher level languages, instead of being machine based, are orientated more towards the problem to be solved.
- Such problem-oriented languages (such as Fortran) enable the programmer to write instructions using certain English words and conventional mathematical notations, therefore making it easier for the programmer to think about the problem.
- The first available high-level language was FORTRAN developed in 1956 for use on an IBM 704 Computer.

Its primary *purpose* was to solve mathematical and scientific problems which were allowed to be written in a simple English style with the mathematical expressions stated naturally *e.g.*, A=B+C−D.

- During the middle 1960s, it became widely used on a number of machines resulting in a variety of *dialects*, the most important being IBM FORTRAN II and IBM FORTRAN IV.
- By 1962, the American Standards Institute (ASA) set up a working committee to produce a specification for the language. Two versions were finally approved in March 1966, ASA FORTRAN (similar to IBM FORTRAN IV) and ASA BASIC FORTRAN (similar to IBM FORTRAN II).
- A new *standard* FORTRAN, called FORTRAN 77, was defined in 1977.
- The latest in the field is FORTRAN 86.
- The *fortran language*, the name being an abbreviation of the two words *formula translation* is a problem-oriented programming language.
- Fortran is extensively used throughout the world.
- Because it resembles familiar arithmetical language, it greatly simplifies the preparation of problems for machine computation. Data and instructions may be organized in the form of a sequence of fortran statements. This is the *source program*.
- The *fortran compiler*, also called the *translator* or *processor*, then analyzes these statements and translates them into an *object program* in machine language.
- A program written in fortran language can be processed on any machine which has a fortran compiler.

  In this sense the language is *machine independent*.

  However, the compiler must in each case be prepared with the particular machine in mind.
- Because machines do differ in their internal organization, a number of *dialects* of Fortran have developed, each dialect being suited to a class of machines. The differences between dialects are not severe and one easily adjusts from one to another.

  The dialect to be presented here is known as *Fortran IV*.
- The *alphabet* of Fortran includes the following characters ;

Letters ----> . A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Digits ----> 0 1 2 3 4 5 6 7 8 9

Other characters -> + − * / = . , ( ) $

From this alphabet all our symbols, expressions and statements in Fortran language are to be constructed.

(d) **COBOL**

- COBOL implies **Common Business Oriented Language.**
- Work on a common source language suitable to *commercial* (as opposed to scientific) *data processing* began in 1959. A committee composed of several large users, the federal government, computer manufacturers, and other interested parties was formed to develop the language. The CODASYL (Conference on Data Systems Languages) Committee developed the specifications for a language named COBOL. Their report, issued in April 1960, contained the first version of COBOL, called COBOL 60.
- Subsequent revisions of this language were published in 1961 (COBOL-61), 1963 (COBOL-61 Extended), and 1965.

- COBOL has been established as a standard language by the American National Standards Institute (ANSI).
- ANSI released a new standard—ANSI COBOL 85 which includes many concessions to modern thinking.
- CIS-COBOL (Compact, Interactive Standard) is used on personal computers. Lateral versions also include powerful debugging* aids to speed up interactive development of COBOL programs.
- COBOL is a higher-order language oriented towards commercial *data processing* procedures. Data processing is the processing of information, specifically business type information, by computer.
- COBOL is a procedure-oriented language designed for coding business data processing problems. These types of problems are characterized by the use of large *files* (organised collection of records having a common feature or purpose), a high volume of input and output, and production of report output requiring editing and formatting of output data.
- COBOL looks and reads like ordinary business English. The programmer uses English words and conventional arithmetic symbols to direct and control the complicated operations of the computer.
- Like all procedure oriented programming languages, COBOL requires a source language for coding instructions and a compiler to convert the source program into a machine language object program. Although the source language is common, the compiler is unique for each computer.
- The following are typical COBOL sentences :

MULTIPLY QUANTITY BY PRICE GIVING TOTAL PRICE

ADD SALES TO 600 GIVING TOTAL

The COBOL *compiler* translates these instructions into machine language and the machine language program thus generated is known as *object program.*

- A COBOL program consists of four parts or divisions as named below :

Division	*Purpose*
IDENTIFICATION	Identification of the program
ENVIRONMENT	Description of the equipment to be used.
DATA	Form and format of the data files
PROCEDURE	Processing steps to be performed.

(*e*) PASCAL

- PASCAL (not an acronym, but named after the great Frenchman) is a high level language.
- It was originally designed by Nicklaus Wirth in 1968, belongs to the ALGOL stable and the first operational compiler became available in 1970.
- One of its more important features is to allow the programmer to structure data in *his* way.
- Pascal was developed as a teaching aid to students of programming, but has expanded rapidly that it is now used in business and scientific applications.
- Pascal is relatively easy to learn.
- Pascal is available on micro-computers.
- Compared to other languages like FORTAN, Pascal has poor input/output capabilities.

* Debug : To locate and correct errors in a program or malfunctions in equipment.

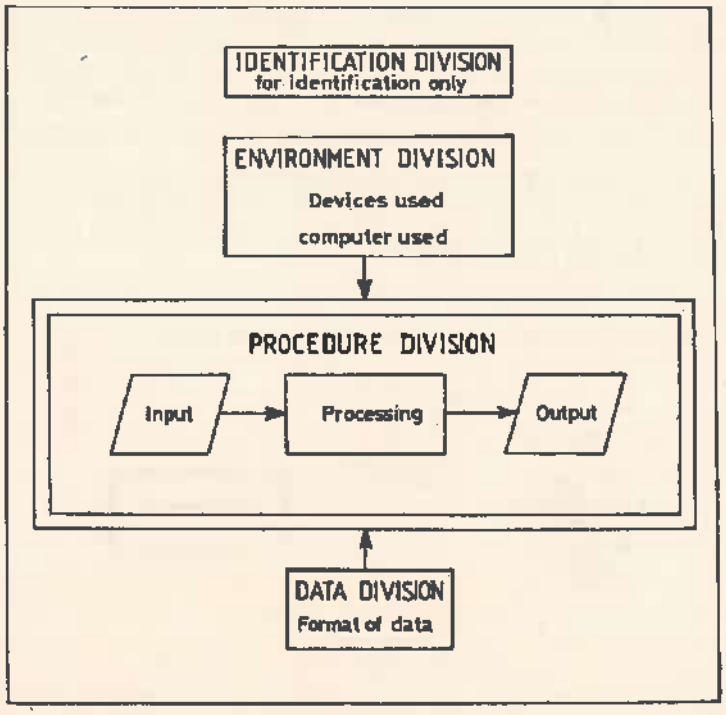


Fig. 36.32. COBOL Divisions

(*f*) BASIC

- BASIC implies **Beginners All-purpose Symbolic Instruction Code.**
- BASIC was developed in 1963-64 at Darmouth College in the U.S.A., under the directions of Professor John Kemeny and Thomas Kurtz for use on a *time sharing* system. Since then it has been used in a number of computers and applications.
- Most of the present day micro and home computers and graphics terminals use only BASIC language.
- To understand BASIC it is not necessary to learn complex programming techniques. It is, in fact, intended for those who have no experience with using computers or writing computer programs.
- BASIC has few grammatical rules and can be said to be *user* rather than *system* orientated. It resembles FORTRAN in many respects, making use of standard mathematical notation, but serves business applications equally well.
- BASIC can be learnt in a few hours concentrated study and, though simple, it is flexible and reasonably powerful.
- Because of its simplicity and bias towards the user, BASIC is a language well suited for use in education and has become extremely popular with micro computer users.
- The *disadvantages* of BASIC is that it is limited in scope.

  There are no standards for the BASIC language but the Darmouth specifications form the generally agreed-upon heart of the language.

– The major *application* of BASIC is in **Time Sharing** in which the programmer user has a type writer device such as a Teletype. Programs are typed and transmitted line by line to the computer. After the program is received, it is executed and the results are typed on the typewriter. The typewriter may also have a punched paper tape input and output. This allows a program to be prepared offline (without being connected to the computer) by punching into a tape.

The punched paper tape is then transmitted to the computer, saving online connection time.

BASIC is available on some computers for regular batch compilation from cards, but this use of BASIC is much less common than its use as a *time sharing language.*

36.26. COMPUTER OPERATING SYSTEMS

Introduction

– People communicate with a computer *via* an *operating system.*

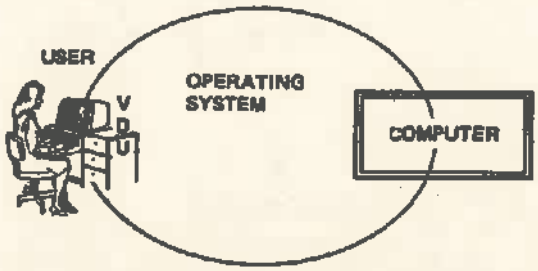


Fig. 36.33. User, computer and operating system.

– The more *friendly* (and easy to use) the operating system, the easier it is for people to interface with and make use of the computer.

– An *operating system* is really a collection of separate units (programs) which function as a harmonious whole, for example :

(*i*) The *Language translators*, which convert source code into machine code.

(*ii*) The *disc operating system*, which transfers data and programs, to and from the *disk* into and out of control *memory.*

(*iii*) The *text editor*, a program which allows a user to correct or amend any information stored on disk/tape ; to *add* new information or to *delete* unwanted information.

(*iv*) *Direct commands* to save, rename, copy, delete, and print files of data or programs or list the names of files held on mass storage.

Types of Computer Systems

– Today, there are many types of *computer systems* :

(*a*) Batch processing,

(*b*) Multi programming,

(*c*) Interactive processing,

(*d*) Time sharing,

(*e*) Real time processing, etc.

(*a*) Batch Processing

– It is desirable to hold *programs* until a reasonable size *batch* of programs can be processed.

– In batch processing, data to be processed is accumulated over a period of time. The accumulated batch is processed periodically. This method *i.e. batch processing* is very efficient, but its use

means that there is always a processing delay.

– Since the speed of the CPU in executing programs is far greater than the speed of most input/output units, the CPU will remain idle for a large fraction of the total time between input and output, when processing *one program* at a time. Batch processing, hence, is an improvement over the single-job submission and frequently increases the number of programs executed by 50% or more.

(*b*) Multi-programming

– The technique for having the computer handle several programs concurrently is known as *multi-programming* or *parallel processing*. The programs are placed in different sections of memory (Fig. 36.34). The computer can switch the CPU from one program to another. This task is incorporated into the overall operating system, usually called the *supervisor, monitor* (IBM) or the *executive* (ICL).

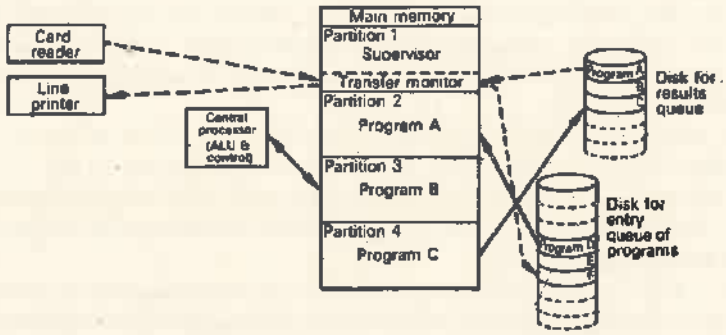


Fig. 36.34. Principle of a multi-programming system.

– In Fig. 36.34 the main memory is divided into *partitions*. The first partition is reserved for the supervisor, which has to remain in main memory all the time.

The other three partitions (in this instance) each hold a program, A, B and C. Although there are more than two programs in main memory, only *one* is ever being executed at any point in time.

Program B is currently being executed and Program C is passing some results to disk.

Program A has completed its work and is being replaced by Program D from the entry *queue*. Note that a second disk is illustrated to hold the results of each program in separate areas.

The *transfer monitor* (a part of the supervisor partition) is reserved permanently to organize the transfer of these queued results from the disk to the line printer. It is also used to build up the entry queue on disk, which has been input from a card reader(Program F in the diagram).

Comparison between Batch Processing and Multi-programming

1. Multi-programming is using *complex* operating systems whereas the operating system is *simple* in batch processing.
2. In multi-programming two or more programs remain in central *memory* at one time whereas there is only one program in memory at one time in batch processing.
3. Magnetic tapes, disks or drums are used as secondary storage devices in batch processing whereas only magnetic disks are employed in multi-programming because of *random access*.

(*c*) Interactive Processing

– Interactive processing refers to a direct link between the user and the computer. In this type of processing, the user enters his data through a terminal and receives results directly. Such

immediate interaction between the user and the computer is the single greatest advantage of this type of processing.

- *As a comparison*, in traditional batch processing, the user codes his *program*, punches it, gives it to CPU for processing etc., whereas in interactive processing, all intermediate handling is eliminated. Here the user types his program segments which are entered into computer's storage and displayed on his terminal simultaneously. Once the program has entered into the computer, it can be compiled, tested and executed at the terminal.

  Thus a procedure that was extended over several days in the batch processing is reduced to a matter of minutes or hours in the interactive processing.
- In most of the micro-computer installations the interactive processing is adopted.
- The *terms Time Sharing, real time processings,* etc., are *related* to *interactive processing.*

(*d*) Time Sharing

- *Time sharing* is the concurrent use of a single computer system by many users, each of which has an input/output device and can access the same computer at the same time. The computer gives each user a small, but frequently repeated, slice of the time, so that each user gets almost immediate response. Each user operates independently without an awareness of the use of the facility by others.
- Time sharing is *popular* for universities and for certain types of scientific and engineering computation, but it is quite *limited* for commercial data processing use.
- Time sharing may be viewed as an *extention* of multiprogramming in which the computer works on several programs concurrently, going from one to another for the purpose of maximizing the use of the system hardware.
- Users of a time-sharing system communicate with their computer *via* visual display terminal which is connected to the computer by land or telephone lines. In this way, they have a direct means of communicating with the central processor.
- Time sharing systems have many, even hundreds, of terminals linked up to the central processor at the same time.
- The basic idea behind time-sharing system is to allow *all* programs to have a brief share of the central processor in turn. The time-sharing *supervisor* (resident in main memory all the time) gives each job a short period of time during which it is in sole control of the processor.

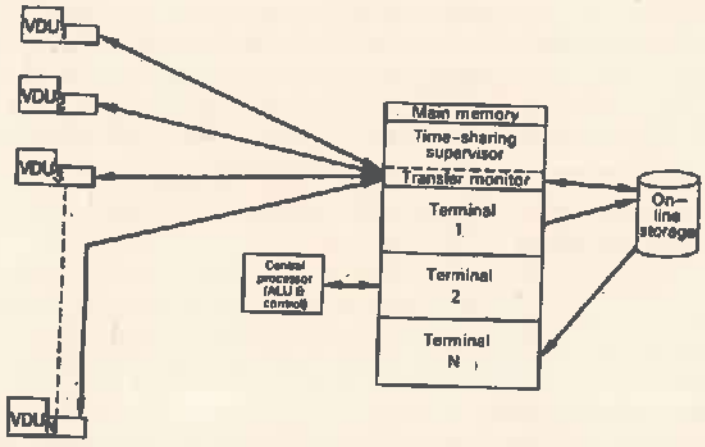


Fig. 36.35. Concept of a time-sharing system.

– In time sharing systems, a *transfer monitor* is required to coordinate the flow of information between the terminals and the disk storage. It is resident in the central memory and works in conjunction with the time-sharing supervisor which is responsible for the overall operation of the time-sharing system.

Fig. 36.35 illustrates these concepts and shows

Terminal 1's program being swapped out,

Terminal N's program being swapped in, whilst

Terminal 2's program is currently being executed.

(e) Real-time processing

– In real-time processing, each transaction is processed as soon as it is received. There is no waiting to accumulate a batch of transactions. Real-time processing is used especially in situations such as a computerized *reservation* system where an immediate response is required.

– *As compared to time-sharing*

(i) Real time processing is devoted mainly for one application whereas time-sharing has many different applications.

(ii) User can make *enquiries* only in real-time processing whereas in time-sharing, user can write and modify programs.

– The expression *Real-time* is applied to any system which produces an almost immediate response as a result of inputting data. The essential feature is that the input data must be processed quickly enough so that further action can then be promptly taken on the results.

– Real time system is able to receive continuously changing data from outside sources and to process that sufficiently quickly to be capable of influencing the sources of data (*e.g.* air traffic control).

– Two *examples* of systems which operate in real-time are

(i) process control systems as in nuclear reactor plants and steel mills, and

(ii) transaction systems such as airline reservations.

– Real time systems cannot break down without causing some disruption. This is one difference between real time and time sharing; the latter should not fail, but if it does, the outcome is never disastrous.

In many instances, real time systems are *duplicated* so that, in the event of a break-down, back-up facilities are immediately available.

– The term *on-line* refers to a system in which all necessary devices are immediately accessible (*on line*) to the computer. As soon as the user enters his input data, it is processed immediately. If the output results are returned quickly enough to be useful in some current activity, a *real-time* environment is created.

– The *major disadvantage* of on-line and real time systems is that of complexity and hence cost.

– The overwhelming *advantage* of on-line and real-time systems, however, is that of *timeliness.*

36.27. APPLICATIONS OF COMPUTERS

– Computers find applications in many walks of life. Their applications mainly in the following fields will be discussed in this article.

1. *Scientific*
2. *Business*
3. *Production*

36.27.1. SCIENTIFIC RESEARCH

– In science, the advent of computers has meant that, calculations which were previously beyond

contemplation, because of the time-span and drudgery involved in carrying them out, have now become possible.

This has greatly accelerated and expanded research in such sciences as physics, chemistry, astronomy and genetics.

- More recently there has been an increasing use of computers for research and data analysis in less mathematical areas such as medicine, the social sciences and even the humanities where applications include concordances, textual criticism and stylistic analysis.
- Computers are now a standard feature of life in universities and industrial laboratories. Almost every branch of science and engineering has benefited from their development. Elementary particle physics is one field of study which has been broadened considerably. Molecular biology is another, resulting in spectacular progress in our understanding of the structure of living matter.

36.27.2. BUSINESS APPLICATIONS

- Computer applications to business and commerce date from the middle of the 1950's.
- The pace of the technology has since quickened and today most large and some medium sized companies are dependent on their computers for administrative functions.
- Micro-electronic technology is enabling offices to function more efficiently and micro-computers are used, now-a-days, by various concerns:

(*a*) In business forecasting.

(*b*) To keep records up-to-date.

(*c*) To carry out automatic checks on the stock of a particular item.

(*d*) To prepare pay bills and personnel records.

(*e*) In accounting, invoicing and billing.

(*f*) In banking operations and data storage.

(*g*) In business correspondance and communications.

(*h*) In functions of various types in Life Insurance Business.

(*i*) As an aid to management, etc.

36.27.3. DATA PROCESSING

- Although computers were initially designed to solve scientific problems, the bulk of computing today is concerned with **data processing**, which covers a wide field of applications relating to commercial, governmental and industrial tasks.
- The purpose of discussing data processing is that it brings us back to a major concept, namely that computers process information.
- *Data processing means* the processing of information, specifically *business* type information, by computer.
- Almost any organisation has a certain amount of administrative work that used to be carried out *manually :* staff must be paid, raw material has to be ordered, records have to be maintained of the personnel employed, the tax deducted from their pay, suppliers, orders placed with suppliers, customers, customers orders etc., in order that the organisation may work efficiently and meet its legal obligations.

  It was during the 1950s that the term data processing came into widespread use to describe all these administrative processing and record-keeping functions.

  Although the activities included in the term data processing were diverse, they nevertheless shared some common features. Among these were :

1. Need to maintain accurate records and files.
2. Need to sort, merge and tabulate the records in the files.
3. Need to carry out basic calculations.
4. Large volume of records handled.
5. Routine and repetitious nature of much of the manipulation performed on the records.

– Given the above features, it was natural that *machines* should be developed to help in the processing of data with the objectives of improving accuracy, reducing tedious manual work, speeding up the work and, above all reducing the costs involved.

– The *machines* used for data processing until the 1950s were mechanical or electro-mechanical.

– In 1951 the world's first commercial data processing computer was developed by British food company Lyons to perform some of the commercial tasks described above.

– A period of rapid development followed and a significant point was reached in 1959 when IBM introduced the 1401 computer.

– With the widespread use of computers for data processing work, the terms *Electronic Data Processing* (EDP) and *Automatic Data Processing* (ADP) came into use to distinguish data processing carried out using the new tools from that using the (then) conventional tools.

– The flexibility of computers has also caused the scope of the term data processing to be broadened and today it often includes such activities as

(*i*) Scheduling the work to be performed in manufacturing plants,
(*ii*) Calculating statistics,
(*iii*) Monitoring the performance of industrial plant or machinery, and
(*iv*) Analysing a wide range of technical facts and figures.

– The study of data processing is actually the study of the organisation and techniques for the collection, processing, storage and output of data.

– We shall now briefly examine the *steps* by which information (current and past paperwork) is expressed as data, processed and returned to managers, as updated and useful information. There are basically *five* steps :

1. Preparation of source documents
2. Input of data
3. Manipulation of data
4. Output of information
5. Storage of data.

1. *Source documents.* The first step is to obtain the relevant facts and figures and to set these out on source documents. For example, in a population survey, the name, address, age, sex, occupation etc. must be first written down onto a survey sheet.

2. *Data input.* Once the data has been extracted from the source document, it must then be transposed into some form suitable for entry into the computer so that processing can take place. The method will depend upon the input device *e.g.* punched cards, paper tape, VDU etc.

3. *Manipulation of data.* Information, input as data, for processing, may have to be *classified* or *sorted*. It is this data manipulation, rather than pure computation, with which data processing is mainly concerned. For example, in the population survey, we may want to classify people by age. All these forms of data manipulation will produce results in the form of *summaries e.g.* the number of adults and children in a given town, etc.

4. *Output of information.* The object of outputting results or *summaries* is to provide meaningful information to all concerned. The summaries should be such that they can be digested easily and quickly.

5. *Data Storage.* In most cases, the results of processing (one set of) data are retained for future use or reference.

36.27.4. INDUSTRIAL APPLICATIONS/PRODUCTION

- Computers are used to direct the operation of individual machine tools (drills, lathes etc.) and also to operate assembly machines. The use of *numerically controlled machine tools* directed by computer-produced tapes can speed up production, ensure greater precision and reduce scrap.
- In certain industries *e.g. chemical, oil refining* etc., the computer can be used to monitor and regulate total processes (*i.e.* to perform process control) without human intervention, just as it can control air-conditioning (and heating) systems in modern multi-storey buildings.
- The design calculations of any piece of engineering, whether an aeroplane, ship, car, bridge, road, building or machine, can be done by computers. Moreover, the computer can evaluate the *alternatives* more quickly and more accurately than would otherwise be possible. This means a great saving in time and elimination of technical faults and human error.

  Computers are also used in calculations of space and layout as well as strength requirements.

  Computer can also help with graphical display, the creation of drawings and schematic drawings.

  Computers are also used as an aid to circuit board design, even assisting electronic engineers in designing circuits for other computers.
- The application of computers to design is known as CAD (Computer-aided design) and where it applies specifically to engineering, it is often referred to as CAE (Computer-aided engineering).

  CAD makes use of a computer to interact with a designer in developing and testing product ideas without actually building prototypes. The computer assists in the design of an individual part or a system such as an aircraft. The design process usually involves computer graphics.
- In *industry,* production may be planned, coordinated and controlled with the aid of a computer.

Computer may be used to assist in :

(*a*) Inventory control

(*b*) Product scheduling

(*c*) Line balancing

(*d*) Network analysis (PERT and CPM)

(*e*) Operations research problems (Linear programming such as transportation problems, waiting line theory, etc.).

- The solution of a **linear programming** problem of a good size and complexity involves hundreds of thousands of simple repetitive calculations which would be impractical without a computer. In fact, linear programming methods were developed specifically to take advantage of computer technology.

  Linear programming is used by business firms to find the optimum solution to such problems as the least-cost blend of ingredients for feed (Fig.36.36), the most profitable combination of oil refinery production, and the most economical shipping schedules.
- *Critical Path Analysis (CPM/PERT) by Computer*

  The scheduling of projects with interdependent activities can become quite complex. Computer programs have been written which analyze activities in order to calculate which are critical to the timely completion of a project and which can take longer than expected time without delaying the completion date. This technique is called PERT, CPM, or critical path scheduling.

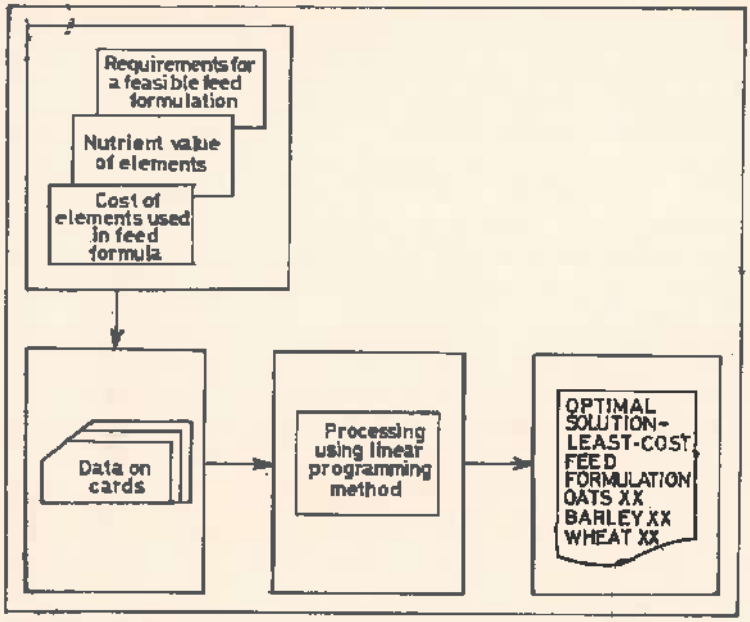


Fig. 36.36. Linear programming (for least cost feed) formula.

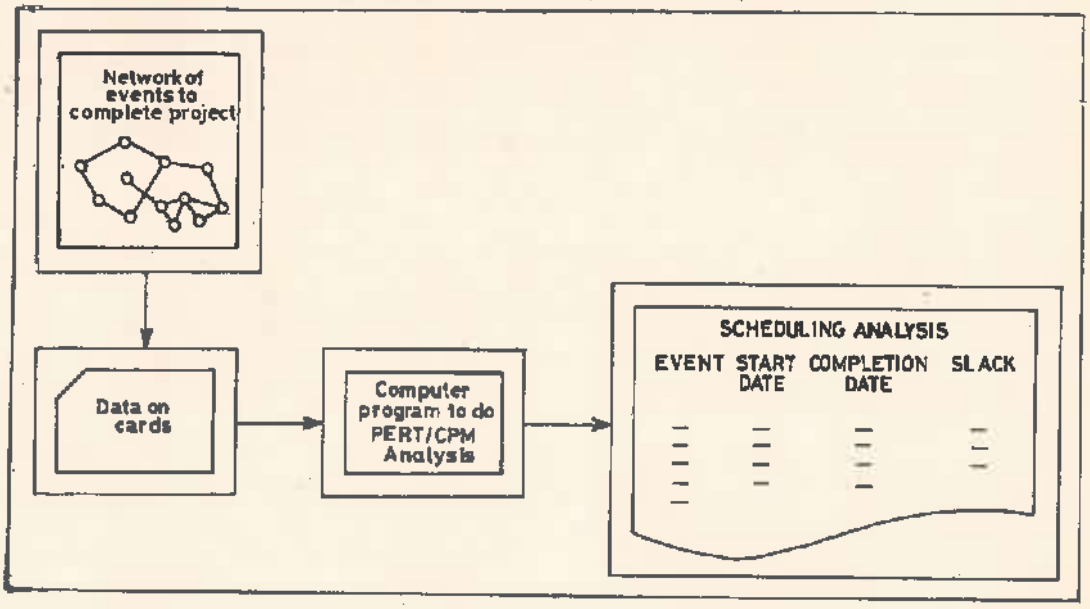


Fig. 36.37. Critical Path Analysis by Computer.

37

Business and Environment

37.1 MEANING OF BUSINESS

— *Business* may be *defined as the organized efforts* by certain persons, (entrepreneurs, firms or enterprises) to supply the consumers with *goods* and *services.*

Examples of goods : T.V., Refrigerators, electric goods, cooking utensils, cloth etc.

Examples of services : Repair shops for the goods sold, hospitals, etc.

— *Business*, in fact, is a *system* created to satisfy the needs and desires of the people or *society.*

— Persons engaged in business either *produce* (manufacture) or *distribute* (trading) the goods or render services to the consumers of their goods.

— *Business*, which is a complex field of commerce and industry:

(1) Creates employment opportunities,

(2) Contributes to the economic growth of the country,

(3) Improves standard of living.

— To be prosperous, *society* needs business and businessmen.

— *Business involves the following activities:*

(1) Manpower (2) Financing

(3) Buying (4) Selling

(5) Earning profit etc.

— Broadly, business embraces three terms namely — *Industry, Commerce, Profit.*

Business is a commercial activity to make profit.

37.2 EARLIER BUSINESS OBJECTIVES

— In the past, economic theory made a fundamental assumption that **profit maximisation** was the basic objective of every firm or business enterprise.

— *Profit* is the excess of income over expense.

— No doubt, profit is the (*i*) main incentive, (*ii*) motivator, (*iii*) strong sustainer, (*iv*) judicious allocator of resources. (*v*) objective indicator of productivity, (*vi*) and hence a solid base for growth.

— *Profit* enables *Business* to realise his *other objectives* too, such as (*i*) expansion of business, (*ii*) buying modern machinery, (*iii*) making quality products, (*iv*) better service to society, (*v*) market leadership, (*vi*) employee satisfaction, (*vii*) better working conditions and above all (*viii*) joy of creation.

37.3 CHANGING CONCEPT AND OBJECTIVES OF BUSINESS

— As explained in Article 37.2, in the past *profit maximization* was the basic objective of any business.

— *The modern out-look, however, is different.* For many business organisations, now, profit maximization in the short run is not the primary objective. For them *profit* is only *secondary.*

— The *old concept* of business, confining it merely to commerce and private profit has undergone a radical change.

— Today the *business* is regarded as a *social institution.*

(1) It should actually work as a *social institution,* performing a *social mission* and having a broad influence on the way people live and work together.

(2) The *direction of business* should be towards public welfare. The public should get quality products and services at most reasonable economic prices.
There is a growing recognition that the business should pay due attention to the long-term *welfare of society.*

(3) Modern thinking expects the business to take on to itself the responsibility for serving or safeguarding societal interests as one of its important *objectives.*

(4) Large companies, top executives and even major shareholders today have the opinion that
(*a*) Profit is not the primary objective of a firm
(*b*) The objective of a firm should not be *profit maximization,* but it should be *sales maximization,* subject to a *minimum profit constraint.*
(*c*) The business companies may strive to gain leadership in market share, sales volume, fixed assets, employment etc., even sacrificing profit maximization.

(5) With the general change in outlook of large business houses, *the changed business objectives today are:*
(*a*) The reduction in the prices to be charged from the customers.
(*b*) The extension, development and improvement of the company's business and the building up of its financial independence.
(*c*) The payment of fair and regular dividends to the share holders.
(*d*) The payment of fair wages under the best possible conditions to the workers.
(*e*) To enhance labour welfare.
(*f*) To enhance customer service and goodwill.
(*g*) To create safe and good working conditions in the factory.
(*h*) To help in developing the industry (i.e., automobile industry) of which a firm (*i.e.,* Escorts Tractors) is a member.
(*i*) To contribute to national goals.

(6) *Lastly, it is worth mentioning* that a reasonable level of *profit* is not only compatible with the concept of a socially responsible business but also necessary for the discharge of social obligations and responsibility.

— Profit can be *primary* but not the *ultimate object* of a *responsible company.*

— In a responsible company, profits will continue to be the criterion of financial health—as blood is the life of man, so are the profits for the life of an industry.

Just as a man must maintain life before he can pursue for the objectives of his life, similarly, profits are necessary for the life and health of any business organization.

— *Profit should work as seed money for*

(*i*) Exploring more products and markets
(*ii*) More plants (diversification into new areas)
(*iii*) More dividends
(*iv*) More tax payments
(*v*) Creating more jobs
(*vi*) More opportunities
(*vii*) Cutting down production costs and increasing productivity.
(*viii*) Promoting well-being of all—rich and poor, privileged and less privileged, consumers and producers, investors and non-investors etc.

37.4. PROFESSIONALISATION

— A **professional** is one (1) who possesses systematic knowledge and skill to perform certain responsible functions with authority *and* (2) who is bound by certain *ethics* in the use of his knowledge and skill.

— A *professional* has to have *autonomy*. He cannot be controlled, supervised or directed by the client and he is not subject to political or ideological control. But he sees himself as affected with the public interest. He is *public* in the sense that the welfare of his client sets limits to his deeds and words.

— A professional has enormous *responsibilities*. He shall not use his knowledge, skill and authority unscrupulously. He shall not knowingly do harm to his customers. He is socially bound by the ethics of his profession.

— The *growth of management education* and training has contributed to the growing ***professionalisation*** of management.

— **Professionalisation of Business** iemplies that the business should be managed by persons

(1) Who have formally acquired the specialised knowledge and skill for management.
(2) Who have authority and freedom to take the right decision.
(3) Who have no ideological bias in the discharge of the functions.
(4) Whose decisions and actions are guided by certain ethical considerations.

— **Professionalisation**

(1) Contributes to the growing social orientations of business.
(2) Makes business more efficient, dynamic and socially responsible.

37.5 BUSINESS ETHICS

— *Business ethics* imply a system of *moral principles* and *rules of conduct* applied to business so that the business should be conducted according to certain self-recognised moral standards.

This is with a view that the interests of society and of the business sector itself should not suffer.

— The *ethics of business* are the same as those which every individual in society and society as a whole should abide by.

Individuals do not acquire exemption from ordinary rules of personal behaviour because of their work or job. Nor, do they cease to be human beings when appointed General Manager or President of a business organization etc.

— An individual learns moral values from his family and moral education from his school.
— However, certain *norms and principles of conduct* have been commonly advocated as constituting *business ethics*:
  (1) Do not cheat customers by selling them defective. substandard and poor quality products.
  (2) Avoid hoarding, black-marketing or profiteering.
  (3) Have a healthy competition with other firms producing or distributing the same products.
  (4) Your product advertising should not be false. Labelling and packaging should be accurate (as regards its weight, composition etc.)
  (5) The business records should be accurate, kept current and made available to all authorised persons.
  (6) Taxes and other obligations should be discharged promptly.
  (7) Ensure payment of fair wages and fair treatment to employees.
  (8) Avoid giving bribe to administrators, politicians, purchase personnels or engineers (of the firm intending to buy your products) etc.

37.6 SOCIAL RESPONSIBILITY OF BUSINESS

Introduction

— The *social responsibility of business* means the responsibility of business (firms) towards customers, workers, shareholders, Government and the community.
— Business *depends* on society for
  (1) its *inputs* like, money, men and skills,
  (2) markets where products can be sold to customers (buyers).
— A *Business concern* is so much dependent on society that if people loose interest in its product, the business fails.

  Thus business depends on society for its existence, subtenance and encouragement.
— Every decision the businessman takes and every action he does, has social implications. Be it deciding on diversification, expansion, opening of a new branch, recruitment of new employees, or replacing men by machines (robots) society is always affected in one way or the other. Whether the issue is significant or not, the businessman should keep his social obligation in mind before contemplating any action.
— Being so much dependent on society, the business has definite responsibility towards society.

(1) Responsibility towards Shareholders

— The responsibility of a business company to its shareholders, who are the owners of the concern, is indeed a primary one. The fact that the shareholders have taken great risk in making investment in the business should be adequately recognised.
— The business should be able to safeguard the capital of the shareholders and to provide a reasonable dividend to them.
— Shareholders also expect that
  (*i*) The business should be managed *profitably*.

(*ii*) Fair and *regular return* on capital employed should be ensured.
(*iii*) *Capital appreciation* should be guaranteed.
(*iv*) The *financial position* of the business should be consolidated so that it can withstand fluctuating fortunes (so common) in business.
(*v*) The Company should build its *image* and *reputation* in the market.

In return, the shareholders should not only extend their whole-hearted co-operation and support in the positive efforts of the company, but also guide and control properly its policies and activities.

At the same time, they should appreciate the responsibility of the business to other sections of society i.e.—consumers, employees, and the community.

2. Responsibility towards Consumers/Customers

— If any business cannot *create customers*, it fails. The customer is the *foundation* of a business. He keeps the business in existence.
— Therefore, the business has highest responsibility towards the consumers of its products.
— *Consumer satisfaction* should be the foremost goal of any business enterprise.
— *Unluckily it is not so in India.* Here, the consumer is only a vehicle conveniently used by businessmen for driving towards the goal of profit maximization. Today, you buy a product, tomorrow it stops working completely or at-least stops functioning as efficiently as claimed in its advertisement.

Now, government has started interfering to protect the interests of consumers. *Consumer Grievance Cells* have been formulated for the said purposes.

Moreover, *Consumers*, themselves, are also forming into a *movement* popularly called *consumerism* to protect their interests against business malpractices.

— In general, the responsibility of business towards consumers, includes the following aspects:
(*i*) To supply goods at reasonable price.
(*ii*) To provide prompt after-sales service.
(*iii*) To avoid creation of artificial scarcities.
(*iv*) Not to give a false advertisement about the product to enhance its sales.
(*v*) Producing and distributing only quality goods worth the price charged from the customers.
(*vi*) Providing the same weight, composition etc. of the product as marked on the (product) package (or label).
(*vii*) Provide full information to the customer as regards the care and handling/use of the product.
(*viii*) To improve the product distribution system to avoid blackmarketing or profiteering by unwanted middlemen.
(*ix*) To hear and redress genuine grievances of the customers.
(*x*) To understand customers needs and to satisfy them by *either* improving upon the product *or* by other means.

3. Responsibility towards Employees

— *Dissatisfied employees means*

(*i*) Low production and productivity.
(*ii*) Poor quality of products or defective products.
(*iii*) Careless handling of production machinery.
(*iv*) Higher labour turn-over rate.
(*v*) Loss of interest of sales personnel to sell the product.
(*vi*) Untimely payments to vendors, etc.

The result is the *death* of the business enterprise.

— All those businessmen who want to see their business flourishing and progressing must be aware of their *responsibilities towards the employees* (*as listed below*) because the success of any business house depends to a large extent on the morale of the employees, their whole-hearted cooperation and the employer-employee relations.

(*i*) Fair selection, training and promotion of employees.
(*ii*) Fair wages and adequate incentives to them.
(*iii*) Safe and comfortable working conditions.
(*iv*) Worker's participation in management.
(*v*) Labour welfare schemes.
(*vi*) Proper recognition, appreciation and encouragement of special skills and capabilities of the workers.
(*vii*) The installation of an efficient grievance handling system.

4. Responsibility towards Community

— *Community* means persons residing in and around that area where the *factory* is located and also the society at large.

— *The responsibilities of a business enterprise thus include:*

(*i*) To prevent environmental pollution and to preserve the ecological balance.
(*ii*) Assisting in overall development of the locality.
(*iii*) Giving jobs to the local people.
(*iv*) Promotion of small-scale and ancillary industries.
(*v*) Contribute to causes such as promotion of education and literacy in that area.
(*vi*) To conserve scarce local resources and to develop alternatives.

5. Responsibility towards Government

It covers the following aspects:

(*i*) Complying with all government regulations and legal requirements.
(*ii*) Paying taxes honestly; deducting income-tax from the salaries of the employees and depositing the same with the government.
(*iii*) Executing government contracts.
(*iv*) Making services of executives available for government.
(*v*) Working as a willing partner with government in pursuit of public welfare.

37.7 THE INDIAN SITUATION

— As far as the responsibility of business towards consumers, employees, government, community etc. is concerned, the Indian Business sector (both public and private sector) presents a *mixed* picture.

— Whereas on the side of

Production	Productivity
Efficiency	Growth,

the Indian industry (especially private sector) has on the whole, done well, however, its record has often been poor when judged by the size of the

Black market	Volume of black money

General corruption in our economic life etc.

— Hoarding and black marketing mercilessly gouge the unfortunate consumer. The producer firm should make sure that the product reaches in the hands of consumer at reasonable price and in time so that no shortage or scarcity of the same is felt by the public.

— The Indian producers have yet to go a long-way in bringing the *quality* of their products at par with foreign firms. A foreign-made *jacket*, in winter, is more warmer and cheaper as compared to its Indian counterpart. A foreign-made refrigerator, washing machine, car, TV, VCR, camera is still a craze for Indian public, Why?

— Once a product fails working or does not function properly, the poor consumer has to move from door-to-door to get it replaced or repaired. Many times spare parts are not available or they are very costly, more costlier than the foreign-made spare parts.

— Comparing the performance of *public sector* with *private sector*, the huge losses incurred by some Indian public sectors are not the result of any charity given to society; they are the inevitable outcome of inefficiency, irresponsibility and mismanagement at various levels. The failure of the public sector in discharging its primary duties has made the plight of the common man worse than it would have been, because it resulted in shortages, higher prices and more taxes. Companies in the *public sector* which account for about 7% of the total investment in the corporate sector must reckon with the social costs and social benefits arising out of any given investment. This should be equally applicable to *private sector*.

The accountability of the *public sector* to the people through Parliament must find its parallel in the *private sector* in the form of social accountability, at least, to the extent of informing the public about the extent and manner in which the private sector has or has not been able to discharge its social obligations in the course of its own economic operations.

— The Indian business houses have not been able to become fully responsible to society, *otherwise*

(1) Why they are raided by Income-tax or other Government Authorities?
(2) Why there is unrest amongst the employees and their trade unions?
(3) Why the customers prefer to buy foreign products from clothes to cars?
(4) Why the industrial towns, rivers and lakes are getting polluted more and more?

— *It is not that* the business houses have done nothing. There is a brighter-side of the picture also, as explained here under:

(1) A number of leading companies in India have set up hundreds of institutions of public service like schools, engineering and medical colleges, management institutes, dispensaries, hospitals, research institutes, libraries, dharamshalas, institutes for deaf, dumb and blind, museums etc.
(2) Many other enterprises arrange health and medical facilities to the people of surrounding areas. Eye camps and blood donation camps are becoming very common.
(3) Many businessmen have helped the victims of floods, droughts, earthquakes,

epidemics and other natural calamities by way of money, food, clothes and medicines.

It is worth-mentioning here that high standards of behaviour and the discharge of social obligations should not only be demanded from the *business enterprises*, but also from all economic groups in the country whose action have an impact on the *public weal* (welfare, prosperity etc.). This applies in particular to *trade unions*, who in recent years have acquired enormous economic powers. If trade unions recognise their social obligations, the millions of man-days of production shall not be lost every year due to labour unrest and strikes. The *participation* of workers in management may prove to be a remedy for many a cause of industrial unrest.

37.8 MEANING OF ENVIRONMENT

— **Environment** means *surroundings* or persons, things, places, regions, even atmosphere surrounding an *object* (which can be a *business enterprise*).

— *Environment* influences the *object* it surrounds, just as hot or cold weather, dusty and polluted atmosphere, pushes and pulls of people in the crowd do.

— In the light of above *definition of environment*, the *business environment* refers to all *external forces* which have a bearing on the functioning of a business.

These external factors/forces or environmental factors are

(*a*) Economic (*b*) Social

(*c*) Political (*d*) Legal

(*e*) Technological factors.

It is interesting to study how each of these factors influence the business and how they are in turn influenced by the business.

37.9 BUSINESS FIRM AND ITS ENVIRONMENT

— **Business firm** may be visualized as an *institution* in society surrounded by **environment** i.e., various *external forces* influencing its functioning.

— It is said that *business is a product of environment, OR*

Business is the creation of its environment.

— (1) The *nature* of business, (2) *location* of a business enterprise, (3) the *product* to be manufactured or *service* to be rendered by the business unit, (4) *size* and *volume* of operations of the firm, (5) price to be fixed for the product, etc., are determined by the *environment* within which the business operates.

— The *business firm* consists of a set of *internal factors* and is *confronted with* a set of *external factors* (i.e., environment). This is the relation between a firm and its environment.

— The **internal factors** are regarded as *controllable factors*, as the firm has got control over these factors. The firm can alter or modify internal factors to its advantage.

The examples of *internal factors* are nature and number of personnel, physical facilities, organisation and functional means, such as marketing mix, to suit the environment.

— **The external or environmental factors** are beyond the control of the business firm and the success of the firm will depend to a very large extent on its adaptability to the environment (factors) i.e., its *ability* to properly design and adjust the *internal* factors/variables to take *advantage* of the opportunities and to combat the *threats* of the *environment.*

— The environment, if poses threats to a firm, it offers immense *opportunities* also for exploitation. Both these situations depend upon the *environmental factors* influencing the firm, (refer article 37.8).

37.10 RELATIONSHIP BETWEEN BUSINESS FIRM AND ITS CAPITAL ENVIRONMENT

Refer. Fig. 37.1

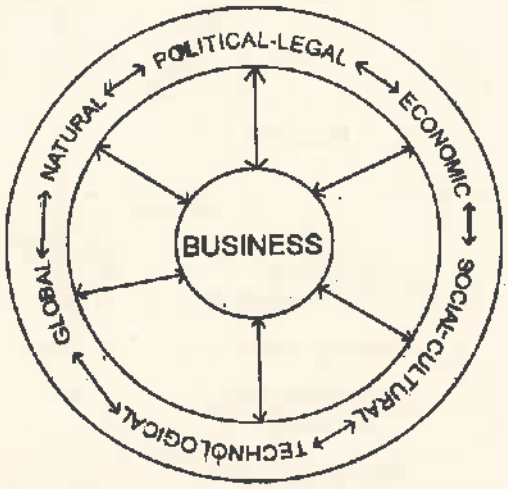


Fig. 37.1 Relationship between business firm and its environment

— The business is the product of environment or of factors such as technological, political, legal, economic, social, cultural, global and natural factors amidst which it (i.e., the business) functions.

— Three features are common to this web of *relationship* between business and its environment.

(1) There is symbiotic *relationship* (Fig. 37.1) between business and its environment and among the environmental factors.

In other words, business is influenced by its environment and, *in turn*, to a certain degree, it will influence the external forces.

Similarly, political-legal environment influences economic environment and *vice versa.* The same is the relationship between other environmental factors too.

(2) These environmental factors are *dynamic.* They keep on changing as time passes and so does business.

(3) A particular business firm, by itself, may not be in a position to change its environment. But along with other firms, business will be in a position to mould the environment in its favour, to a large extent.

37.11 CONSTITUENTS OF BUSINESS ENVIRONMENT

— Fig. 37.2 shows constituents of business environment.

— *Business environment (external factors) is classified as*

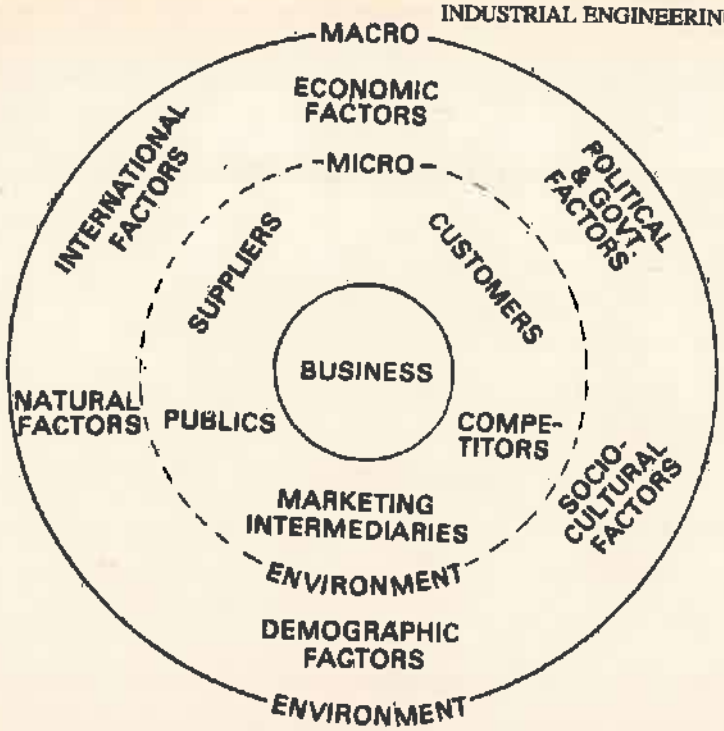


Fig. 37.2 Constituents of business environment

(1) Micro Environment
(2) Macro Environment

— The **micro environment** consists of the factors of the firm's *immediate environment*, (Fig. 37.2).

These include :

Suppliers	Marketing intermediaries
Competitors	Customers, and the Public

— The **macro environment** consists of larger societal forces that affect all the factors in the company's micro environment, (Fig. 37.2).

These include :

Demographic	Economic
Natural	Technological
Political and	Cultural forces

37.12 SUPPLIERS

— *Suppliers* or *vendors* are those persons or firms who *supply inputs* like new materials, certain parts, cutting tools etc., to the company.

— The vendor quality and reliability is a must for the smooth functioning of the business. They should supply all imputs of right quality and stated quantity in time.

— In order to be on safe side, adequate stock of input elements should be preserved in the company and services should be taken of more than one vendor to supply the goods.

37.13. CUSTOMERS

— Today with the advancement of technology and because of foreign collaborations, it has become easy to manufacture any product, but it is still very difficult to sell i.e., to create, increase and sustain the customers.

Every day we watch a new advertisement e.g., buy one tooth paste tube and take another free alongwith it or take two shampoo bottles at the price of one etc., to allure the customers.

Monitoring the customer sensitivity is, therefore, a prerequisite for the business success.

— How many different *categories of customers* shall be there to buy a product, depends upon the product itself.

For example, an automobile tyre manufacturing concern, can sell their tyres to

(*i*) Individual scooter or car owners,
(*ii*) Scooter, car, truck manufacturing industries,
(*iii*) Governments and other user institutions.
(*iv*) Public sector or private sector transport undertakings etc.

— *The choice of customer segment is made by considering the following factors:*

(*i*) Relative profitability
(*ii*) Stability of demand
(*iii*) Sale growth prospects
(*iv*) Extent of competition etc.

— Customers should be many, because it is risky to depend upon a single customer, who tomorrow may shift to another competitor or press for reduction in price or may close his business to undertake another more profitable venture, etc.

37.14 COMPETITORS

— Take an example of a firm 'A' making Televisions.

— Its competitors are not only the firms making and marketing T.V., but are all those firms who compete for the *discretionary* income of the customers.

— There are so many firms making T.V., scooters, refrigerators, cooking ranges, stereo sets etc. The *first* is the *desire competition* amongst them. In other words, the primary task of firm 'A' here is to influence the basic desire of the customer to buy only T.V. and no other product. This desire can be created in the customer by giving festival discount or by introducing some instalment scheme etc.

— The *second* is the *product form competition* if once the customer decides to by a T.V.

Product form competition implies, whether the customer should go for a black and white T.V. or a colour T.V., should he buy a T.V. with or without remote control. Should he buy a 14" TV or 21" TV or still of bigger size.

The firm 'A' may or may not be making all these models. So it has to attract, by its advertisement, the attention of the customers to go for a model being manufactured by them.

— The *third* is the *brand competition* i.e., the competition between the different brands of the same product form. For example, there are a number of T.V. makes in the market, such as, Onida, BPL, Soni, Beltek, Videocon, Crown, Texla, etc.

Now, the firm 'A' should work to create primary and selective demand for his T.V. sets,

by alluring the customers by enchanting advertisements, and attractive schemes.

37.15 PUBLIC

— Public means a group of people.

— *Public opinion can be a threat to a business firm whereas it can be an opportunity for another business firm.*

— Public normally forms an opinion about different brands of the same product after using the same.

— Opinion travels from friend-to-friend, neighbour-to-neighbour etc.,— Use this brand of washing powder or buy that brand of T.V. or refrigerator. They are using it for the last five years and it is working trouble-free etc.

This is *consumer publics* which has an important effect on any companies business, can make or mar it.

— The second is the *Media publics* where some *newspaper* tries to tarnish the image of a business firm by giving his own reasons or logic, and this adversely affects the business of the firm. Its share price may also come down.

— The third is *Local publics*. The issue of environmental pollution caused from chimneys or waste liquid streams from the factories has often been taken up by local public and, at times, it has resulted in the suspension of production operations and/or take pollution abatement measures by the factories.

37.16 MARKETING INTERMEDIARIES

— *Marketing Intermediaries* are those firms/individuals who help the company in promoting, selling and distributing its goods to final buyers.

— *Examples of marketing intermediaries are* :

(*i*) *Middlemen* (agents/merchants) who help the company find customers.

(*ii*) *Physical distribution firms* who assist the company in stocking and moving goods from their origin to their destination, such as warehouses and transportation firms.

(*iii*) *Marketing service agencies* such as advertising agencies, market research firms etc., which assist the company in targeting and promoting its products to the right markets.

37.17 ECONOMIC ENVIRONMENT

— *Economic environment* refers to all those *economic factors* which have a bearing on the functioning of a business unit. Some such *factors* have been discussed below:

(*i*) **Growth strategy**

— The economic environment in our country is the result of the economic growth strategy pursued during the past five decades by the Government of India.

— The growth strategy followed was based on the Soviet Planning Model which believed that the saving rate in the economy and growth rate could be increased by investing heavily in the capital goods and heavy industry sectors at the expense of the consumer goods sector.

(*ii*) **Economic system**

— The economic system is a very important determinant of the scope of (private) business.

The economic system and policy are a very important external constraint on business.

— *There are three economic systems*

(*a*) Capitalism (*b*) Socialism (*c*) Communism.

— *Characteristics and comparison* of the three systems have been given below in Table 37.1.

Table 31.1 Comparison of Capitalism, Socialism and Communism

Characteristics (1)	Capitalism (2)	Socialism (3)	Communism (4)
Economic Markets	Freedom to compete with the right to invest	Limited competition with State-owned industries	Absence of competition with State-owned markets and industries.
Individual Incentives	Profits and wages in relation to one's ability and willingness to work	Profits recognised. Wages fairly in relation to efforts.	Profits not allowed. Workers urged to work for the glory of the State.
Capital Sources	Capital invested by owners who may also borrow on credit. Capital may be reinvested from profits. Depreciation is legal.	Obtained from owners and from State-issued bonds for State-owned industries. Depreciation permitted.	State provides all resources to start business owned by the State. No depreciation.
Labour	Workers are free to select an employer and an occupation.	Workers allowed to select occupation. State planning encourages employment.	The State determines one's employer and employment.
Management	Managers are selected on the basis of ability. Managers have freedom to make decisions.	Managers in State-owned industries are answerable to the State. Non-monetary rewards emphasised.	Key managers must be party members. Absence of freedom to make decisions.
Business Ownership	Individuals have the right to own a business and to contract with others	State owns the basic industries. Other businesses may exist.	State owns all productive capacity including communes.
Risk Assumption	Losses assumed by owners. May transfer business risks to other businesses through insurance.	People assume risks of State-owned industries. Losses taken from taxes.	Economic production owned by the State. Risks assumed by the State. Losses reduce standard of living.

(*iii*) Economic Planning

— The Government prepares and implements a comprehensive economic plan integrating the private sector with the public sector.

— India has been doing economic planning since 1951, when *First Five Year Plan* was

launched.

— *The objective of a Five Year Plan is* :

(*a*) To increase production to the maximum possible extent to achieve a higher level of national and per-capita income.

(*b*) To achieve full employment.

(*c*) To reduce inequalities of income and wealth.

(*d*) To set-up a socialist society based on equality and justice and absence of exploitation.

(*iv*) Industry

— Around mid-1960s, India had a better industrial base and possessed more pre-requisites for industrial growth than South Korea, Malaysia, Taiwan etc.

But the country subjected all outputs and other factors to rigid price and quantity controls, investment was strictly rationed, there were multiple barriers to entry, and the objective of the financial system was to supply subsidised development funds irrespective of returns. As a result all the countries mentioned above are far ahead of India in industrial growth.

— In 1970's, Indian Government started believing that mini-plants constituted appropriate technology, not withstanding strong evidence to the contrary. Such plants were encouraged through fiscal concessions and subsidised development finance. Mini-cement, mini-paper, mini-steel, mini-sugar plants were set up. None of these were technically viable, so they fell short of economies of scales, and could only exist under a regime of subsidies, high tariffs, severe quotas and purchase preferences. In 1980's as the financial situation worsened, all these mini-plants became *sick units*.

— According to the Industrial Policy of the Government of India until July 1991, the development of 17 of the most important industries were reserved for the *state*.

In the development of another 12 major industries, the state was to play a dominant role. In the remaining industries, cooperative enterprises, joint sector enterprises and small-scale units were to get preferential treatment over large entrepreneurs in the public sector.

The government policy, thus limited the scope of private business. However, the new policy ushered in, since July 1991 has wide opened many of the industries for the private sector.

(*v*) Human Resource

— Human Resources play a crucial role (of *people*) in an economy.

— People work to produce goods and services.

— People provide markets for goods produced.

— Degree of economic prosperity depends on the quality and skill of the people.

— People need economic growth just as prosperity demands services of people.

— Unluckily, our country has more number of people than the economy could afford.

However it goes to the credit of the country that it was the first in the world to adopt family planning as a state policy.

(vi) National income and per capita income

— The aggregate flow of goods and services represents the total income earned by factors of production (such as) land and other natural resources, labour, capital and enterprise) employed during the year and this is popularly called *national income*.

— The rate of growth of the national income in an economy is an indication of the pace at which the economy has been growing.

— A *high growth rate* indicates that the *economy is a developed one. Low growth rate* implies that the *economy* is a developing or a poor one.

— A *high national income* indicates that the *economy is developed* and the overall environment is favourable for business growth.

— Given below is the data about national income and per capita income

Year	*National Income* (Rs. Crore)	*Per Capita Income* (Rs.)
1990-91	4,18,074	4983
1991-92	4,79,612	5602
1992-93	5,45,434	6255
1993-94	6,26,957	7060
1994-95	7,44,663	8237
1995-96	8,56,663	9473
1996-97	9,85,162	10,708

Other Economic Factors are

(*vii*) Agriculture

(*viii*) Financial and fiscal sectors

(*ix*) Removal of regional imbalances

(x) Price and distribution controls.

(*xi*) Economic reforms.

37.18 TECHNOLOGICAL ENVIRONMENT

— *Science* is a systematised body of knowledge and when this knowledge is put into practice (or to practical tasks) it becomes *technology*.

— Technology changes very fast and a firm which is unable to cope with the technological changes may not survive.

— Further, changing technological environment call for product modification.

1. Electrical appliances and instruments in the U.S.A. are designed for 110 volts but they need to be converted into 220 volts if they have to be sold in India etc.
2. Voltage stabilizers or inbuilt voltage stabilizers have to be provided in refrigerators and televisions if certain markets (like India) are characterized by frequent voltage changes and fluctuations in power supply.

— The fast changes in technologies also create problems for enterprises as their plants and products become obsolete quickly. Earlier VCP came, then VCR and now CD (Compact Discs). Video cassette tapes have no more demand as CDs are becoming popular because of their longer life and much better audio and video qualities (performance).

Impact of technology

Impact of technology can be discussed under the following heads:

(1) **Technology and Society**

It is a fact that practically every area of social life and the life of every individual

has been, in some sense or the other, changed by the developments in technology.

(*a*) *Technology reaches people* through business in the form of goods and services.

(*b*) Technology has contributed to the emergence of *affluent societies* through production of new varieties of automatic products, superior in quality, more safe and comfortable.

(*c*) Technology has made the *products more complex* which if stop working, require the services of experts to repair them. Every electrician cannot repair a VCR or newer generation T.Vs.

(*d*) Setting up of a new factory as a result of technology advancements, makes people to move to new geographical locations.

(*e*) Besides uprooting population, advancement in technology may directly change the pattern of social life. For example, an invention (e.g. computers) may open new employment opportunities to women.

(2) Technology and Economy

— Technological advancements increase both production and productivity, thereby raising the wages of the employees and declining the prices of some products. Thus the beneficial economic effects of technology spread throughout the whole social system.

— Research and development (R & D) assumes considerable relevance in organisations as technology advances. Firms are required to ponder over, decide and take action on following issues :

(*i*) Allocation of resources to R & D.

(*ii*) Technology transfer — the process of taking new technology from the laboratory to the market.

(*iii*) Time factor is important in R & D. The time between innovation and commercialisation should be reduced.

(*iv*) The R & D Manager must determine *when* to abandon the present technology to develop or adopt the new technology.

— With advancement in technology, jobs tend to become more intellectual or upgraded. Services of an educated and competent worker may be required now, in place of an unskilled or semi-skilled worker previously doing the job. A clerical post in an office may now demand the services of an expert in computers etc.

— Technocrats, also, need to be qualified in management education in addition to the proficiency they have acquired in chosen fields of specialisation. That is the reason that, today to fill up a factory manager's post, the desired qualification stipulated is B.Tech + M.B.A.

— A by-product of technological advancement is the ever-increasing regulation imposed on business by the *government* of the country and at times, stiff opposition from the *public*.

For example, government banned certain meat products which hurt the feeling of a community and public opposed construction of plants that eject harmful affluent or setting up of hydro-electric plants in certain hilly areas etc.

(3) Plant level implications

— Technological changes demand a modification in organisation structure of the company, length of the line of command and the span of control.

— New technology may bring some changes and pose new problems which may

not be to the liking of the workers, clerks or officers of the company. They feel that the introduction of technological change may harm their interests. For example, the workers feel that if *Time & Motion Study* is introduced in the factory, they shall have to work more to get the same wages.

— Import of latest technology is not easy, because developed countries are not willing to lend it.

Whatever we get is somewhat older technology but still very much new for us. Even to obtain it there are difficulties in getting a right foreign collaborator and obtaining clearance from government.

— Even if a collaboration is obtained, at times, we are unable to absorb western technology in our firms. For example, a motor-cycle manufacturing firm, for a long time, could not change the side of the foot-brake lever from left to right.

— Introduction of *Total Quality Management* (TQM), *Business Process Reengineering* (BPRE) and *Flexible Manufacturing System* (FMS) have further added several implications for employees and the organisations adopting these concepts.

— *TQM* replaces the *traditional beliefs* about quality which are :

(*i*) High quality costs more

(*ii*) Quality can be improved by inspection

(*iii*) Defects cannot be eliminated completely

(*iv*) Quality is the job of the quality control personnel.

The new principles of TQM are

(*i*) Meet the customer's requirement on time, the first time, and 100% of the time.

(*ii*) Strive to do error-free work.

(*iii*) Manage by prevention (of defects) and not by correction (of defective jobs).

(*iv*) Measure the cost of quality.

Employees become more and more involved in Quality improvement process.

— *Business Process Reengineering (BPRE)*

BPRE helps an organisation to cut down its costs, eliminate waste and improve its quality. These factors are essential to compete in the modern world.

BPRE essentially involves considering how things would be done if the organization were to start all over from scratch.

Both TQM and BPRE search for excellence in serving customers.

TQM aims at (further) improving what is good, but BPRE seeks to reject what is irrelevant and starting afresh.

TQM is essentially a *bottom-up* approach, wherers BPRE is driven by top management.

BPRE has implications for employees. Many of them lose jobs, others who retain jobs find that they are not the same any longer.

The new jobs require a wider range of skills, include more interaction with customers and suppliers, offer greater challenge, have increased responsibilities and give higher wages.

— *Flexible Manufacturing System (FMS)*

FMS integrates *Computer aided design* (CAD), *engineering* and *manufacturing* to produce low-volume products at a cost comparable to what had been previously possible

through mass production.

With FMS, when management wants to produce a new part, it does not change machines; it needs to change the computer programming.

FMS needs trained and skilled workers.

FMS needs decentralisation of authority into the hands of operating teams to make necessary decisions.

37.19 POLITICAL ENVIRONMENT

— Political environment is another important constituent of the business environment which can raze any business enterprise to the ground.

— A *Political (and Government) Environment* or system prevailing in a country decides, promotes, fosters, encourages, shelters, directs and controls the business activities of that country.

— A *political environment/system* that is stable, honest, efficient and dynamic and which ensures political participation of the people, and assures personal security to the citizens, is a primary factor for *economic development.*

— *Two basic political philosophies* exist all over the world.

The *first*, known as *Democracy* refers to a political arrangement in which the supreme power is vested in the hands of *people*. They have got the right to *rule* and *vote* on every matter. But this form of *pure democracy* is not workable in a complex society. Hence the *Republican* form of government comes into the picture in which the people/public, in a democratic manner, elect their representatives who do the ruling.

The *second* system known as *totalitarianism* also called *Authoritarianism* is one in which individual (person's) freedom is completely subordinated to the power of authority of the state and concentrated in the hands of one person (i.e., a Dictator) or in a small group which is not constitutionally accountable to the people. Societies ruled by military or by a dictator, plus most oligarchies and monarchies belong to this category.

— The *political system* under democratic dispensation, as *in India* comprises three vital institutions i.e.,

(1) Legislature
(2) Executive or Government
(3) Judiciary

(1) **Legislature**

— *Legislature* being most powerful of the three does:

(*a*) Policy making
(*b*) Law making
(*c*) Budget approving
(*d*) Executive control
(*e*) Acting as a mirror of public opinion.

— *Legislature decides*

(*a*) Type of business activities in the country
(*b*) Who should own them
(*c*) Size of operations
(*d*) What should happen to their earnings etc.

(2) **Judiciary**

— *Judiciary* settles legal *disputes* that affect the business considerably.
The disputes could be between employees and employer, or employer and public or employer and government.

— *Judiciary* examines if the authority exercised by government is in accordance with the rules laid down by the legislature.

— Judiciary protects the public and business from unlawful acts passed by the legislature and arbitrary acts done by the government.

(3) **Government**

— Government/Executive/State is the centre of the political authority having the power to govern those it serves.

— ***Responsibilities of business towards Government***

(*a*) To pay taxes

(*b*) To assist government in voluntary programmes such as drought relief works, tree planting, training of unemployed and rural youths etc.

(*c*) To place their expert view points on business before the political leaders so that while taking decisions politically, the interests of business do not suffer unnecessarily.

(*d*) To bid and work for government contracts such as those of housing projects, oil pipelines, etc.

(*e*) To lead or accompany government delegations to foreign countries for exploring trade and industry prospects there.

(*f*) Political Activity. Political participation of business has arguments both for and against it. Whether business should stay out of politics or should it involve in politics, is not easy to reply.

Business involvement in politics can be in one of the following ways:

(*i*) Business can make money contributions to political parties, particularly at the time of elections.

(*ii*) Business leaders can contest elections.

(*iii*) *Lobbying*, which refers to the behaviour after the election to secure legislation in favour of business.

— ***Responsibilities of Government towards Business***

(*a*) To establish and enforce *rules and regulations* under which the business functions smoothly and which help maintain competition.

(*b*) To provide peaceful atmosphere by maintaining *law and order* in the country so that business persons and property can be protected.

(*c*) To provide a system of *money and credit* by means of which business transactions can be effected.

(*d*) To provide *infrastructural facilities* such as transportation, power, finance, manpower etc., for the effective functioning of business.

(*e*) To provide information about economic and business activity in general, specific lines of business, scientific and technological developments and many other things of interest to business.

(*f*) To encourage small scale sector to grow.

(*g*) To make available to business, the details of technologies developed by

Government owned R & D units.

(*h*) To use *Tariffs* and *Quotas* to protect business from foreign competition.

(*i*) To issue licences to competent business establishments to carry on different activities.

(*j*) To inspect foods, drugs etc., so that only quality products reach the customers.

— ***Government Policy influences the business in a number of ways:-***

(1) For example, in India, the advertisement of alcoholic liquor is prohibited.

(2) Packets of cigarette must carry the statutory warning that *Cigarette smoking is injurious to health.*

(3) Certain changes in government policies such as the industrial policy, fiscal policy, tariff policy etc., may have profound impact on business.

(4) Government has an all-pervasive and predominantly restrictive influence over various aspects of business, e.g., industrial licensing which decides location, capacity and process,
Import licensing for materials and machinery,
Size and price of capital issue,
Loan finance,
Pricing,
Managerial remuneration,
Expansion plans,
Distribution restrictions etc.
As a result, the chief executive and the managers of the business enterprise have to have continuous dialogue with various government agencies to ensure growth and profitability within the framework of controls and restraints.
And, not only must perceptive managers respond to social pressures, but they also have the problem of foreseeing and dealing with political pressures, as well as laws that might be passed. As can be readily understood, this is not an easy matter.

37.20 SOCIAL ENVIRONMENT

The *social environment* is made up of the attitudes, desires, expectations, degrees of intelligence and education, beliefs, and customs of people in a given group or *society.*

— Social desires, expectations and pressures give rise to *laws* and laws, in turn, influence the business.

— *Social factors include*

(*i*) Attitude of people to work
(*ii*) Attitude to wealth
(*iii*) Desires and expectations
(*iv*) Family and customs
(*v*) Religion and Marriage
(*vi*) Values and beliefs
(*vii*) Intelligence and education
(*viii*) Ethics–personal conduct
(*ix*) Tastes and preferences
(*x*) Social responsibility of business

— For any business, the cost of ignoring the customs, traditions, taboos, tastes and preferences, etc., of individuals or of society can be very high.

— The buying and consumption factors, habits of people, their language, beliefs and values, customs and traditions, tastes and preferences, education, all these factors affect the business.

— In Thailand, Helene Curtis switched to black shampoo because Thai women felt that it made their hair look glossier.

— Nestle, a Swiss multinational company, today brews more than 40 varieties of instant coffee to satisfy different national tastes.

— The differences in language sometimes pose a serious problem, even necessitating a change in the brand name. *Prett* was, perhaps, a good brand name in India; but it did not suit in the overseas market and hence it was changed to a new brand name — *Prestige.*

— *Social inertia* comes in the way of the promotion of certain products, services or ideas e.g., use of bio-gas for cooking.

— Many *demographic factors* such as the age and sex composition of population, family size, habitat, religion, etc., also influence the business. There is a marked difference between ladies-wear of Europe and Arabian countries. Earlier, telephone was not accepted in muslim countries.

— Marketing personnel are at interface between company and society. In this position, they have the responsibility not merely for designing a competitive marketing strategy but for sensitizing business to the social, as well as the product, demand of society.

— While dealing with the social environment, one must also consider the social environment of the business which encompasses its social responsibility and the alertness or vigilance of the consumers and of society at large. **(Refer Article 37.6 also).**

37.21 LEGAL ENVIRONMENT

— Judiciary settles *legal disputes* between the employer and the employees, employer and public or employer and government and hence affects the business.

— Legal authority also sees to it that the exercise of government conforms to the general rules laid down by the legislature, it may declare that the particular order issued is, in fact, *ultra vires.* The courts of justice protect the citizens from unlawful acts passed by the legislature and arbitrary acts done by the government.

Many times, judiciary has ordered the closure of fume-emitting and other factories spreading pollution which became dangerous for society. Judiciary has also restrained and censored human rights violations etc.

— The legal environment has far-reacting consequences on business.

The consequences will become more intense and severe because

(*i*) Judicial errors do occur, though infrequent.

(*ii*) Possibility of wrong assessment of penalty. Judges vary in the severity of punishment inflicted.

(*iii*) At times there are conflicting verdicts on the same or similar disputes.

(*iv*) In labour laws themselves, there is a lot of confusion.

It is said that particularly in the area of industrial relations, the role of judiciary has been more pronounced and unfortunately regressive.

By those whose horizons are limited, trifles are easily confused with technicalities. The result is that indiscipline in industry spreads like wildfire and saps the national production and productivity.

— Every manager in every kind of organization is encircled by a complete web of laws, commission and official regulations, and court decisions. Some are designed to protect workers, consumers, and communities. Some are designed to make contracts enforceable and to protect property rights. Many are designed to regulate the behaviour of managers and their subordinates in business and other enterprises. There is relatively little that a manager can do in any organization that is not in some way concerned with, and often specifically controlled by, a law or regulation.

This is not to imply that many of our laws and regulations are unnecessary, even though, as noted above, many become obsolete. But they do comprise a complex environment for all managers. Managers are expected to know the legal restrictions and requirements applicable to their actions. Thus it is understandable that managers in all kinds of organizations, and in business and government especially, usually have a legal expert close at hand as they make their decisions.

Table 37.2 Environmental Factors Affecting Managerial Functions

	Environmental Factors			
Managerial Functions	*Educational*	*Sociological-Cultural*	*Legal-Political*	*Economic*
Setting Objectives	Technical and Higher Educational Systems	Role of Religion; View of Management; Goals and Values Important in Culture	Government Influence/ Regulations	Fiscal and Monetary Policies
Policy Formulation and Implementation	Educational Match with Requirements	Attitude toward Management and Managers	Political Stability	Economic Stability
Research and Development	Scientific Orientation	Acceptances of Change	Government Support: Finanical Investment	View of Risk-Taking and Progress
Production and Procurement	Supply of Engineers and Technicians	Attitude toward Efficiency	Government Support; Defense and Other Government Contracts; Industrial Zoning	Availability of Resources; Adequatre Infrastructure

Finance	Specialized Training in Accounting and Economics	View of Savings and Investment	Tax Reliefs; Subsidies; Financial Restrictions	Central Banking System: Foreign Aid and Private Investment
Marketing	Literacy Level	Attitude toward Material Possessions	Import-Export and Foreign Exchange Regulations	Market Size; Degree of Competition; Per Capita Annual Income; Price Stability
Planning and Innovation	Technical Capability for Budgets, Schedules and Basic Policies	View of Time and Change; Use of New Knowledge and Statistical Data; Population Growth	National Planning by Central Government	Inflationary-Deflationary Tendencies
Organisation	Functional Specialists, and Type of Education	View of Authority; Group Decision-Making; Interorganizational Cooperation	Predictability of Legal Actions; Political Influence	Division of Labor; Factor Endowment
Staffing	Educational Level	Interpresonal Cohesion, Class Structure and Individual Mobility	Status of Management Vis a Vis Government, Labor Laws	Labor Union Influence, Attitude toward Unemployment
Direction, Supervision, Motivation	Management Development	View of Achievement: Dedication to Work; Language Barriers to Communication	Tolerance of Bribes, Fraud, and Tax Evasion	Worker Participation in Management; Use of Monetary and Fringe Benefit; Incentives
Control	Ability to Use Feedback for Corrective Action	Attitude toward Scientific Method	Accounting Data, Reports for Government Regulation	Private Property Rights; Quotas

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38

Professional and Business Ethics

38.1 CONCEPT OF PROFESSIONAL/PROFESSIONALISM

— The meaning of **professional** was spelled out clearly, about 2500 years ago, in the Hippocratic oath of the Greek physician : *primum non nocere*—"*Above all, not knowing to do harm*".

— No *professional*, be he doctor, lawyer or manager, can promise that he will indeed do good for his client. All he can do is try to do good. But he can promise that he will not knowingly do harm.

And the *client*, in turn, must be able to trust the professional not knowingly to do him harm. Otherwise he cannot trust him at all.

— The professional has to have *autonomy*. He cannot be controlled, supervised or directed by the client.

He has to be *private* in that his knowledge and his judgement have to be entrusted with the decision. But it is the foundation of his autonomy, and indeed its rationale, that he see himself as *affected with the public interest*.

— A *professional*, in other words, is *private* in the sense that he is *autonomous* and not subject to *political* or *ideological* control. But he is *public* in the sense that the welfare of his client sets limits to his deeds and words.

— And *Primum non nocere*, "not knowingly to do harm" is the *basic rule* of **professional ethics**, *the basic rule of an ethics of public responsibility*. **(For more details refer article 37.4).**

38.2 CONCEPT OF ETHICS

— Ethics concerns Morals and Philosophy.

— The study of *moral*, as contrasted with legal, obligations is called *ethics*. Ethical rules are not enforced by public authority, whereas legal rules are.

— *Business ethics* is the study of the moral problems that confront members of business organizations and others who engage in business transactions.

— The *ethics of profession/business* are the same as those which every individual in society and society as a whole should abide by. **(refer article 37.5 also).**

— One main thing that ***ethics tells*** is the plain, everyday honesty Businessmen should not cheat, steal, lie, bribe or take bribes. But nor should anyone else.

Men and women do not acquire exemption from ordinary rules of personal behaviour because of their work or job.

Nor, however, do they cease to be human beings when appointed vice-president, general manager or chief executive of a firm.

And there has always been a number of people who cheat, steal, lie, bribe or take bribes.

The *problem* is one of *moral values* and *moral education*, of the individual, of the family, of the school they have studied.

But there neither is a separate ethics of profession, nor is one needed.

All that is *needed* is — stiff punishments to those — whether businessmen, professionals or others — who yield to temptation and go against the moral values of life.

— The **ethical environment**—which could well be included as an element in the social environment—includes sets of generally accepted and practiced standards of personal conduct. These standards may or may not be codified by law, but for any group to which they are meant to apply, they sometimes have virtually the force of law.

— **Ethics** is a conception of right and wrong *conduct*. Ethics tells us when our *behaviour* is *moral* and when it is *immoral*. Ethics deals with fundamental human relationships—how we think and behave towards others and how we want them to think and behave towards us.

Ethical principles are guides to moral behaviour. For example, in most societies lying, stealing, deceiving, and harming others are considered to be unethical and immoral. Honesty, keeping promises, helping others, and respecting the rights of others are considered to be ethically and morally desirable behaviour.

Such basic rules of behaviour are essential for the preservation and continuation of organized life everywhere.

— These *notions* of right and wrong come from many *sources*. *Religious beliefs* are a major source of ethical guidance for many. The *family institution*—whether two parents, a single parent, or a large family with brothers and sisters, grandparents, aunts, cousins, and other kin—imparts a sense of right and wrong to children as they grow up.

Schools and school teachers, neighbours and neighbourhoods, friends, admired role models, ethnic groups influence what we believe to be right and wrong in life. The totality of these learning experiences creates in each person a *concept of ethics, morality* and socially acceptable behaviour. This *core of ethical beliefs* then acts as a moral compass that helps to guide a person when ethical puzzles arise.

— *In the context of ethics*, "Mahatma Gandhi" mentioned the seven ills of the society which should be avoided: (*a*) politics without principle, (*b*) wealth without work, (*c*) pleasure without conscience, (*d*) knowledge without character, (*e*) science without humanity, (*f*) commerce without morality and (*g*) worship without sacrifice. These statements are particularly true in the context of any profession or any department in the organization and hence is bound to be a wisdom of temptations and allurements and compromises in the form of wine, women, wealth, arts, commission, kickbacks, donations, winding up charges, bribery, fraud, gifts, hospitality, complimentaries and entertainment. How we avoid these temptations is a difficult question to answer. But *ethics* is the first and foremost engine to shape the moral character to its best.

To Conclude:

Ethics represent the eternal and prevalent moral standards, personal values, corporate code of conduct and are generally part of the cultural tradition of a country.

38.3 ETHICS AND MORALS

— In the consideration of this subject, we are first beset with terminological problems. Such words as "*ethics*" and "*morals*" seem to be used interchangeably, but neither is consistently employed. Indeed, in our own day, "**ethics**" seems to be a term chiefly referring to high standards of *professional conduct*. This narrow application is unfortunate, for it leaves us without a similar word with which to characterize high standards of conduct in other affairs. For the purposes of this analysis, it is perhaps best to define ethics as the collective term for principles of personal conduct. Being principles, they should be universally applicable, and they should also provide the standards with which the conduct of all persons may be compared. Being principles, they can also be taught and, in this way, help to establish general standards of personal conduct throughout the land.

— **Morals** are often quite a different matter. While ethics are grounded on moral standards, "*morals*" *can refer to any generally accepted customs of conduct and right living in a society*. There are many societies and there are many changes in these societies. Furthermore, within a society numerous local customs emerge. Therefore, what is moral in one society may be immoral in another; and what is moral in one sector or province may be immoral in another area within the same society. There is every reason to suspect that the moral practices of a given society are probably more closely adhered to than any universal principles of ethics. Furthermore, what is considered moral in certain societies or groups may well be contrary to some more universally held ethical principle. For instance, in some countries it is a moral practice to bribe an official to secure a favour, but surely an ethical principle is fractured in the process.

38.4 BUSINESS ETHICS

— The *role of business* is to provide the goods and services that society requires, in the most efficient manner possible.

— **Business ethics** is the study of the moral problems that confront members of business organizations and others who are engaged in business transactions.

— **Business ethics** is the application of general ethical ideas to business behaviour. Business ethics is not a special set of ethical ideas different from ethics in general and applicable only to business. If dishonesty is considered to be unethical and immoral, then anyone in business who is dishonest with employees, customers, stockholders, or competitors is acting unethically and immorally.

— If protecting others from harm is considered to be ethical, then a company that recalls a dangerously defective product is acting in an ethical way.

— To be considered ethical, business must draw its ideas about what is proper behaviour from the same sources as everyone else. Business should not try to make up its own definitions of what is right and wrong. Employees and managers may believe at times that they are permitted or even encouraged to apply special or weaker ethical rules to business situations, but society does not condone or permit such an exception. People who work in business are bound by the same ethical principles that apply to others.

— What executives from 300 U.S. and non-U.S. corporations consider to be ethical issues in business. Nearly half (45 per cent) of the issues involve *employee relations*—in other words, the way people interact with each other and are treated on the job. About one-fifth of the issues deal with *customer relations*. *Community ethical concerns* account for

another one-fifth of the list.

— These same executives, when asked to name the *ethical issues* they believed would be very important in the following years, identified *six as particularly important: environmental issues* (86 per cent said it would be a serious or critical issue), *product safety* (78 percent scored it serious or critical), *employee health screening* (77 per cent), *security of company records* (73 per cent), *shareholder interests* (70 per cent), and *workplace safety* (70 per cent). These are the ethical challenges in business, as they see them **(for more details refer article 37.5)**.

38.5 PROFESSIONAL ETHICS

— Ethics related to a professional e.g., a manager of a factory are known as **professional ethics.**

— *Ethics* may be *internal* or *external.*

— As regards *internal ethics*, a manager must be honest with oneself, since one's greatest asset is one's *character.*

And one should be honest and straightforward with *others* also, treating them in the same manner in which one wishes to be treated (*external ethics*).

— *Fairness* in dealings with compeers and subordinates is mandatory; one should never discriminate by dispensing special favours or privileges, whether for remuneration or not.

— Information coming to a professional confidentially should neither be revealed nor used to the disadvantage of any subordinate or worker.

— One should ensure one's employment right to privacy.

— With reference to *external ethics*, the same suggestions as stated above can be followed.

38.6 NEED FOR PROFESSIONAL AND BUSINESS ETHICS

(Refer article 37.4 also)

— *The need for* a set of generally accepted and practiced standards of personal conduct is evident in all parts of the world. The need is plainly evident in the conduct of heads of state, politicians, judges, professors, doctors, lawyers, accountants, and just plain workers.

— This situation is distressing because we really cannot be sure what ethical standards will guide the conduct of the person we vote for, of a lawyer, of the judge who tries a case, of the teacher of our children, of the doctor who does an operation, of the labour-union leader, of a business owner we deal with, or even of our neighbour. In the United States, the assumption is chiefly made that others will abide by the same principles as one's self. To a considerable extent, this is all to the good because it assumes a certain degree of commonality of ethical standards. But care must be taken. The uncertainty concerning another's ethical standards establishes a situation in which we learn of them through trial and error.

— In the world as it stands today, relationships are worldwide in scope. We make treaties with unknown heads of state and commercial agreements with distant and often foreign strangers; we send our children to distant colleges to be instructed by unknown professors. In these and many similar situations, trial-and-error methodology is often disastrous.

38.7 IMPORTANCE OF ETHICS

Professional ethics are important for several reasons as explained below :

(*a*) **Ethics corresponds to basic human needs**

It is a human trait that the man desires to be ethical, not only in his private life but also in his profession/business affairs where, being a manager, he knows his decisions will affect the lives of thousand of *employees.*

Also, most people want to be a part of an *organisation* which they can respect and be publically proud of, because they perceive its purpose and activities to be honest and beneficial to society.

These basic ethical needs compel the organisations/business enterprises to be ethically oriented.

(*b*) **Ethics create credibility with the public**

A company ethically and socially responsive is honoured in the society, people favour its products and its public issues attract an immediate response.

(*c*) **Ethics give management credibility with employees**

The management automatically gets credibility with its employees when it has credit with the public. The leadership and the people (employees) come and work together.

(*d*) **Ethics help better decision making**

An ethical attitude of management helps making decisions in the interest of public, their employees and the company.

(*e*) **Ethics and profit**

Ethics and profit go together. Value driven companies are always successful in the long run.

(*f*) **Ethics can protect society**

What ethics can do, probably government, and law cannot, to protect society. For example, an ethical oriented management can prevent pollution and protect the health of their workers, and people in general, much before being mandated by law.

38.8 NEED FOR BUSINESS TO BE ETHICAL

— Why should business be ethical? What prevents a business firm from piling up as many profits as it can, in any way it can, regardless of ethical considerations?

The reasons for the above, are as follows:

A business need to be ethical, in order to:

(1) *Fulfill public expectations for business.* The business shall gain widespread public approval and flourish.

(2) *Prevent harming others* i.e., its employees, and public in general. A company that is careless in disposing of toxic chemical wastes that cause disease and death, if adheres to ethical principles of conduct can definitely do good to society.

(3) *Improve business relations and employee productivity.* Being ethical imparts a sense of trust amongst business partners, firm and its employees and the firm and the public. In 1994 Malaysian government gave a cold shoulder to French executives because of the reason that the chairman of the French firm was in jail at that time.

(4) *Protect business firms* from abuse by its unethical employees and unethical competitors. Not only customers steal products from the departmental stores, their employees also do it. Store owners admit they are often at the mercy of the employees honesty.

(5) High ethical performance of a business enterprise also *protects people who work in*

it. For example, they shall not be compelled to falsify an accounting report, etc. Businesses that treat their employees with dignity and integrity reap many rewards in the form of high morale and improved productivity. It is a win-win-win situation for the firm, its employees, and society.

(6) A final reason for promoting ethics in business is a personal one. *Most people want to act in ways that are consistent with their own sense of right and wrong*. Being pressured to contradict their personal values creates much emotional stress. Knowing that one works in a supportive ethical climate contributes to one's sense of psychological security. People feel good about working for an ethical company because they know they are protected alongwith the general public.

38.9 ETHICAL DILEMMAS

In some business situations, it is really difficult to decide what is right and what is wrong. For example, *what should the company do if:*

(1) Production manager of your competitor firm wants to join your firm and would tell you all the competitor's plans for future.

(2) Sales personnel (of your firm) want that the product packaging should be changed and it should be mentioned thereon *new and improved* whereas there is no change in the product (which may be a hair dye, tooth paste or a shaving cream).

(3) Your assistant recommends sending a colour T.V. to the purchase manager of another firm which buys raw material from you.

(4) Your chemist says that your anti-dandruff shampoo shall be sold more if you label such instructions on the pack that use atleast two times for results.

38.10 ETHICAL PROBLEMS IN BUSINESS

— As explained above also, ethical problems appear in business in many different forms and frequently. Finding out just *what* is responsible for causing them is one step that can be taken toward minimizing their impact on business operations and on the people affected. Some of the main *reasons* in this connection are given below in Table 38.1.

TABLE 38.1

Reason	*Nature of Ethical Problem*	*Typical Approach*	*Attitude*
Personal Gain and Selfish Interest	Selfish interest vs. others' interests	Egoistical mentality	"I want it!"
Competitive Pressures on Profits	Firm's interest vs. others' interests	Bottom-line mentality	"We have to beat the others at all costs!"
Business Goals vs. Personal Values	Boss's interests vs. subordinates' values	Authoritarian mentality	"Do as I say or else!"
Cross-Cultural Contradictions	Company's interests vs. diverse cultural traditions and values	Ethnocentric mentality	"Foreigners have a funny notion of what's right and wrong!"

38.11 ETHICS ISSUES

There are three types of ethics issues

(*a*) Face-to-face ethics
(*b*) Corporate policy ethics
(*c*) Functional-area ethics. (*refer Table 38.2*)

(*a*) Face-to-face ethics

There is a *human element* involved in most business transactions. Manager, employee, supplier, purchasing agent, sales representative etc., all meet face-to-face in the business, because business is composed of human interactions which may be about their family or colleagues in the factory or their products etc. Studies have shown that managers and employees commonly encounter *face-to-face ethics issues/everyday moral issues* as they go about their work. Observations of unethical acts by a predominantly female group of employees are given in Table 38.3.

(*b*) Corporate policy ethics

Companies are sometimes faced with ethical issues that affect their operations across all departments and divisions of the firm. Top managers and the board of directors then are faced with establishing companywide policies to cope with the issues, such as the following:

"Even though our company is not a government contractor and does not receive any federal government funds, should we recruit S.C., S.T., or backward area persons in our firm as government concerns do?"

(*c*) Functional-area ethics

Because business operations are highly specialized, ethics issues can appear in any of the major *functional areas* of a firm, as shown in Table 38.2.

TABLE 38.2

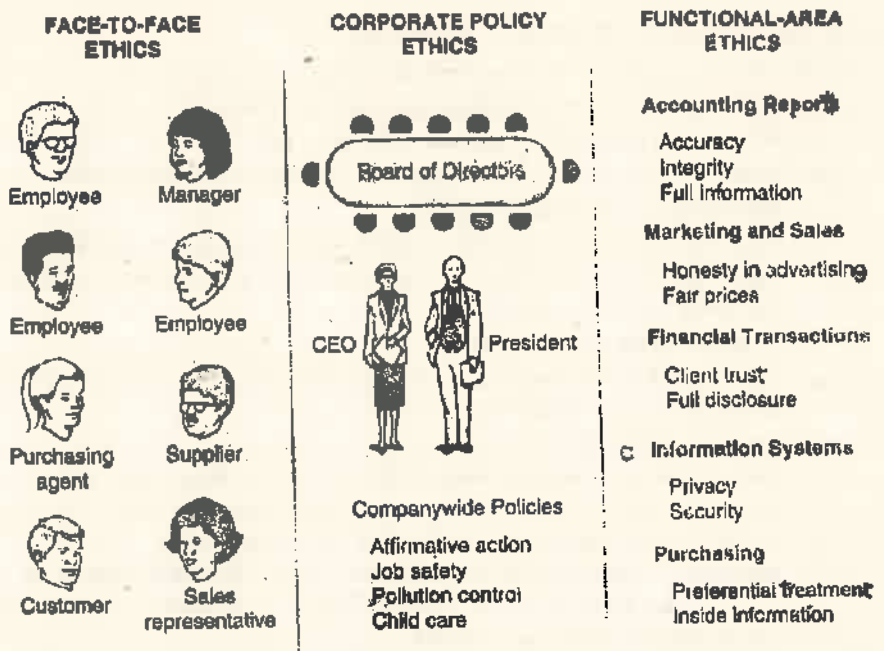


TABLE 38.3

Unethical acts personally observed by readers of working woman

	Percent Observing Action		Percent Observing Action
Fairness Violations		**Dishonesty**	
Favouritism or nepotism	70	Violating confidentiality	64
Taking credit for other's work	67	Lying to employees	52
Doing business with sexist clients	52	Lying to make a sale	31
		Sexual Trading	
Discrimination	47	Flirting to make a sale	43
Sexual harassment	41	Sexual intimacy with boss	29
		Sex with coworker on company time	19
Stealing			
Expense-account abuses	52	Sex with client to make a sale	10
Bribery	5		

38.12 HOW TO MAKE BUSINESS ETHICAL

Making business ethical, involves the following three steps:

(*i*) Drawing up a *company policy* or **code of ethics.**

(*ii*) Making all employees familiar with this *code.*

(*iii*) Implementing this *code* by means of a formally designated *ethics committee.*

(*i*) Drawing up the code of ethics

The code of ethics should be drafted after carrying out discussions at all levels of organisational hierarchy and cooperation and consent of all employees should be obtained before finalising the code.

(*ii*) Familiarising the employees

To familiarise the employees with the code of ethics, its printed copies should be given to all the employees.

(*iii*) Implementing the code

— The company should implement the code with all genuine interest and sincerity.

— Let every employee know any unethical behaviour shall not be tolerated and suitable action shall be taken against erring employees.

— An *ethics committee* having directors as its members should be constituted to monitor the ethical conduct of employees at all levels and take remedial action wherever deviations are noticed.

— *Social audit* may be conducted to ensure that the code is implemented and its

contents are adhered to.

38.13 CODES OF BUSINESS AND PROFESSIONAL ETHICS

Codes of ethics

Their purpose is to provide guidance to managers and employees when they encounter an ethical dilemma. A typical code discusses conflicts of interest that can harm the company (for example, guidelines for accepting or refusing gifts from suppliers, hiring relatives, or having an interest in a competitor's firm).

— Rules for complying with various laws, such as antitrust, environmental, and consumer protection laws, also are popular code provisions.

— The most effective codes are those drawn up with the cooperation and widespread participation of employees. An internal enforcement mechanism, including penalties for violating the code, puts teeth into the code.

— A shortcoming of many codes is that they tend to provide more protection for the company than for employees and the general public. They do so by emphasizing narrow legal compliance—rather than taking a positive and broad view of ethical responsibility towards all company stakeholders—and by focusing on conflicts of interest that will harm the company.

Business and Professional Codes

Another phenomenon that has some potential in the area of furthering ethical practices is the rather widespread tendency of *business groups, professional people*, and even *politicians* to adopt or to consider the adoption of codes of conduct. Examples abound in the codes adhered to by the medical, legal, and accounting professions; the many business codes usually developed by trade associations; and the various proposals for codes to govern the conduct of professors, politicians, and legislators.

Purpose: The usual reasons for the development of these codes are two. — **In the first place**, it is considered that the publication of a code of ethics will improve the confidence of customers, clients, patients, or voters in the quality of service they may expect. This is why education, which is presumed to be the best safeguard against quackery, is stressed. So also are truth-in-advertising, something more than *caveat emptor*, conflicts of interests, and similar matters covered in the codes.

— **A second reason** for the development of this practice concerns the interrelationships of the members themselves. Business simply cannot be carried on in its present complexity without trust in the ethical standards of vendors and suppliers, of financial houses, and of government agencies. It is believed that their business risks will be somewhat minimized if the competitors within the group, and between groups, can rely upon at least some expectation of a given standard practice.

— It is believed that there are *two additional reasons for codes*. They can be used as a crutch for the weak, who, if approached to undertake some unethical act, can point to the code to underwrite their refusal. And then there is the practical result that codes simplify the detection of unethical behaviour in competitors and employees.

38.14 CHIEF PROVISIONS OF A PROFESSIONAL CODE

An example of the chief provisions of a code for professional accountants is given below in summery form. On the same lines. codes can be framed for other professionals.

A. Professional conduct

1. An appropriate firm name, style, and description.
2. Practice as a corporation is forbidden.
3. Occupations incompatible with public accounting are prohibited.
4. If engaged in another business, the same rules of conduct apply.
5. Advertising and solicitation of business are prohibited.
6. Members of the Institute of Accountants must observe the rules of State societies, where they exist, on competitive bidding.
7. Offers of employment to employees of other accountants are forbidden.

B. Confidence of clients

1. Confidential relationship must not be violated.
2. Splitting fees with, or paying commission to, the laity is forbidden.
3. Excepting partners and employees, members may not permit others to use their names on financial documents.
4. Members may not sign the work of others, excepting their own associates or other accredited accountants.

C. Confidence of third parties

1. Members must conform to generally accepted accounting and auditing standards in certifying statements.
2. Contingent fees relating to audits are prohibited.
3. Members must not vouch for the accuracy of earnings forecasts.
4. Members may not express an opinion on financial statements of an enterprise financed by public issues of securities if they, or their immediate relatives, have a substantial financial interest. With private financing, their interests must be exposed.

38.15 ETHICS TRAINING PROGRAMS

— Many companies provide ethics training for their managers and employees. After all, firms frequently train their employees in accounting methods, marketing techniques, safety procedures and technical systems, so why not also give them training in ethics?

— *The two most common approaches* for establishing a training program in ethics are: (1) developing employee awareness of ethics in business, and (2) drawing attention to ethical issues to which an employee may be exposed. Nearly all ethics training programs include messages from the chief executive officer, discussion of codes of ethics, and procedures for discussing or reporting unethical behaviour.

— *Numerous approaches are used* to promote ethical awareness and decision making : case studies, corporate rules or guidelines, decision frameworks (such as the Golden Rule or ethical principles), and approaches which attempt to develop higher stages of moral reasoning.

Most of the corporate ethics training programs are permanent modules in the employee training curriculum, with a majority offered to all managerial employees.

38.16 COMMUNICATING ETHICAL VALUES

— Every day management is faced with a series of ethical questions. These are concerned with treatment of personnel, safety in the work place, pollution control, minority employment, relations with customers, and a wide range of financial matters involving

investors and the financial community.

— One of the toughest dilemmas facing managers today may be how to communicate ethical values to their employees.

Some suggestions in this connection are given below:

— Create an open environment in the work place that makes employees feel comfortable in bringing problems or ethical dilemmas to superiors.

— Be consistent and reward ethical behaviour. For example, donot tell employees that you want an ethical environment at work and then issue an ultimatum:

"The quarterly profit goals had better be reached, or else."

— Ask questions on value-related issues when visiting offices or factories.

— Include criteria in performance-evaluation systems that incorporate performance according to key ethical values.

— Prepare a statement of the values or "way" certain kinds of business problems should be handled.

— Use employee publications and other media to demonstrate and reinforce key values.

— Establish special ethics training or integrate such discussions into existing programs.

— Instruct by a good personal example.

38.17 ROLE OF PROFESSIONAL BODIES

Professional associations, like Institution of Engineers (India), Indian Institute of Welding, Indian Institute of Materials Management, etc., can strive a great deal to influence the thinking of professionals on ethical lines. They can play a significant role in promoting the professional image, as these associations act as the beacon light for the professionals. Being voluntary organizations, the full benefits can be reaped only by the efforts of individual members. It would not be out of place, to quote here the biblical St. Mathew 16-26 quotation, "For what is a man profited, if he shall gain the whole world and lose his own soul!"

SHEETAL GAUTAM

39

Management Information Systems (MIS)

39.1 DEFINITION

— *Management Information System may be defined as* a formal method of making available to management the accurate and timely information necessary to facilitate the decision-making process and enable the organisation's planning, control and operational functions to be carried out effectively.

— The system provides information on the past, present and projected future and on related events inside and outside the organisation.

— The *purpose* of MIS is to aid decision making and not to automate the decision making process itself. Secondly MIS should focus only on those decisions whose benefit/cost ratio is attractive.

Data

Uninterpreted raw statement of facts.

Management

The direction of an enterprise, (through planning, organizing, coordinating and controlling of its human and material resources) toward the achievement of a predetermined objective.

Information

An aggregate of facts so organized or utilized as to provide knowledge or intelligence. Information is the common element that holds an organisation together.

System

An assembly of procedures, processes, methods, routines or techniques united by some form of regulated interaction to form an organized whole.

39.2 EVOLUTION OF MIS

— Organisations have always had some kind of management information system, even if it was not recognised as such. In the past, these systems were of a highly informal nature in their setup and utilisation.

— Not until the advent of computers, with their ability to process and condense large quantities of data, did the design of MIS become a formal process and field of study.

— When computers were first introduced into organisations, they were used mainly to process data for a few organisational functions—usually accounting and billing. As the speed and ease of processing data grew, other data processing and information management tasks were computerized.

— The growth of EDP departments spurred managers to plan their organisation information systems more rationally. These efforts led to the emergence of the concept of

computer-based information systems (CBIS), which became better known as *computer based MIS-or simply MIS.*

— Recent advances in computers have made it possible for EDP/MIS experts, and then for managers, to gain *on-line* or *real-time* access to the data bases in CBISs.

— The near future will witness the widespread use of *expert systems* using artificial intelligence to diagnose problems, recommend strategies to avert or solve these problems, offer a rationale for these recommendations, and *learn* from each experience. In effect, the *expert* system acts like a human expert in analyzing unstructured situations.

39.3 NEED/OBJECTIVES/FUNCTIONS OF AN MIS

Need

Effective planning and controlling in any organisation requires relevant information. The accurate is the information, the better is the resulting decision. Unfortunately, an organisation has no memory other than the memory of the people who manage it. Because individuals come and go, the company management must out of necessity *develop some type of information system.*

Purpose

One of the vital tasks performed by managers is *decision making.*

To make decisions they must have alternatives from which to choose, authority to implement the alternative they choose, and *information.*

The *importance of information* becomes obvious when one realizes that managers rarely work with *things* but rather with *information about things.* Thus, *management information systems* have one *primary purpose*:

"To provide the manager with the necessary data for making intelligent decisions".

Objectives

1. To provide the desired information available in the right form at the right time.
2. To supply the desired information at a reasonable cost.
3. To keep the the information up to date.
4. To store important and confidential information properly.

Functions of an MIS

The MIS should provide management with the following four major information services:

(1) Determination of information needs.
(2) Information gathering.
(3) Information processing
(4) Information utilization.

(1) ***Determination of information needs***

The beginning point is to attempt to answer such questions as given below:

— How much information is needed? More information does not mean better performance.
— How, when and by whom will the information be used?
— In what form is it needed?
— What information is necessary for planning and controlling operations at different organisational levels?
— What information is needed to allocate resources?

— What information is needed to evaluate performance?

(2)&(3) ***Information gathering and processing***

— The purpose of this service is to improve the overall quality of the information. It includes five component services.

— *Evaluation* involves determining how much confidence can be placed in a particular piece of information. Such factors as the credibility of the source, and reliability and validity of the data, must be determined.

— *Abstraction* involves editing and reducing incoming information and data in order to provide the managers with only that information which is relevant to their particular task. Once information has been gathered, the service of indexing is important in order to provide classification for *storage* and *retrieval purposes*.

— *Dissemination* entails getting the right information to the right manager at the right time. Indeed, this is the overriding purpose of an MIS.

— The *final information* processing service is that of *storage*. As noted earlier, an organization has no natural memory so every MIS must provide for storage of information in order that it can be used again if needed. Modern electronic information storage equipment has greatly improved the "memory" capabilities of organizations.

(4) **Information use**

— How information is utilized depends greatly on its *quality (accuracy)*, how it is *presented (form)*, and its *timeliness*. This all relates to the *basic need* determined in the beginning. If the right questions are asked in the beginning, and the system is planned carefully, the user will be provided with relevant information.

— Remember that the major goal is to provide the right information to the right decision maker at the right time. This brings up the point that *timeliness* may take precedence over *accuracy*. If information is not available when it is needed then its accuracy is not important.

In most cases, however, both are critical and timeliness is determined by the nature of the decisions that must be made. *For example*, a sales manager may find accurate weekly reports of sales for each company product to be adequate, while an air-traffic controller needs accurate information every second. The functions of an MIS are presented in Figure 39.1.

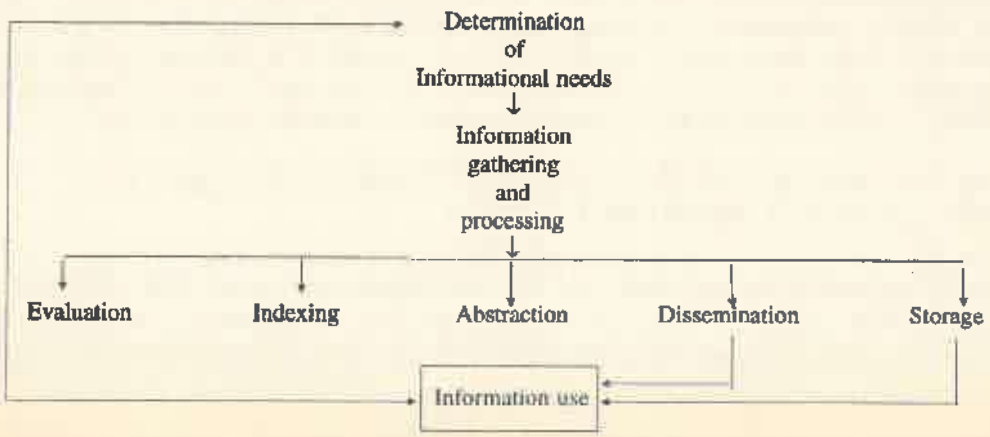


Fig. 39.1 Functions of a management information system.

39.4 DIFFERENCE BETWEEN DATA AND INFORMATION

— **Data** is uninterpreted raw statement of facts *whereas* **information** is an aggregate of facts so organised as to provide the desired knowledge.

In general terms, *data* are processed in some way to form *information.*

Data

— *Data can be defined as* groups of non-random symbols (words, values, figures) which represent things that have happened.

— Data are facts obtained by observation or research and which are recorded. Frequently they are called *raw or basic data* and are often records of the day to day transactions of the organisation. *For example*; the date, amount and other details of an invoice or cheque, payroll details of pay, National Insurance and tax for a person, the output for a machine or shift, the number of vehicles passing a road monitoring point and so on.

— Data are derived from both *external* and *internal sources* and whilst most external data are in readily usable and concrete forms — for example, bank statements, purchase invoices — internal activities require appropriate measuring and recording systems to be developed and maintained so that facts are recorded.

— Data may be produced as an automatic by-product of some routine but essential operation such as the production of an invoice or alternatively a special counting or measuring procedure must be introduced and the results recorded. Much of cost accounting, stock control, production control and similar systems would fall into this latter category.

Information

— Information is data that have been interpreted and understood by the recipient of the message. It will be noted that the *user* not just the sender is involved in the transformation of data into information. There is a process of thought and understanding involved and it follows that a given message can have different meanings to different people. It also follows that *data* which have been *analysed, summarised* or *processed* in some other fashion to produce a message or report which is conventionally deemed to be *management information* only becomes *information* if it is understood by the recipient. It is the *user* who determines whether a report contains *information* or *just processed data.* Accordingly, it is vital for the producers of reports and messages of all types to be aware of the user's requirements, education, position in the organisation, familiarity (or otherwise) with language and numeracy and the context in which the message will be used in order to increase the likelihood of information being derived from the message.

— *In summary, information* is knowledge and understanding that is usable by the recipient. It reduces uncertainty and has surprise value. If a message or report does not have these attributes, as *far as the recipient is concerned,* it contains merely *data not information.* This is a crucial point not always fully appreciated by information specialists.

39.5 DISTINCTION BETWEEN A DATA PROCESSING SYSTEM AND A MANAGEMENT INFORMATION SYSTEM

— The *data processing functions* are data collection, manipulation, and storage as used to report and analyze business activities. The data processing system is oriented primarily to processing transactions for day-to-day operations. The transactions include sales orders, shipping orders, inventory orders, and payroll data. For most of these transactions, routine

procedures can be established and carried out repetitively to do the processing required. The procedures become part of the data processing system.

— An MIS that functions properly processes and analyses data to provide, in particular *planning* and *control* information that supports the decision making role of management.

A management information system (MIS) performs substantial functions beyond those of a data processing system. The MIS involves a man/machine system that provides information for managers to use as they perform their managerial functions of planning, organising, staffing, directing, and controlling. Such a system supports basic transaction processing as does a data processing system. It also provides information about the past, present, and future (forecasts) as each relates to the operations within the organisation and within its environment.

A data processing system is not an MIS. Two major distinctions between these types of systems are : (1) the characteristics of the information they require, and (2) the decisions that are made, based on this information. Fig. 39.2 summarises these differences.

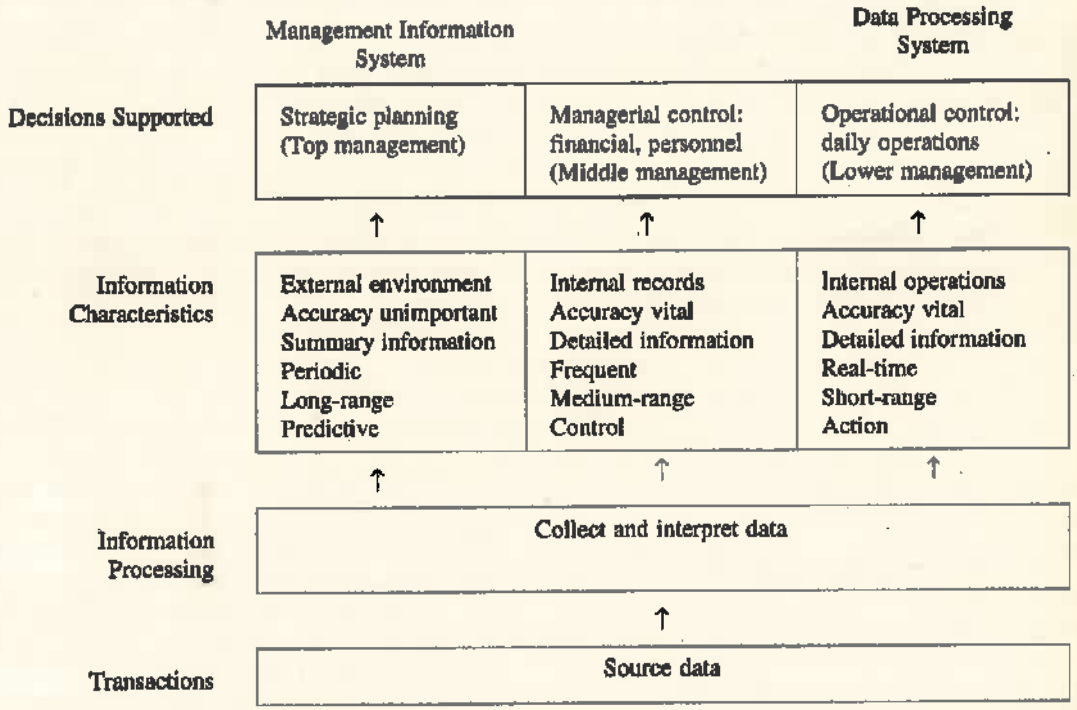


Fig. 39.2 A comparison of data processing and management information systems.

39.6 NEED FOR INFORMATION

— Information is very much needed to make right decisions.

— Management is faced with an accelerating rate of change and an ever more complex environment. A multitude of *factors* may need to be considered for a given decision. *Examples include*; planning regulations, local and central government legislation, the attitudes of employers, customers, trades unions, consumer groups and so on, the financial consequences of the decision, environmental factors, technological and capacity

considerations, marketing and advertising implications, resource and supply problems etc. etc. For each and every one of the above examples—and others—the manager needs *relevant information* which is information that increases his knowledge and reduces his uncertainty and thus is usable by the manager for the *intended purpose*. Without relevant information no manager can function effectively. A worthwhile extension to the well known adage that *management get things done through people*, would be that, 'management get things done through people, by using relevant information.

— One of the most important processes in managing the activities of an organization is making *decisions about alternatives*. When the information available is not sufficient to make a decision, the manager needs to gather more information about the alternatives, compare them, and then choose an alternative. Decisions made without sufficient information are at best only estimates and typically lead to poor management performance. As shown in Fig. 39.3, quality information in the hands of those who can make good use of it supports appropriate management decision making. The resulting management performance should then lead to the successful achievement of the organisational objectives.

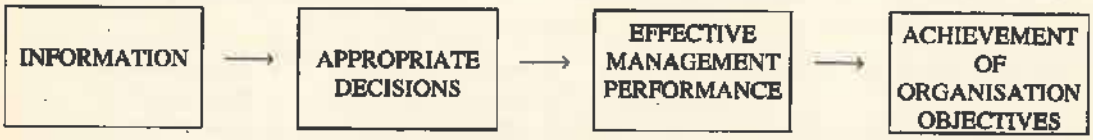


Fig. 39.3. The role of information

— Thus, information is the common element that holds an organisation together. The relationship of the *information systems* of an organisation to the *decision making* within that organisation is given below:

Management Systems Supply Information to the Following officers

	To take decisions on
1. Top Executives	(*a*) Policy making
	(*b*) Strategic planning
2. Personnel Managers	(*a*) Recruitment and selection
	(*b*) Wage and Salary policies
3. Marketing Managers	(*a*) Marketing Research
	(*b*) Advertising and Promotion
	(*c*) Pricing and Selling policies
	(*d*) Product Distribution and Logistics
4. Finance Managers	(*a*) Accounting policies and practice
	(*b*) Capital goods financing
	(*c*) Investments
5. R & D Managers	(*a*) Research thrust
	(*b*) Product development
6. Manufacturing Managers	(*a*) Purchasing
	(*b*) Raw materials distribution
	(*c*) Branch plants.

The above clearly shows the need for information in any organisation.

39.7 QUALITIES OF GOOD INFORMATION

— Every organisation is dependent upon information for its survival. In order for managers to take action that will yield effective results, they need information that is accurate, timely, complete, concise, and relevant.

— There is no assurance that the manager will use this type of information effectively; however, it must be available to be used. In most cases, the availability of information to a manager will have a strong influence on the rationale applied in decision making.

— Managers are often required to make decisions with information that lacks one or more of the properties above. This can have an undesirable impact on the effectiveness and efficiency of their decisions.

(1) **The accuracy** of information is the ratio of correct information to total amount of information produced over a period of time. *For example*, if the monthly sales forecasts provided to a plant manager are not consistently accurate, it is difficult for the manager to make effective decisions concerning production schedules.

(2) **Timeliness** of information is a reflection of whether or not the information arrives in time to be used by a manager in making a decision. The plant manager must receive the monthly sales forecast in time to make a decision about the monthly production schedule.

(3) **Completeness** of information requires that a manager be provided with all of the information needed to make a decision. If sales forecasts cover only two-week periods, it is difficult to make decisions about monthly production schedules.

(4) **Conciseness** of information is obtained through the summarization of relevant data. Such data may point out exceptions to normal or planned activities. A manager who receives concise information is saved a great deal of time otherwise spent in analysis of information for decision making.

(5) For information to be **relevant**, it must provide to each involved manager what he or she *needs to know*. Information should not be given to a manager who does not have the authority to make the decision(s) which should be based on the information.

(6) Information should be produced and provided at a **frequency** which is related to the type of decision/activity involved. The frequency may be an hour, a day, a week, a month etc.

(7) Information should be presented in a style and format readily **understandable** by the person concerned. The producer of the information must be aware of the recipient's knowledge, literacy level, experience etc.

39.8 INFORMATION AS AN ORGANISATIONAL RESOURCE

A frequent problem in many organisations is that a great deal of information is generated for no real purpose and should be eliminated. Apparently there seems to be a tendency to generate large quantities of information on the assumption that a direct relationship exists between the amount of information and the quality of decisions. As we have seen this can only be true if the information is relevant and provided to the right decision maker-that is, is provided to the right person at the right time. One useful approach to the effective design and utilisation of an MIS is to think of information as a basic resource of the organisation as we do money, materials, personnel, and plant and equipment. Thus

as a basic resource, information:

1. Is vital to the survival of the organization.
2. Can only be used at a cost.
3. Must be at the right place at the right time.
4. Must be used efficiently for an optimal return on its cost to the organisation.

Each user of information should consider the cost of the information relative to its utility for decision making. For example, the cost of complete information for a decision must be weighed against the expected value of a decision with incomplete information.

39.9 MANAGEMENT INFORMATION CATEGORIES

— *Information implies facts that are gathered in any way, as by reading, observation, hearsay etc.*

— *Management information can be conveniently categorized into three main areas:*

1. Strategic planning information
2. Management control information
3. Operational information

(1) **Strategic planning information** relates to the top management tasks of deciding on objectives of the organisation, on the levels and the kinds of resources required to attain the objectives and on the policies that govern the acquisition, use and disposition of resources.

Strategic planning depends heavily upon information external to a specific organisation. When this is combined with internal data, management can make estimates of expected results. The specifics of this information are often unique and tailor-made to particular strategic problems.

(2) **Management control information** sheds light on goal congruence; it keeps managers to take those actions which are in the best interests of the organisation; it enables managers to see that resources are being used efficiently and effectively in meeting the organisational goals.

— Robert Anthony pinpoints three types of information needed for management control:

Costs by responsibility centres,

Direct program costs and

Full program costs (including allocations for indirect costs).

— Management control information is often interdepartmental.

(3) **Operational information** pertains to the day-to-day activities of the organisation and helps assure that specific tasks are performed effectively and efficiently.

It also includes the production of routine and necessary information, such as financial accounting, payrolls, personnel rosters, equipment inventories and logistics. *Operational information* can be well defined and easily reduced to a routine of a series of instructions, whereas *strategic information* is difficult to define; *control information* falls in between.

39.10 DESIGNING INFORMATION SYSTEMS

— Much of the literature on design emphasizes the development of mechanized systems. Electronic computers have fostered the design of sophisticated systems of information

flow. But the analysis involved is applicable to information systems of all kinds--computerized or not.

— A hazard in designing information systems is that of attempting to develop as much data as possible for use in the system. Voluminous data of many types might be collected and stored in case they are needed at some point in time. It is easy to see that massive amounts of useless data might result.

— The best approach is oriented to decision making. It minimizes the development of useless information because only data likely to be meaningful at various points are collected. The object is development of better information systems for management.

— Three stages in a continuous process of design and implementation for *computerized information systems* can be described as follows:

Stage-1 *Systems specification*...includes the design of all of the aspects of a management information system that are important to the users. It includes principally the basic decisions as to what information should be provided by the system.

Stage-2 *Data Processing Implementation*...is concerned with those things that are important to the processing of the data. The purpose in this stage is to design a data processing system that will most efficiently implement the systems specified in stage-1.

Stage-3 *Programming*...starts with the system flow charts and ends when the program is running on the computer.

39.11 COMPUTER SYSTEMS

— In one sense, *a computer system* is like any other *data processing system*. It takes *input, processes it,* and provides *output*. In other ways, a computer system is quite different from other data processing systems. *For example data is processed electronically, rather than manually, mechanically, or electromechanically. Computer systems are often called electronic data processing (EDP)* systems.

— The machines usually included in a basic computer system are a *card reader*, a *computer*, and a *printer*.

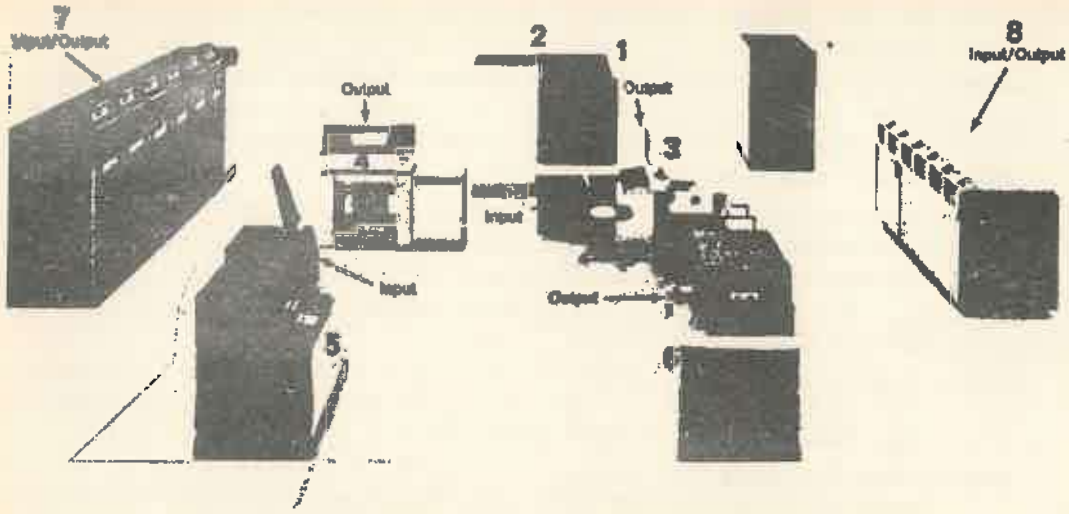
— A *card reader* reads data stored on punched cards; a *computer* processes the data; and a *printer* prints the results.

— A larger system may also include *magnetic tape units* and *magnetic disk units*, which are used to store data. (A computer system with all of these machines is shown in Fig. 39.4) In addition to these machines, a variety of other machines can be used. The basic factor determining which machines are appropriate is the data processing that is required.

— Although the machines in a computer system are developed as separate units, they are connected prior to operation of the system. Each of the input and output machines is attached to the computer by means of electric cables. When a card reader reads a punched card, the data is transferred to the computer. Similarly, after the computer has processed the data, the results are transferred from the computer to the printer to be printed out. Thus the components of a computer system work together.

39.12 THE COMPONENTS OF A COMPUTER SYSTEM

A computer system is composed of (1) machines, which are referred to as *hardware*, (2) programs and operating aids, referred to as *software*, (3) user programs, (4) procedures, and (5) data processing personnel.



1. Console
2. Computer (CPU)
3. Console printer-keyboard
4. Printer
5. Card reader
6. Card punch
7. Magnetic tape units
8. Magnetic disk units

Fig. 39.4 Typical computer system

Thus, the term computer system refers to the machines; programs and operating aids, and user programs that cause these machines to function: the procedures required to prepare and process the data and distribute the results of the processing; and the people who keep the hardware, software, user programs, and procedures efficiently and effectively functioning.

(For details refer article 36.12).

39.13 CHARACTERISTICS OF COMPUTER SYSTEMS

— A *computer system* has three basic units. These are its *input, output*, and *central processor*. The input unit is the means by which data are supplied to the computer (see Fig. 39.5). Input devices include punched-card readers, magnetic tapes, and disks. The central processing unit (CPU) is usually considered the heart of the computer and is composed of a control, arithmetic, and memory unit.

— When a set of operations is to be performed by the computer, a set of instructions called

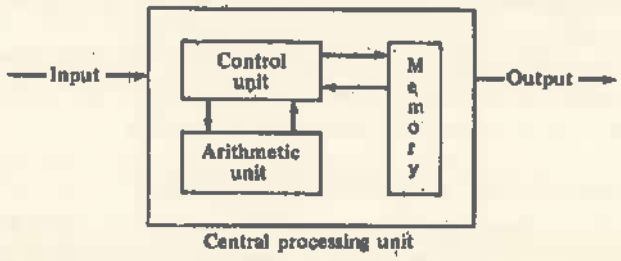


Fig. 39.5 Central Processing Unit

a *program* is entered through the input unit and stored in memory. In addition, any data that are required are also entered and stored. To be acted upon, the data and program are moved into the control unit and the appropriate arithmetic and logical operations are executed.

— Finally we have the computer *output* units. Output can be presented in several ways, including punched card, tape, disk, printed records, and video display.

— Two distinguishing features between computers include their *storage capacity* and their *response time*. *Storage capacity* is the ability of the computer to both temporarily and permanently store data. *For example*, in an inventory control system, the computer must be capable of storing inventory levels, data for forecasting purposes, reorder levels, and reorder quantities. When hundreds of thousands of items are carried in inventory, a sizable storage capacity is required. The *second* distinguishing feature is the *response time*. This is the time between when the input is supplied to the computer and when the output becomes available.

39.14 INTEGRATED INFORMATION SYSTEMS

— The concept of an integrated total information system has been a goal of management for two decades or more. At last this goal is now becoming a reality as more and more private and public organisations are establishing components of information systems. The Planning, Programming, and Budgeting Systems [PPBS] used in many governmental agencies are examples of integrated information systems in the public sector.

— *The value of such an approach is apparent*: Information in one area can be made available to other areas of the organisation. If stored in a central computer, it can be utilized by all departments. Thus, sales data would not have to be kept by accounting, marketing, and production but would be available in one central data bank. This would likely increase both the accuracy and certainly the timeliness of the data. Figure 39.6 portrays the integrated information system concept illustrating two subsystems in more detail.

The Information Center

If the concept of a truly integrated management information system is to become a reality, a single, separate information center must exist in the organisation in order to make one individual responsible for the information. This is necessary because both users and suppliers of such information are scattered throughout the organization and some unit is needed to oversee the operation. In fact, a basic structural weakness in most organisations has been the absence of a central entity for the gathering and processing of information. As noted earlier, the information requirements of most managers have greatly changed in the past decade while the information arrangements within most organisations have remained essentially the same. *Specifically, three tasks are necessary.*

1. Dispersed information activities must be identified throughout the organisation.
2. These activities must be viewed as parts of a whole.
3. These activities must be managed by a separate centralized information center.

— This organisational unit must be responsible as a consultant, coordinator, and controller, for the functions of an MIS determining information needs, information gathering, information processing, and information use. In order to justify its existence, it must facilitate improved managerial performance through more as well as better information availability and use.

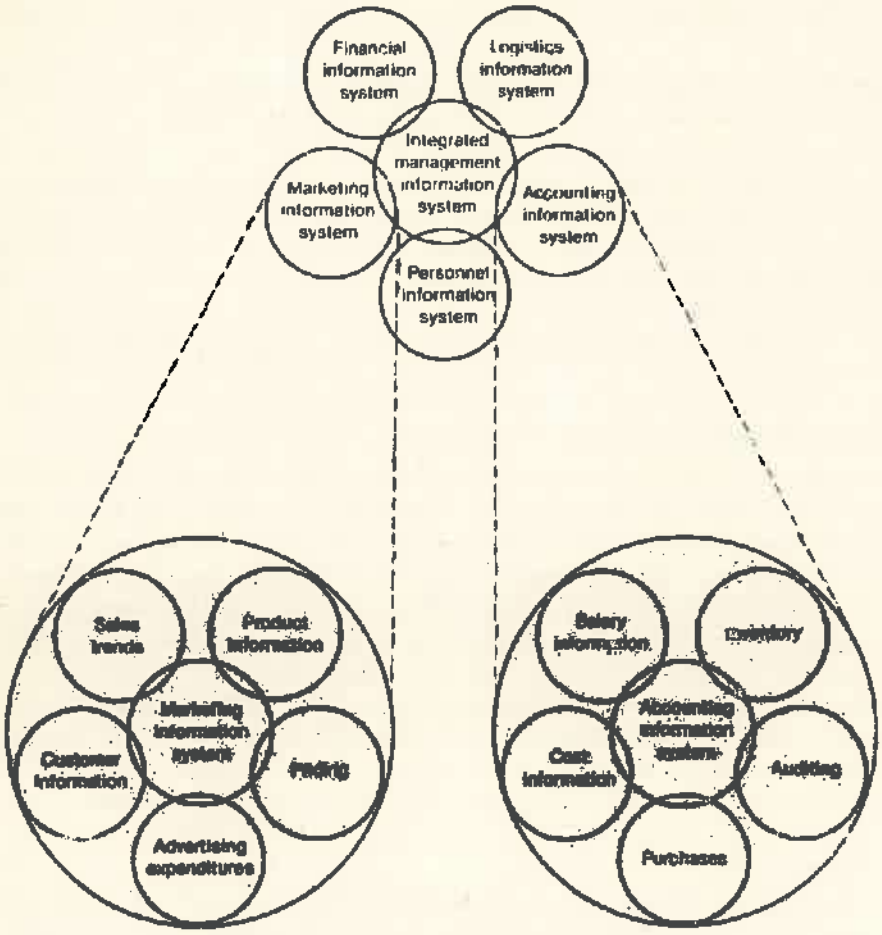


Fig. 39.6 Integrated Management Information System

— In many organizations which are *information oriented*, there has been the development of a separate centralized, company-wide informatin office. It is probably more widespread in highly competitive, volatile, consumer goods industries. However, the need is becoming more recognized in other areas both of private industry and the public sector.

— This organizational arrangement offers several *advantages* such as increased efficiency and more effective use of information. All computer facilities, knowledge, and storage and retrieval facilities become available to all other functions in the organisation.

39.15 APPLICATIONS OF MIS

To name a few:

1. Reservation systems being operated in Airlines.
2. In health maintenance and diagnosis centres.
3. Forecasting.

4. Inventory management.
5. Scheduling problems.
6. In Banking.
7. In Judicial system for court scheduling etc.

39.16 THE FUTURE OF MIS

Although some individuals still refer to MIS as a *mirage,* many organisations are operating with an MIS that is very effective. These organisations have been dissatisfied with the quantity and quality of the information provided to managers and have realised that to develop an effectively functioning integrated MIS involves a great deal more than expanding or automating the data gathering process. Certainly, one of the major reasons for the increased interest in the concept of information systems has been the rapid growth in information technology. However, *the study of information systems is not the study of computers. The study of management information systems is part of a much larger task, the study of more effective methods of managing organisations.*

To Conclude

Management information systems, computers, and many management science models have made it possible to reduce the number of decisions required by some managers, especially at the operations level. These are in areas where the problems are deterministic and arise with great regularity (e.g. inventory decisions) and preestablished decision rules can, therefore, be developed. However, it is difficult to foresee the elimination of the manager as the critical factor in an effective MIS. Even with the increased sophistication of computers, most decision making is as we have noted, a human activity.

• • •

Question Bank

1. (a) What do you understand by 'Plant Design'? Discuss the various factors to be considered in deciding the location of a plant.

   (b) To compare three sites, the various factors are listed, as given below. Select the optimal location and give reasons for your choice :

	Site A Rs.	*Site B* Rs.	*Site C* Rs.
Rent	20,000	10,000	10,000
Labour	1,35,000	1,30,000	1,60,000
Freight Charges	81,000	64,000	28,000
Taxes	Nil	3,500	2,000
Power	6,000	6,000	6,000
Community attitude	Indifferent	Want business	Indifferent
Employee housing	Excellent	Adequate	Poor

(Ans. Site B)

2. What are the principal considerations for location of :-
   i) Steel industry around Bihar
   ii) Zinc smelter plant at Udaipur (Rajasthan)
   iii) Plastic industry in Bombay
   iv) Khetri Copper Project in Rajasthan
   v) Textile industry at Bombay and Ahmedabad
   vi) Sugar industry in Maharashtra and U.P.
   vii) Glass and Bangle industry at Firozabad
   viii) Woollen carpets at Mirzapur
   ix) Silken sarees at Kanjiwaram (Tamil Nadu)
   x) YMCA Institute of Engineering at Faridabad
   xi) Indian Oil Refinery at Mathura
   xii) Iron foundries at Agra
   xiii) Brass sheet industry at Moradabad
   xiv) Bed sheet industry at Sholapur
   xv) Escort Tractors Ltd. at Faridabad.

3. A new young entrepreneur wants to set up a small plant. There are three different possible sites with different advantages. The total intial investment is going to be of the order of Rs. 2,00,000. Calculate rates of return of the three sites and choose the optimal location for the purpose of locating the small plant.

		Site A Rs.	*Site B* Rs.	*Site C* Rs.
i)	Expected sales	2,50,000	2,50,000	3,00,000
ii)	Distribution expenses	40,000	40,000	75,000
iii)	Raw material	90,000	80,000	70,000
iv)	Cartage	20,000	25,000	35,000
v)	Power & water supply	20,000	30,000	30,000
vi)	Wages & salaries	25,000	30,000	25,000
vii)	Other expenses	15,000	15,000	20,000

(**Ans.** 20%, 15%, 22.5% : Site C)

N.B. Rate of Return = $\frac{\text{Total Sales} - \text{Total Expenses}}{\text{Total Investment}} \times 100$

4. (a) What factors are considered while designing a factory building? Will you prefer an 'L' shape building or a rectangular building for a new plant? Why?
   (b) Give the advantages of a multistorey building over a single storey building for a factory.
5. (a) Define plant layout and give its objectives.
   (b) What are the various types of layouts? Explain and give their relative advantages.
6. (a) Explain the term "Material Handling". What are the advantages of a well planned and integrated system of material handling.
   (b) State and discuss the economy principles of material handling.
7. (a) Name the common types of industrial organisations. Describe the 'line and staff' organisation with the help of a line diagram, and discuss its advantages and disadvantages.
   (b) What is a Committee Organisation? Explain briefly.
8. (a) Define the following and differentiate :
   (i) Organisation (ii) Administration (iii) Management
   (iv) Industry (v) Factory (vi) Plant
   (b) Describe clearly and compare the three different types of organisations, *viz.* Line Organisation, the Functional type of organisation and the line & staff organisation.
9. (a) What is linear programming? List out various methods of linear programming.
   (b) In the moulding department, we can mould either 120 dozen lamps or 200 dozen shades per week, in the assembly department we can assemble either 240 dozen lamps or 80 dozen shades per week and in the finishing department we can paint either 150 dozen lamps or 100 dozen shades per week. The profit on lamps is Rs. 4/- each while on shades it is only Rs. 3/- each. Find out by graphical method how many of each we should schedule in each of the three departments in order to have maximum profit.

   (**Ans.** Lamps 100 Dozens ; Shades 30 Dozens ; Max Profit Rs. 5880.)
10. We want to manufacture paper Napkins of two sizes A & B. Find the number of each size to be manufactured for maximum profit from the following data :

Department	*Time (Minutes)*		*Constraints (Minutes)*
	A size	B size	
Cutting	10.7	5.0	2705
Folding	5.4	10.0	2210
Packing	0.7	1.0	445
Profit/Unit	Rs. 10/-	Rs. 15/-	

(Ans. 200, 140).

11. A plant is manufacturing washing machines and dryers. The capacities of the three major manufacturing departments are :-

Stamping Department	10,000 washing machines or 10,000 dryers/month.
Motor and transmission Department	16,000 washing machines or 7,000 -do-
Washing machine Assembly Department	9,000 washing machines per month
Dryer Assembly Deptt.	5,000 dryers per month.

The profit is Rs. 90/- per washing machine and Rs. 100/- per dryer.
Find the number of each item to produce for maximum profit.

(Ans. Washing Machine 5333 ; Dryers 4667).

12. A manufacturer makes two types of products I & II. Three machines A, B & C are required for the manufacture of each product. One unit of product I requires 2 hours on machine A, 1 hour on machine B and 6 hours on machine C, whilst one unit of product II requires respectively 2 hours, 5 hours and 2 hours on machines A, B and C. In a given period there are 24 hours available on machine A, 44 hours on machine B and 60 hours on machine C. The profit per unit on product I is Rs. 6/- and on product II is Rs. 9/-. Given that machines are available when required, how many units of each product should be made in order to maximise profit.

(Ans. I = 4, II = 8, Max. Profit 96).

TUTORIAL SHEET
PRODUCTION PLANNING AND CONTROL
SECTION 2

13. (a) Define production and productivity. Explain the difference between the two.

(b) There are three car manufacturing factories A, B and C, and they are producing the same type of cars. They are employing 1000, 2000 and 3000 men and producing 10, 15 and 25 cars per month respectively. Find

(i) the labour productivity of each firm.

(ii) the production of each firm per year.

[Ans. (i) 1/100, 3/400, 1/120 (ii) 120, 180, 300]

14. a) What do you understand by productivity? In what units can it be expressed?

b) A manufacturing concern was producing 120 locomotives per year by employing 20,000 men in the past. To increase production they have now recruited 1,000 men more and as a result production has increased to 140 locomotives per year. Find :

(i) What was the labour productivity previously?

(ii) What is the labour productivity now?

(iii) What is the percentage increase in production and productivity?

[Ans. (i) 3/500, (ii) 1/150, (iii) 16.6%, 11.1%)

15. (a) What do you understand by 'Centralised Production Planning and Control' ? Give its advantages.

(b) What is the position of P.P.C. in a works organisation? Show it with the help of a chart.

16. (a) What is forecasting? Describe the various methods of forecasting sales of a product.

(b) What is a production order? Explain with an example.

17. (a) Define process planning. Why is it required?

(b) Find the Economic Batch Quantity from the following data :

Cost of carrying inventory	15% of value per year
Set up cost	Rs. 5,000/- per batch
Average yearly consumption	3,000 units
Cost per unit	Rs. 100/-

(Ans. 1414, 1500)

18. (a) List and explain the factors to be considered in detail before deciding a process plan for a job.

(b) Find the economic batch quantity for manufacturing 20,000 fountain pens per year :

Value of raw material in each fountain pen	= 2.00
Labour including on cost per fountain pen	= 2.50
Set up cost per batch	= Rs. 600.00
Cost of carrying inventory	= 12 per cent of the value per year.

(Ans. 6667)

19. Given that $U = 2$ pieces per day, P = Rs. 20 per batch, C = Rs. 5, Procurement time 3 days and minimum stock 8 pieces, calculate (a) Reorder point

(b) Standard order quantity

(c) Maximum stock.

(Ans. 6, 70 and 78 pieces respectively)

20. (a) What is meant by 'Economic Batch Quantity'. Derive the formula for it.

(b) Determine the Economic Batch Quantity from the following data :

(i) Total sales in a year	= 1500 units
(ii) Set up cost per job order	= Rs. 1800/-
(iii) Cost of unit product	= Rs. 120/-
(iv) Inventory carrying charges	= 10 percent of the value of the product.

(Ans. Calculated 668 ; Rounded off 750)

21. (a) What are the inventory quantity standards ? Give their importance in stock control.

(b) A.B.C. Co. uses brass rods 2 mm in diameter and 1 m long in one of their manufacturing processes. The rod costs Re. 1/- each, and the total expenses involved in purchasing and receiving them are Rs. 10/- per order. An interest rate of 10 percent annual is charged on capital investment. The average usage of these brass rods is 10 pieces per day. Find the standard ordering quantity. Assume 300 working days in the year. (Ans. 775, 750).

22. (a) What is the object of inventory control? Explain.

(b) Find the Economic Order Quantity from the following data :

Average annual demand	= 30,000 units
Inventory carrying cost	= 12% of the unit value per year
Cost of placing an order	= Rs. 70/-
Cost per unit	= Rs. 2/-

(Ans. 4183, 4286)

23. (a) What is meant by 'Economic Order Quantity'? Derive a relation for it.

(b) Discuss the concept and utility of ABC analysis as applied to inventory control.

24. (a) What do you understand by the 'Follow up' function of production planning and control? Explain.

(b) Give a specimen of "Gantt Chart" which is normally used in the production planning and control department and describe briefly how it could be used for checking the actual progress of a job against the schedule.

25. Explain briefly

(a) ABC Analysis.

(b) Dispatch station procedure.

(c) Difference between Loading and Scheduling.

TUTORIAL SHEET NO. 3
INDUSTRIAL ENGINEERING

26. (a) What is importance of inspection in an industry? Describe the various kinds of inspections.

(b) Sub-groups of five items each are taken from a manufacturing process at regular intervals. A certain quality characteristic is measured, and $\bar{X}$ and R values are calculated for each sub-group. After 25 subgroups $\Sigma\bar{X} = 357.50$) and $\Sigma R = 9.90$. Compute the control limits. It is assumed that all the points lie within both the control charts.

(Ans. $\bar{X}$ Chart 14.53, 14.07, R chart 0.835, 0)

27. (a) What is inspection? What is the basic difference between inspection and quality control?

(b) The results of inspection of 10 samples each containing 4 units are tabulated in the following form. Compute the control limits for the X and R charts.

No. of observations	*Sub-group size*				*Average*	*Range*
	a	*b*	*c*	*d*	$\bar{X}$	*R*
1	47	32	44	35	39.50	15
2	33	33	34	34	33.50	1
3	34	34	31	34	33.25	3
4	12	21	24	47	26.00	35
5	35	23	38	40	34.00	17
6	19	37	31	27	28.50	18
7	23	45	26	37	32.75	22
8	33	12	29	43	29.25	31
9	25	22	37	33	29.25	15
10	29	32	30	13	26.00	19

[Ans. $\bar{X}$ Chart 42.866, 17.75 ; R Chart 39.216, 0]

28 a) Explain the following terms :-
i) Statistical Quality Control
ii) Normal Distribution

b) The number of products inspected is constant, and the data is compiled in the following form. Compute the control limits of the np, p and $100\,p$ Charts)

Date	*Number inspected* n	*Number of defectives* np
Sept. 3	400	2
4	400	5
5	400	0
6	400	15
7	400	3
8	400	0
9	400	1
10	400	0
11	400	18
12	400	8
13	400	6
14	400	0
15	400	3
16	400	0
17	400	6
	$\Sigma n = 6000$	$\Sigma np = 67$

[Ans. np chart 10.65, -1.9 *i.e.* 0 ; p chart 0.0266, -0.00456 *i.e.* 0 ; $100\,p$ chart 2.664, 0]

29 a) What is a Statistical Control Chart? Explain it with a sample.

b) An analyst collects twenty samples of size 200 each from the output of a final assembly line. The items in each sample are inspected and the number of defectives in each sample noted. The results are :

Sample No.	*No. of defectives*	*Sample No.*	*No. of defectives*
1	8	11	26
2	8	12	18
3	15	13	11
4	18	14	8
5	9	15	10
6	7	16	10
7	9	17	15
8	11	18	13
9	17	19	9
10	12	20	12

Compute the 3 sigma control limits for a chart for number of defectives which the analyst wants to maintain at the last station of this assembly line.

(Ans. 22.50, 2.107, Modified control limits* 21.23, 1.56)

* Modified control limits are calculated after discarding the samples which are out of control limits.

30. (a) What do you understand by acceptance sampling? When is it used? Give its advantages and disadvantages.

(b) Describe briefly the double acceptance sampling plan.

31. (a) Name the different types of costs involved in manufacturing a product in a factory.

(b) A small firm is producing 100 pens per day. The direct material cost is found to be Rs. 160/-, direct labour cost Rs. 200/- and factory overheads, chargeable to it Rs. 250/-. If the selling on cost is 40% of the factory cost, what must be the selling price of each pen to realise a profit of 14.6% of the selling price. (Ans. Rs. 10)

32. (a) Explain in detail the various elements which go to make up the total cost of any product.

(b) The market price of a lathe is Rs. 50,000/- and the discount allowed to the distributor is 20% of the market price. It is found that the selling expense cost is ¼th of the factory cost and if the material cost, labour cost and factory overhead charges are in the ratio of 1:4:2, what profit is made by the factory on each lathe ; the material cost being Rs. 4,000/-? Neglect other overheads. (Ans. Rs. 5000)

33. (a) What is cost accounting? How does it differ from cost estimation?

(b) A certain piece of work is produced by a firm in batches of 100. The direct material cost for that 100 pieces work is Rs. 1600/-, and the direct labour cost is Rs. 2000. Factory on cost is 35% on the total material and labour cost. Overhead charges are 20% of the factory cost. Calculate prime cost and factory cost. If the management wants to make a profit of 10% on the gross cost, determine the selling price of each article. (Ans. Rs. 64.15)

34. (a) What is break even point? Explain.

(b) Two workmen engaged on a forging Hammer complete 20 connecting rods, each weighing 4 kg. The workmen are paid at the rate of Rs. 50/- and Rs. 30/- per day and material cost is Rs. 20/- per kg. If 140% of direct labour is charged to compensate for both factory overheads and administrative expenses, what will be for unit cost or production of these units.

(Ans. Rs. 89.60)

35. (a) Distinguish between fixed and variable costs.

(b) A factory is producing 1000 bolts and nuts per hour on a machine. Its material cost is Rs. 3750/-, labour cost Rs. 2450 and the direct expense is Rs. 800/-. The factory on cost is 150% of the total labour cost and office on-cost is 30% of the total factory cost. If the selling price of each nut and bolt is Rs. 10, calculate whether the management is going in loss or gain and by what amount. (Ans. Loss Rs. 2.775 per piece)

36. (a) What are the various indirect Expenses which are essential in estimating the total cost? Explain.

(b) A factory is producing two components *A* and *B*. Component *A* requires 20 hours and is manufactured by the workers paid at the rate of Rs. 10/- per hour, while component *B* also requires 20 hours but the workers producing it are paid at the rate of Rs. 7.50 per hour. Find out the on-cost of each component, if (i) it is 40% of the direct labour cost (ii) Rs. 4/- per man hour. (Ans. (i) Rs. 80,80 (ii) Rs. 60,80)

37. (a) What do you understand by depreciation? Explain.

(b) If the cost of machine is Rs. 100,000 and its scrap value is Rs. 10,000/-, determine depreciation charges for each year by the sum of the year's digits method if the estimated life of machine is 5 years. (Ans. Rs. 30000, 24000, 18000, 12000, 6000).

38. (a) A boiler was purchased in Rs. 45,000/- on 1st Jan. 1946, the erection and installation costs were Rs: 7,000/-. The boiler was replaced by a new one on 31st December, 1965. If the scrap value

was estimated as Rs. 15,000/-, what should be the rate of depreciation, and depreciation fund on 15th June, 1955. (Ans. Rs. 17482.5)

(b) If after 12 years of running, some boiler tubes are replaced and the replacement cost is Rs. 1,500/-, what will be the new rate of depreciation. (Ans. Rs. 2037.5)

39. The estimated life of a lathe is 10 years and it works 16 hours a day. The initial cost of lathe is Rs. 8,000/- and scrap value after 10 years is Rs. 2,500/-. If the machine works for 5840 hours in a year, calculate the rate of depreciation charges annually under machine hour basis method. (Ans. Re. 0.94 per hour)

40 (a) What is the difference between Method Study and Work Measurement? State the objectives of each.

(b) What steps are followed for doing a Method Study of job process?

(c) In Method Study all activities can be recorded with the help of certain symbols. Write the symbols and explain what each stands for.

41. (a) What are the objectives of Method Study?

(b) Which are the recording techniques used in the Method Improvement?

(c) Enumerate the principles of motion economy pertaining to work place layout.

42. (a) In estimating the standard time of a job, what different elements of time are considered ? Explain.

(b) Write the procedure of time study.

43. (a) Describe the steps for taking a Time Study.

(b) Why is it necessary to apply rating to the actual time which an operator takes to perform an operation?

(c) An operator is observed to complete a job in 0.33 minutes at a 75 rating (B.S. Scale 0-100). If he worked at rating of 60; 80, 90 and 100, how long would it take to complete the job in each case? (Answer to be correct to two decimal places). (Ans. 0.4125, 0.3093, 0.275, 0.2475).

44. (a) What are the various allowances considered in Time Study?

(b) Define standard time, Basic time, observed time and rating factor. Write a relation between these quantities and allowances.

(c) The normal cycle time for an operation is 1.14 minutes. It is estimated that 405 minutes of 480 minutes day are available to the operator for production purposes.

Determine the standard time (S.T.) and the number of pieces for a standard hour.

(Ans. S.T. = 1.35 minutes, 44 pieces)

45. (a) What is the purpose of Work Measurement? Enumerate its uses.

(b) What are the various allowances considered in Time Study?

(c) Define "Rating". What is its necessity?

46. (a) "Incentives are necessary for smooth and efficient running of a factory", discuss. State some important incentive schemes.

(b) Standard time for a given job is 15 hours and hourly rate of wages is 50 paise. If a worker completes the job in 10 hours, calculate the total earnings of the worker by the Rowan Premium Plan. (Ans. Rs. 6.67)

47. (a) What are the essential requirements of an incentive scheme? Describe the preparatory work required to be carried out before the introduction of an incentive scheme.

(b) Four workers have taken 7, 6, 5 and 3 hours respectively for the completion of a job. The day rate is Rs. 10 per hour. A bonus of 25% on the time taken is fixed for those who complete the job wthin 6 hours.

Calculate the earnings of individuals and their hourly rates by Gantts Task and Bonus System.

48. (a) Describe the various methods of wage payments.
    (b) A worker is employed for the manufacture of M.S. pins at a piece rate of 50 paise. He has to prepare 40 pins in 8 hours of work, but he prepared 55 pins in 8 hours. Calculate his total daily earning by piece rate system.

49. (a) What are the different types of incentive schemes? Discuss.
    (b) The standard time for the completion of a job is 8 hours and the worker is paid Rs. 40/- for it. If he completes it in 6 hours, calculate his earnings by cent per cent premium system for the whole day (i.e. for 8 hours of work).

N.B. The questions numbers from 50 to 65 are from the question papers of Industrial Engineering Examination of YMCA Institute of Engineering, Faridabad for the years 1991 and 1989.

50. (a) State the factors governing the choice of site for a manufacturing plant in a city or a sub-urban part of a country. 10
    (b) Suggest suitable locations for the plants of following products (i) Ships (ii) Cameras (iii) Readymade garments and (iv) antibiotic medicines. Give reasons for your choice. 10

51. (a) Describe the objectives and functions of production planning? 10
    (b) What is the main difference between planning and follow up. 10

52. (a) Describe clearly the function of routing, scheduling and dispatching? 12
    (b) Show how the Gantt chart is used for planning a project? 8

53. (a) Describe the single sampling and double sampling inspection procedures. 10
    (b) What are the factors that determine sample size? 10

54. (a) What are incentives? How these help the production? 10
    (b) What are the essential features of Halsey Premium Plan. 10

55. (a) What is utility of Man-Machine chart? How such chart can be drawn? 10
    (b) Write short note on Performance Rating. 10

56. (a) State some possible objectives of $\bar{X}$ and R Charts. 10
    (b) Determine the Control limit for $\bar{X}$ and R Chart if $\Sigma\bar{X} = 357.50$, $\Sigma R = 9.90$, number of sub-groups = 20. It is given that $A_2 = 0.18$, $D_3 = 0.41$ and $D_4 = 1.59$. 10

57. Write short notes on any *four* of the following. 5×4
    (a) Linear programming
    (b) Forecasting techniques
    (c) Productivity
    (d) Depreciation
    (e) Inventory control
    (f) Indirect expenses

58. (a) Define Plant Layout. Describe the major steps of planning any layout.
    (b) Discuss Product type layout, where it is used. State its advantages and disadvantages. 10, 10

59. (a) Discuss the fundamental requirements of a good financial incentive system.
    (b) What is meant by non-financial incentive? Name few non-financial incentive schemes. 10, 10

60. (a) What are basic components of an inventory system?

(b) In what ways can inventories serve to reduce the cost and to increase the cost?

(c) Determine the economic order quantity for a product whose average daily consumption rate is 80 units. The cost of each unit is Rs. 0.50 and the inventory carrying charges is Rs. 0.20. The cost of placing and receiving the order is Rs. 10. Assuming total working days in a year as 300, obtain the annual inventory capital, also. 5, 5, 10

61. (a) Describe clearly the function of routing, scheduling and dispatching?

(b) Describe what is the utility of Gantt chart as a tool of production. Prepare a Gantt chart showing picture of future operation? 10, 10

62. (a) What are the techniques of work measurement? Explain each of them briefly.

(b) Why is a job broken down into elements and what are the general rules for selection of elements? 10, 10

63. (a) Why is inspection important in an Industry? Describe the various types of inspection methods.

(b) State the important objective of "quality control". Explain briefly how these objectives are achieved in Engineering Industry. 10, 10

64. (a) What is meant by a "basic feasible solution" to a linear programming problem?

(b) A company plans to manufacture and sell two products *X* and *Y*. These two products require the use of 3 different raw materials, A, B, and C which are available in limited quantities. The profit per unit of products *X* and *Y* is 5 and 6 units of money respectively. The other relevant data are given below :-

Raw material	*Units of raw material needed for making one unit of product*		*Total units of raw material available*
	X	*Y*	
A	2	3	18
B	2	1	12
C	3	3	27

10, 10

The company wants to determine the product-mix that would maximize the total profit. Fractional units are permissible both for products and raw materials.

(a) Formulate as a linear programming problem.

(b) Determine the capital product-mix graphically or by using the simplex method.

65. Write short notes on any *three* of the following :-

(a) Plant-location

(b) Cost-accounting.

(c) Acceptance sampling.

(d) Depreciation.

(e) Forecastng-techniques. 20

66. Solve the transportation problem represented by Availabilities and Requirements matrix given below.

WARE HOUSES

PLANTS		A	B	C	D	Total Availability
	1	10	9	7	11	10
	2	8	6	9	7	8
	3	11	12	14	11	7
	4	4	6	3	9	9
	Total Reqd.	11	12	5	6	

(Ans. 242)

67 Solve the following cost matrix by

(a) N-W Corner method

(b) Vogel's method

PLANT

WARE HOUSES		1	2	3	4	Total Reqd.
	1	6	5	12	11	10
	2	9	3	6	4	9
	3	11	14	12	11	7
	4	7	9	6	8	11
	Total Available	11	10	7	9	

(Ans. 233)

68. Solve the following cost matrix

(a) By N-W corner method

(b) By Vogel's method

WARE HOUSES

PLANTS		A	B	C	D	E	Total Available
	1	11	8	7	14	9	11
	2	8	7	8	12	11	22
	3	9	9	6	10	10	14
	4	9	6	10	9	8	31
	5	8	10	12	11	8	17
	Total Reqd.	18	15	17	24	27	

(Ans. 731)

69. Solve the transportation problem represented by Profits, Availabilities and requirements as in matrix below.

PLANTS

		A	B	C	D	E	Total Reqd.
WAREHOUSES	1	11	7	6	9	8	22
	2	8	9	10	11	9	14
	3	6	12	9	10	8	19
	4	7	12	10	8	11	23
	Total Available	15	17	10	21	14	

(Ans. 839)

70. Solve the following profit matrix and find the maximum profit.

DEALERS

		D_1	D_2	D_3	Factory Capacity
FACTORIES	F_1	3	1	3	8
	F_2	3	4	1	7
	F_3	4	2	2	9
	Dealers Requirements	10	8	9	

(Ans. 88)

71. Find the maximum profit in the problem represented by the profit matrix given below.

DEALERS

		D_1	D_2	D_3	Total Available
FACTORIES	A	10	12	8	6
	B	15	10	9	10
	C	9	11	10	9
	Total Reqd.	7	13	5	

(Ans. 301)

N.B. The following questions are from "Management Science" and "Industrial Engineering" question papers of AMIE Examinations of the years 1988 and 1989.

72. (a) What is meant by 'Ratio Delay' technique, as advocated by L.H.C. Tippet? Discuss the systematic steps to be undertaken in conducting a ratio delay study in a machine shop, having various types of machines that are handed by a group of workers.

(b) Is it essential to do 'ratio delay' study, before fixing up 'standard time' for rate fixing? Give reasons to your answer.

73. There are four booking clerks in a railway ticket counter. Passengers arrive at an average rate

of 80 per 8 hour day. The mean time for servicing a passenger, in such computerised booking counter capable of considering alternative options of the customer, is 4 minutes and the passengers are served on 'first come-first serve' basis. Find the idle time of a booking clerk.

Deduce the formula you may use in solving this problem.

74. (a) In a linear programming problem the objective function is given by $Z=10x_1+4x_2$ where operating variables are x_1 and x_2. The objective function is subjected to restrictions as under :

$$6x_1+4x_2 \geq 24 \text{.....(1)}$$
$$4x_1+2x_2 \leq 16 \text{.....(2)}$$
$$7x_1+6x_2 \leq 42 \text{.....(3)}$$
$$x_1 \leq 3 \text{.....(4)}$$

usual non-negativity restriction is $x_1, x_2 \geq 0$.

Solve this problem using graphical method.

(b) Show the method of solving same problm through Simplex by tabular matrix. Only formulation and first two tables may be shown.

75. (a) There are five jobs to be assigned to workmen. There are four workmen, none of them should get more than one job. Time taken by each of the four men to do each job in hours is known and given below. Find the assignment of men to jobs that will minimise the total time taken.

		Jobs				
		1	*2*	*3*	*4*	*5*
Men	*1*	2	9	2	7	1
	2	6	8	7	6	1
	3	4	6	5	3	1
	4	4	2	7	3	1

While solving this problem state the systematic steps to be taken. Mention the job which cannot be manned in this case.

(b) With a neat block diagram show the method of analysis of a production system, through 'Systems Approach'. How can a system be identified and characterised to determine the malfunctioning and necessary feedback for corrections thereof?

76. Write short notes on *any three* :

(a) SIMO Charts ;

(b) Evaluating 'Performance Rating' of an operator ;

(c) 'Learning Phenomenon' and factors on which this is dependent ;

(d) 'Time span' for measuring "responsibility".

77. (a) Discuss systematically the various steps to be undertaken to evaluate the life of machine or equipment using 'Monte Carlo' simulation through random numbers. What are the informations essentially needed in such case and the basic assumptions to be made?

78. A manufacturing firm has discontinued production of a certain unprofitable product line. This created considerable excess production capacity. Management is considering to devote this excess capacity to one or more of three products namely A, B and C. The excess capacity available with three facilities *F*1, *F*2 and *F*3 are respectively 250 hours/week, 150 hours/week and 50 hours/week. The number of machine hours required for each unit of respective product is given as :

	Product		
	A	*B*	*C*
*F*1	8	2	3
*F*2	4	3	0
*F*3	2	–	1

The unit profits fetched by the products are Rs. 20, Rs. 6 and Rs. 8 respectively. Find how much of which product should be produced.

79. (a) Distinguish between 'goals', 'objectives' and 'policies'.

(b) Briefly discuss how objectives can be classified and hierarchy of objectives established.

(c) What are the principal differences between 'human behaviour' and 'decision theory' schools of management principle in the context of the present day business environment?

80. (a) The following interindustry transactions table was constructed for an economy for a particular year :

Industry	*1*	*2*	*Consumption*	*Totals*
1	500	1600	400	2500
2	1750	1600	4650	8000
Labour	250	4800	.....	5050
Total	2500	8000	5050	15550

Construct tables indicating :

(i) Direct requirements per monetary unit of output :

(ii) Direct and indirect requirements per monetary unit of final consumption.

(b) There are two business locations in a city. About 70% of the population live near the locality 1 while the remaining 30% of the population live in locality 2. Two competing banks, one large and one small, are planning to open branches in the city. They estimate that if both the banks are located in the same locality, the larger one will get 60% of the business of the city. On the other hand if the two banks are located in different localities, the larger one will get 80% of the business of the locality in which it is located and 40% of the business of the locality in which the smaller one is located. What will be optimal strategies for the two banks?

81. (a) How 'management functions' differ from 'administrative functions' specially in the context of 'differentiation' and 'integration' activities activities involved in realising the organisational objectives?

(b) Distinguish between 'formal' and 'informal' type of communication system.

(c) Considering a manufacturing organisation as a 'socio-technical' system indicate how the four principal functions of management are interrelated.

82. (a) Following the method of Helgeson and Birnie, discuss systematically the 'Heuristic method of balancing' an automated assembly line.

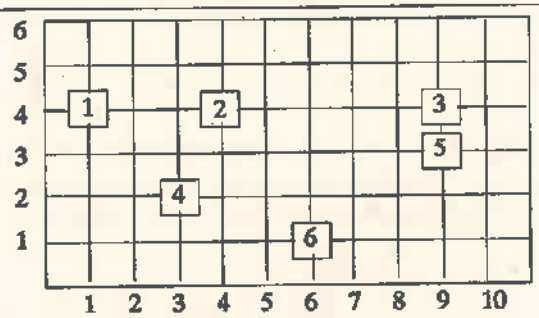
(b) Define the terms (i) cycle time, (ii) work station time, (iii) elemental time, (iv) precedence diagram, (v) precedence matrix, and (vi) off-balance, while discussing the methodology and state their specific influences on the balanced optimum work station.

83. As an industrial engineer yon have been asked to plan positioning of three new machines in an existing plant having six machines shown in the figure below. Traffic data matrix are also shown separately as under. While locating the new machines you are constrained to move along co-ordinates avoiding existing machine locations :

Table : TRAFFIC MATRIX

NEW MACHINES	EXISTING MACHINES					
	1	2	3	4	5	6
A	20	10	4	8	6	10
B	10	8	10	20	4	4
C	8	8	20	10	6	6

TABLE : TRAFFIC DATA MATRIX



EXISTING LAYOUT PLAN

84. (a) A company is faced with the problem of properly assigning four different salesmen to four different territories for promoting its sales. Territories are not equally rich in their sales potential and the salesmen also differ in their abilities to promote sales. The following table gives the expected annual sales (in thousands of Rupees) for each salesman if assigned to various territories.

		TERRITORIES			
		1	2	3	4
SALESMEN	1	60	50	30	40
	2	40	25	30	35
	3	45	20	35	10
	4	25	30	20	25

Find the proper assignment of salesmen, so as to maximum annual sales :

(b) What are the various methods commonly used in production scheduling?

Or,

State the 'Markov chain' analysis forecasting the future sales demand.

85. (a) Discuss briefly the S.Q.C. procedures by charts and diagrams. What is meant by 'quality circle'? Is there any additional benefit derived from this?

(b) Briefly state the 'Monte Carlo' simulations as applicable in evaluating the 'techno-economic life' of a machine.

86. At a one-man ration shop, it takes 12 minutes on an average to service a customer and the customers arrive at an average rate of one every 20 minutes. Assuming a suitable queuing model, find out :

(i) Average number of customers in the shop, (ii) Average waiting time of a customer, (iii) Average idle time for the server.

Deduce any expression that you may need to solve this problem and state assumptions you make in making the model.

87. (a) Explain the term INVENTORY. How would you classify it? Explain, how you would carry out MATERIAL REQUIREMENT PLANNING ? State the basic steps involved in setting up MRP.

(b) Discuss the functions of purchasing department in an industry. Explain some methods of purchasing commonly adopted in an industrial purchasing. Why should the purchasing documents be legally sound?

88. (a) Explain the assumption underlying PERT and CPM network models applied in Project Management.

(b) How is PERT different from CPM? Explain their fields of application.

(c) A project is composed of seven activities whose time estimates are listed in the following table. Activities are identified by their beginning (*i*) and ending (*j*) mode numbers :

TABLE

Activity		*Estimated duration in weeks*		
i	*j*	*Optimistic*	*Most likely*	*Pessimistic*
1	2	1	1	7
1	3	1	4	7
1	4	2	2	8
2	5	1	1	1
3	5	2	5	14
4	6	2	5	0
5	6	3	6	15

(i) Draw the project network and identify all paths for its completion.

(ii) Find the expected duration and variance for the project.

(iii) Calculate the early and late occurrence time for each mode. Calculate expected project length.

(iv) Calculate the slack for each activity.

89. (a) Explain how with the help of Ergonomic concepts motion economy can be ensured in designing a work-place-layout.

(b) Explain how 'workstudy' concepts can be utilised to improve 'productivity'.

90. (a) Explain the term QUALITY and QUALITY CONTROL. How does quality control differ from conventional inspection ?

(b) Explain the following terms in reference to quality control :

(i) Producer's risk, (ii) Consumer's risk, (iii) Average outgoing quality, (iv) Single sampling plan of inspection, (v) p-chart.

91. Write short notes on *any four* of the following :

(a) Depreciation,

(b) Rowan incentive scheme

(c) Linear programming,

(d) Simulation,

(e) Line balancing,

(f) Forecasting system.

92. In a product mix problem, we have a company manufacturing three different products *A, B* and *C*, in quantities x_A, x_B and x_C per month. The objective of the case is to maximise the profits, subject to restrictive equations. The following data are supplied :

(a) Profits per unit are Rs. 10, Rs. 6 and Rs. 5 for products *A, B,* and *C* respectively.

(b) Processing times in hours in Machines I and II are as below :

	Product	*A*	*B*	*C*	*Total Hours Available*
Machines	I	3 hrs.	2 hrs.	2 hrs.	480 hrs.
	II	2 hrs.	3 hrs.	3 hrs.	540 hrs.
	*Total available hours of Machines can't be exceeded.				

(c) It is not possible to sell more than 120 of product *A* in the market, per month.

Find out the quantities to be produced per month to maximise the profit using any method of Linear Programming.

93. (a) Discuss the essential differences between (i) Product layout, (ii) Process layout, and (iii) Cellular layout, in respect of layout of plants and machinery in a manufacturing industry.

(b) Enumerate systematic procedures to be followed in finding out the number of machinery and their types, to be installed for producing a particular product of certain quantity. You may refer to a specific product that you are familiar with.

94. What is meant by Line Balancing? Is it necessary in case of dedicated automated system only?

Explain the 'Heuristic method' of assembly line balancing Precedence Matrix and ranking algorithm.

What is meant by work station time, cycle time and percentage 'off-balance'?

95. (a) A company manufacturing automobiles decides to make a particular item *A* in batches. Following data are available :

(i) Cost of setting up special toolings : Rs. 900

(ii) Annual rate of interest, depreciation etc : 20%

(iii) Consumpation of parts in assembly shop : 60 per month

(iv) Processing of each item takes 4 hours on the machine. Labour rate is Rs. 24 per 8 hour-day. Material cost : Rs. 9 per item.

(v) Overhead expenditure calculated on prime cost is at 150%.

Find out the economic batch size for machining and also duration of Batch run, assuming that the machine loading factor is 90%.

(b) Deduce the formula you use.

96. (a) With nicely drawn charts explain the significant characteritics of 'Man-Machine' and 'Multiple Activities' charts.

(D) In a Time Study the following observations were noted by the observer, while worker was performing a specific task repeatedly. In order to make the study reliable with 95% level of confidence and that the precision needed for predicting the final result is ±5%, find out how many more observations, the observer will have to take :

Observation	*Min.*	*Observation*	*Min.*
1	4.5	6	3.6
2	4.3	7	4.0
3	4.8	8	4.3
4	3.2	9	3.5
5	3.8	10	3.3

97. (a) What are the major points to be looked into while introducing statistical control charts for Quality Assurance in an Industry? Show typical $\bar{X}$ and R charts. With reference to S.Q.C., define clearly the terms : Specified Acceptance Quality Level (A.Q.L.). Producer's risk, Consumer's risk, Operating characteristic curve (O.C.).

(b) Explain the concept of System Analysis, as originated by Von Bertalanffy. State specific areas of Industrial Engineering, where System Analysis plays an important role.

98. What are the basic differences between

(i) Operation process chart,

(ii) Flow process chart,

(iii) Flow diagram, and

(iv) String diagram.

Draw sample charts with a specific product in mind to explain the characteristics of these techniques of Work Study.

99. (a) Explain the process of management as applied to an industry. State some of its characteristics.

(b) Discuss the contribution of Adam Smith, Charles Babbage, Taylor, Gantt, Gilbreth, etc. in the growth of management science.

100. Write short notes on *any four* of the following :

(i) Quantitative measurement school of management ; (ii) Managerial leadership ; (iii) Organisation structure ; (iv) Line Organisation and Functional Organisation ; (v) Organisation Dynamics ; (vi) Delegation of Authority and Responsibility.

101. (a) Discuss the importance of quality control in an industry. Why is statistical quality control perferred? Explain.

(b) Discuss the general structure for double sampling plan. What are its advantages and disadvantages? Explain.

(c) Explain control-limits.

102. Account for the differences between PERT and CPM as they were originally developed.

For the PERT planning methods, discuss and interrelate three phases : (i) Activity-analysis, (ii) Arrow diagramming, and (iii) Node numbering.

Assume any data to explain your reply.

State the applications of PERT in scheduling a project.

103. (a) What are the characteristics of decision problems under risk and those under uncertainty?

(b) Write short notes on the following :

(i) Game theory ; (ii) Dynamic programming ; (iii) Product planning.

104. (a) In what way can inventories serve to reduce costs. Explain the term 'economic ordered quantity' and how you would compute it. State all the assumptions made.

(b) Explain the term 'work-study'. State some of its applications in industries. Explain the following :

(i) Flow diagram ; (ii) Work-measurement.

105. (a) Explain the role of man-machine chart and two-hand process chart in work-place layout.

(b) Under what conditions would you employ the principles of motion economy in developing a work place-layout?

(c) What information is contained in an operation chart.

106. Write short notes on *any four* of the following :

(i) Control of production ; (ii) p-chart ; (iii) Selecting the sources of funds ; (iv) Depreciation ; (v) Determination of fixed and working capital ; (vi) Importance of incentives to raise productivity.

107. (a) Discuss briefly the principles of micromotion study and the basic 'therbligs' as advocated by Gilbreth.

(b) Enumerate the principles of motion economy with particular reference to workplace layout and ergonomic design of a product.

108. At a 'one man' barber shop, it takes on an average 30 minutes to service a customer and the customers arrive at an average rate of one in every forty minutes. Assuming a poisson-exponential model, find out the following :

(i) Average number of customers in the shop ; (ii) Average waiting time of a customer ; (iii) Average idle time of the barber.

(b) Deduce any formula you may use.

109. Write short notes on *any three* of the following :

(i) Multiple activity SIMO charts ;

(ii) Essential difference between product layout and process layout ;

(iii) Training of time study observer by rating film and how to reduce human error caused by conservatism ;

(iv) 'Monte-Carlo' simulation.

110. Deduce an expression for the economic order quantity for purchase of an inventory in an engineering organisation having a consumption pattern of the part in a 'saw tooth' manner and storing approximately 60% of the order point quantity above normal minimum limit as a cushion stock. Inventory stored may be changed on the basis of the maximum, while interest at the bank rate is chargeable to this inventory cost based on average stock level throughout the year.

How can you make out a sensitivity analysis of this particular inventory model to know the effect of minor variation in the parameters upon the order quantity?

111. Describe the scientific method of determining the fatigue allowance, delay allowance, personal allowance etc. statistically following the broad principles of L.H.C. Tippet. How effectively can such a study be conducted? Has it any role to play in determining the 'standard time' for a task?

112. Indian Airlines operate a time table given below for flights between Lucknow and Delhi daily. Crew must have at least 8 hours layover time before starting a second flight. Crew will be stationed at a city that results in smallar layover. Find the pairing of the flights that minimises

total layover period away from the station and also suggest the planning for stationing the crew.

Flight No.	*Delhi*	*Lucknow*	*Flight No.*	*Lucknow*	*Delhi*
IC 101	0600	0700	IC 105	0800	0900
IC 102	0700	0800	IC 106	0900	1000
IC 103	1600	1700	IC 107	1300	1400
IC 104	2000	2100	IC 108	1800	1900

113. Find the critical path of the following project after drawing the complete PERT network.

Activities	*Precedence relationship*	*Time Estimate (days)*		
		Pessimistic	*Optimistic*	*Most likely*
A	–	2	6	4
B	–	1	5	3
C	*A*	4	6	5
D	*C*	4	10	7
E	*B*	5	7	6
F	*E*	1	3	2
G	*E*	2	2	2
H	*F*	3	7	5
I	*G*	3	9	6
J	*D,H,I*	2	12	4

What is the probability that the programme will be completed? Calculate the standard deviation and the expected project length.

114. (a) In the method used for replacement of a machine, we try to determine the 'adverse minimum' of both 'challenger' as well as 'defender machine'. Explain the mathematical formulation to compute the 'adverse minimum' in such a method.

(b) What is meant by techno-economic life of a machine? Briefly discuss any suitable method to find out the techno-economic life of a machine.

115. Three types of gears *A*, *B* and *C* are produced on machines M_1 (gear hobbing), M_2 (gear shaping), and M_2 (gear grinding). The specific requirements, availability of the machine hours and profit per unit are indicated below. Find the optimum production plan and interpret the values in the final table for managerial decisions :

	A	*B*	*C*	In machine hours
M_1	8	2	3	≤250
M_2	4	3	–	≤150
M_3	2	–	1	≤50
Profit per unit, Rs.	20	6	8	

Appendix - 1

ISO 9000 "Quality System"

A 1.1 INTRODUCTION

- The **ISO 9000**, a well-known and widely accepted **Quality Management System**, is a series of *standards* developed by the **International Organization for Standardization** (ISO) in Geneva, Switzerland.
- There are *five standards* in the ISO 9000 series, ISO 9000-9004.
  ISO 9001, 9002 and 9003 are applicable to contractual situations.
  ISO 9004 is for non-contractual cases and used for internal management purposes.
- **ISO 9000**
  It is the contour map furnishing the guidelines for selection and use of ISO series standards.
- **ISO 9001**
  Model for quality assurance in design/development, production, installation and servicing.
- **ISO 9002**
  Model for quality assurance in production and installation.
- **ISO 9003**
  Model for quality assurance in final inspection and test.
- **ISO 9004**
  Quality management and quality system elements—Guidelines.

As part of ISO 9000's commitment to continuous improvement, the standards are reviewed every five years.

A 1.2 NEED FOR ISO 9000 CERTIFICATION

- Customers, all over the world, like to have confidence in manufacturer's capability to design, develop, produce and service. *Competition* is forcing industries to get *ISO 9000 certification.*
- Today, more than 40 countries worldwide have already adopted ISO 9000.
- Already European markets are insisting on ISO 9000 certification. Very soon it will be a pre-qualification for bidding in the markets.
- ISO 9000 is the only credibility passport which certifies that a company meets international standards in designing, developing, producing, installing and servicing the products it supplies.
- The time has already come, when an industry will not be able to export to World markets without ISO 9000 certification.

- Few Indian industries have already got ISO 9000 accreditation of their quality system and many more are at various stages of implementation.
- ISO 9000 is based on the philosophy that an integrated, systematic and planned approach only can ensure quality.

  ISO 9000 has originated from Western Countries and is a documentation oriented quality system requiring participation by *all.*

  Since cultural, economic, political and social differences between Western Countries and India are great, so certain *obstacles* are clearly in the way to implement ISO 9000 in India.
- The Indian Industry will have to overcome the following *obstacles/weaknesses* in order to improve quality and not only to get ISO 9000 accrediation but to sustain it also :

  (1) Lack of faith. The management lacks faith in workers (unions) and vice-versa.
  (2) Lack of clarity/seriousness for achieving targets.
  (3) Lack of precise observation of rules and norms.
  (4) Low quality of items bought from vendors.
  (5) Management view of short term benefits.
  (6) Politicalisation of Labour Unions.
  (7) Lack of accountability for actions.
  (8) Lack of top management commitment.
  (9) Lack of national quality policy.
  (10) Inadequate infrastructure.
  (11) Quantity before Quality.
  (12) Lack of planning.
  (13) Lack of manufacturing and test facilities.
  (14) Lack of education and training of workers.
  (15) Passive attitude of Industry towards Quality.
  (16) Lack of professional attitude.
  (17) Indian cultural factors.
  (18) Resistance to change etc.

A 1.3 BENEFITS OF ISO 9000 CERTIFICATION

There are manifold benefits, direct as well as indirect, resulting from ISO 9000 Quality Systems Standards. Some of them are given below.

(1) ISO 9000 provides a competitive edge in the domestic and global markets.
(2) It provides a climate for consistent improvement in quality.
(3) It reduces wastes and repairs — enhancing profits in turn.
(4) It maintains streamlined records.
(5) It maintains streamlined material handling and storage.
(6) It changes the attitude of workforce, the result is — improved house keeping, work atmosphere and quality awareness.
(7) Process of quality improvement is maintained.
(8) Products right in the first instance, no rework and nothing for rectification.
(9) ISO 9000 gives international recognition of ability, credibility and expertise, thereby increasing the number of customers.

(10) Supplier without ISO certification can face higher insurance rates, or, be denied insurance in some markets.

A 1.4 LIMITATIONS OF ISO 9000

(1) Implementation of this system is very demanding of resources.
(2) Assessment and registration are expensive.
(3) Work-culture need to be changed/improved.
(4) Upgrading of manufacturing and test facilities is essential.
(5) Unless carefully planned, the system can become non cost effective.
(6) Dedication, will to improve and constant improvement are must for success.

A 1.5 THE QUALITY NOTION

- Quality is the conformance to requirement or specification.
- Quality is the fitness for the purpose. In other words if a product serves your purpose well, it can be called of good quality.
- Quality is what the customer wants.
- According to ISO 8402 (1986) :

  Quality is defined as the totality of features and characteristics of product or service, in conformance with the customer's stated or implied *needs*. Needs may include safety, reliability, maintainability, economics etc.
- The term quality is not used to express a degree of excellence in a comparative sense nor it is used in a quantitative sense for technical evaluations. In these cases, a qualifying objective shall be used.
- The *quality* should not be confined to *product* quality alone, rather quality should mean — to be the quality of the *system*. Quality cannot be inspected into a product, it has to be manufactured along it. The concept of quality as an inspection function is obsolete now, it is perceived to be a process control function.

Quality Control

- The operational techniques and activities that are used to fulfil requirements for quality is **Quality Control.**
- *Quality control* involves operational techniques and activities aimed both at monitoring a process and at eliminating causes of unsatisfactory performance at relevant stages of the quality loop (quality spiral) in order to result in economic effectiveness, (Fig. A.1).
- There are two main aspects of Quality control.
  (i) *Make things right first time.* In other words, production should be defect free.
  (ii) Work for continual improvement in quality.

Quality Policy

- The overall quality intentions and direction of an organization as regards quality, as formally expressed by top management.
- Quality policy shall be consistent with Company's policy and the top-management must ensure that its corporate quality-policy is clearly understood, implemented and maintained. This will ensure the degree of commitment of top-management to quality.

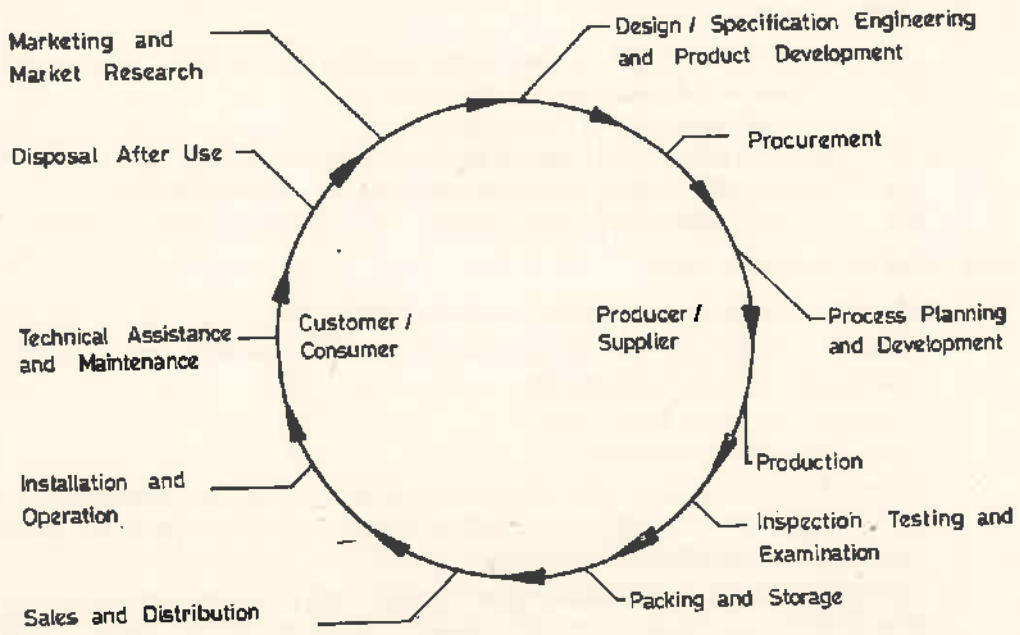


Fig. A. 1. Quality loop

- Quality policy shall cover the areas in terms of quality improvement and strategic planning: the design, conformance to design, field service and marketing.
- Quality policy must clearly state key-elements of quality such as fitness for use, performance, safety, reliability etc. Product design shall meet the customer's quality requirements including functional, safety etc. Every attempt shall be made to adhere to specifications during manufacture.

Quality Management

- That aspect of the overall management function that determines and implements the quality policy.
- Quality management includes strategic planning, allocation of resources and other systematic activities for quality, such as quality planning, operations and evaluations.
- The attainment of desired quality requires the commitment and participation of all members of the organization whereas the responsibility for quality management belongs to top management.

Quality System

- The organizational structure, responsibilities, procedures, processes and resources for implementing quality management.

- The quality system should only be as comprehensive as needed to meet the quality objectives.

Benefits of Quality Systems :

(1) Quality performance is institutionalized.
(2) Efficient tool to achieve and ensure consistent quality improvement.
(3) Reduces wastes and time consuming reworks and repairs — increasing profits in turn.
(4) Saves money as quality system ensures efficient and sound procedures.
(5) Provides a competitive edge in domestic as well as global market.
(6) Brings confidence to the consumer.

Quality Assurance

- All those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality.
- For effectiveness, quality assurance usually requires a continuing evaluation of factors that affect the adequacy of the design or specification for intended applications as well as verifications and audits of production, installation and inspection operations. Providing confidence may involve producing evidence.
- *Within* an organization, quality assurance serves as a management tool. In *contractual situations* quality assurance also serves to provide confidence in the supplier.

Quality Objective

(1) The organization should achieve and sustain the quality of the product so as to meet continually the purchaser's stated or implied needs.
(2) The organization should provide confidence to its own management that the intended quality is being achieved and sustained.
(3) The organization should provide confidence to the purchaser that the intended quality is being, or will be, achieved in the delivered product or service provided. When contractually required, this provision of confidence may involve agreed demonstration requirements.

A 1.6 TOTAL QUALITY ELEMENTS/INGREDIENTS

There are four basic elements of total quality operation :

(a) Quality awareness.
(b) Management Attitude.
(c) Tools and Techniques of Process Management.
(d) Quality System Standards.

(a) Quality Awareness

- Company-wide awareness as regards *quality* is must from top to bottom if manufactured goods and services have to meet the customer's specifications and requirements.
- The company must communicate its *quality objectives* to the workforce, through *quality awareness programmes,* stressing on the following *points* :

(i) To make quality as the foremost policy.
(ii) Customer's requirements first.
(iii) Products/services right first time (prevention tha cure).

(iv) Continuous improvement.

(v) To convince every employee to accept quality as a part of work and to get their wilful support in implementing and maintenance of the quality policy of the organization as their main responsibility.

– **Quality Awareness Programmes**

Quality awareness can be brought out through the following :

(i) *Briefing* employees in small groups atleast once a day.

(ii) *Short films* may be prepared from the briefing sessions and shown to employees from time to time.

(iii) *Articles* based upon importance of quality, maintenance of quality, etc., should be published and circulated among the employees.

(b) Management Attitude

– Management attitude, if positive, can do wonders to improve quality.

– The management should live by a set of values and have an obsession for product quality. The key to quality success is through management improvement.

– It is incumbent upon the management to design and implement a work environment that supports individual enhancement. The development of work force can certainly make a big difference in the consistency and continuous improvement of productivity and quality.

– Management attitude should be a dedicated commitment to support quality program with the help of employees having got job satisfaction.

(c) Tools and Techniques of Process Management

– For improving any management process, it is essential to know what the process is, what we expect out of the process, what the process actually provides and whether it is compatible to the organisational structure.

– *Statistical Process Control Tools* have gained widespread popularity amongst the quality circles in Japan and subsequently all over the world.

(d) Quality System Standards

– Due to brisk technological improvisations, focusing only on the *product quality* is uneconomical; instead, installing a system for managing quality enable an organisation to meet the product or service requirements on a consistent basis.

– ISO 8401 (IS 13999) defines **quality system** as the organisational structure, responsibilities, processes and procedures for implementing *quality management.*

A 1.7 ELEMENTS OF QUALITY SYSTEMS

In the operation of Quality Systems, the following elements have essentially to be taken care of:

1. **Management Responsibility :** The management shall define and document its quality policy in relation to overall corporate policy and identify organizational forms and resources required to effectively manage the implementation of quality policy.

2. **Quality Systems :** Establish and maintain a documented quality system to ensure that the product conforms to specified requirements. The management shall ensure effective implementation of the documented quality system procedures and instructions.
3. **Contract Review :** Establish and maintain the procedures for contract review and for the coordination of these activities. It shall be ensured that the requirements are adequately defined and documented. Any requirements differing from those in the tender are resolved and the management should evaluate its capability to meet contractual requirements.
4. **Design Control :** Establish and maintain procedures to control and verify the design of the product in order to ensure that the design output meets the design input requirements and conform to appropriate regulatory requirements whether or not these have been stated in the input information.
5. **Document Control :** The aim of this element is to recognize the scope on documentation to be controlled, understand the objectives of these controls and identify the essential controls required.
6. **Purchasing :** The management shall understand the steps that need to be taken to select sub-contractors capable of meeting the specified requirements. It shall identify the essential features of a purchase order from the point of view of quality assurance and also identify its own responsibility in the event the purchaser undertakes product verification.
7. **Purchaser-Supplied Product :** Establish and maintain procedures for verification/ storage and maintenance of purchaser-supplied product provided for incorporation into the supplies. The management shall understand the controls necessary in respect of sub-contract.
8. **Product Identification and Traceability :** Identify and maintain procedures for identifying the product from applicable drawings, specifications of other document during various stages of production, delivery and installation. Individual products or batches shall have a unique identification for easy traceability to establish the origin of the product.
9. **Process Control :** Identify and plan the production and where applicable, installation processes which directly affect quality and shall identify references to special processes and shall outline the controls that are required to be exercised over these processes to meet the requirements of the standards.
10. **Inspection and Testing :** Ensure the inspection and testing at each of the three principal stages, that is, receiving, in process and final, since the records of these inspections and tests will be then objective evidence of product quality.
11. **Inspection, Measuring and Test Equipment :** Ensure the control, calibration and maintenance of inspection, measuring and test equipments to demonstrate the conformance of the product to the specified requirements. In this regard, the identification of the measurements to be made and accuracy required, is necessary for the selection of the appropriate inspection, measurement and test equipment.
12. **Inspection and Test Status :** To set up procedures for the control of inspection and test status, for example, by using markings, tags, labels etc. Records shall identify the inspection authority responsible for release of conforming product.

13. **Control of Non-Conformity Product :** Non-Conformity of product be prevented from inadvertent use or installation. The non-conformity product be identified and arrangements be made for its disposition and notification to the functions concerned.
14. **Corrective Action :** Whenever a discrepancy is observed during an audit, the cause of non-conformity be investigated and corrective action taken to prevent re-currence.
15. **Handling, Storage, Packing and Delivery :** The procedures for handling, storage packaging and delivery of the product be well established, documented and maintained.
16. **Quality Records :** Identify the features essential to a record document to qualify it as objective evidence on quality. Records shall be legible and identifiable to the product involved.
17. **Internal Quality Audits :** The management shall plan and execute quality audits to verify whether the quality activities comply with planned arrangements and to determine the effectiveness of the quality system.
18. **Training :** Identify the training needs and provide for training of all personnel performing activities affecting quality.
19. **Servicing :** If servicing is specified in the contract the management shall establish and maintain procedures for performing and verifying that servicing meets the specified requirements.
20. **Statistical Techniques :** Where appropriate, the management shall establish procedures for identifying adequate statistical techniques required for verifying the acceptability of process capability and product characteristics.

A 1.8 ISO 9000 QUALITY SYSTEM SERIES

Introduction

- *ISO is the international organisation* for standardisation, set up with the objective to promote the development of standards and related activities, for facilitating *international exchange of goods and services.*
- *ISO 9000 series of standards* developed in 1987, *relate to quality systems.* It has evolved from the standardization of *quality assurance system standards* of several nations all over the world.
- The standards allow a wide flexibility, but, at the same time, are rigid too. They permit a supplier to formulate his own *quality policy* and write the *quality manual*, procedures and instructions in his own way, within the frame work of the system elements, but does not allow rendering of nonconforming products or services.
- For an organization having several good quality systems, ISO 9000 certification is just a step ahead, for others it means a quantum jump, presenting real challenge.

Characteristics of ISO 9000

(i) ISO 9000 can be implemented in any type and size of organization.
(ii) It is independent of the product, size and country.
(iii) It has international acceptance and recognition.
(iv) It ensures consistent improvement in quality.

ISO 9000 series

- There are *five standards* in the ISO 9000 series, ISO 9000-9004.
- ISO 9001, 9002 and 9003 are applicable to *contractual situations.*
- ISO 9004 is for *non-contractual* cases and is used for internal management purpose.

In the *contractual cases,* the *purchaser* contractually requires that certain quality system elements be part of the *supplier's* quality system so that he gets quality products at consistent level. The purchaser wants to make sure that the supplier has the capability to meet contractual requirements.

The same supplier may sell some products in *Contractual situations* and others in *non-contractual situations* where he is not bound by any specific written quality contract; but some standard of quality is even then to be maintained.

	International Standard	*Corresponding Indian Standard*
(1)	ISO 8402 : 1986 Quality—Vocabulary	IS 13999 : 1988 Quality systems—Vocabulary (identical)
(2)	ISO 9000 : 1987 Quality management and quality assurance standards—Guidelines for selection and use	IS 14000 : 1988 Quality systems—Guidelines for selection and use of standards on quality systems (identical)
(3)	ISO 9001: 1987 Quality systems—Model for quality assurance in design/development, production, installation and servicing	IS 14001 : 1988 Quality systems—Model for quality assurance in design/development, production, installation and servicing (identical)
(4)	ISO 9002 : 1987 Quality systems—Model for quality assurance in production and installation	IS 14002 : 1988 Quality systems—Model for quality assurance in production and installation (identical)
(5)	ISO 9003 : 1987 Quality systems—Model for quality assurance in final inspection and test	IS 14003 : 1988 Quality systems—Model for quality assurance in final inspection and test (identical)
(6)	ISO 9004 : 1987 Quality management and quality system elements—Guidelines	IS 14004 : 1989 Quality systems—Guidelines on elements of quality management system (second revision) (Technically equivalent)

ISO 9000 series of standards deal with generic quality principles, the need for an international minimum standard to establish quality control methods not just to control product quality, but also to maintain it. People, today in the world market, want assurance that whether they will get reliable quality for their money.

ISO 9000 is a big success from day one and probably a first of its kind to go beyond nuts and bolts and attempt to address management practices.

ISO 9000

- It is the contour map furnishing the guidelines for selection and use of ISO series standards.
- It gives guidelines for selection and use of quality standards to have quality assurance.

- It provides the basis for the implementation of quality systems and their assessment and verification. In establishing a quality system it is essential that the organisation clearly defines the personnel who are responsible for functions affecting quality.
- The quality system will generally be codified in a series of documents which are commonly known as the **Quality Manual.** All aspects relating to quality should be identified in these documented procedures which should include all references to work instructions and records. The manual should also contain procedures for specific actions which need to be taken as part of the quality control procedure.

ISO 9001 Quality System

It is for *use* when conformance to specified requirements is to be assured by the supplier during several stages which may include design/development, production, installation and servicing.

ISO 9002 Quality System

It is for *use* when conformance to specified requirements is to be assured by the supplier during production and installation.

ISO 9003 Quality System

It is for use when conformance to specified requirements is to be assured by the supplier *solely* at final inspection and test.

- ISO 9001, 9002 and 9003 provide guidelines for external quality-assurance purposes in contractual situations. Therefore purchaser and supplier should refer to these standards to determine which of these standards is most relevant to the contract.

ISO 9004 Quality System

- ISO 9004 provides guidelines on the technical, administrative and human factors affecting the quality of products or services, at all stages of the *quality loop system* (Fig. A-1). In this standard, emphasis is laid on the satisfaction of the customer's need, the establishment of functional responsibilities and the importance of assessing the potential risks and benefits.

  ISO 9004 can be used for internal quality assurance.

  ISO 9004 may deal with quality related cost, quality in marketing, quality in specification and design, quality in procurement, quality in production, quality in documentation and records, corrective action etc.

It is intended that these international standards will normally be adopted in their present form, but on occasions they may need to be tailored for specific contractual situations. ISO 9000 provides guidance on such tailoring as well as selection of the appropriate quality assurance models.

A 1.9 PREREQUISITES FOR IMPLEMENTING ISO 9000 QUALITY SYSTEM

For effectively implementing ISO 9000 Quality systems, any organization must meet the following requirements:

(1) Development of Quality Awareness.
(2) Imparting Education and Training to Employees.

(3) Introduction of Motivation and Incentive Programs.
(4) Development of Measuring Equipments Laboratory.
(5) Development of Planning Scheme for implementation.
(6) Above all, to have firm commitment of top management to fully support the Quality system with a strong will and faith to make it success.

(1) Development of Quality Awareness

Every body in the organization from top to bottom should extend his wilful support to the quality program and make quality as the first policy.
(for details refer page A-5)

(2) Imparting Education and Training to Employees

- The first and most important component of managing quality project is education and training of employees.
- Purposeful education and training to the workforce at different levels is a must in order to make sure that the desired skill is available within the organization to meet International Quality Standards.
- Education and training should be job-oriented and must be an integral part of quality policy, because education and training are the basic requirements on the road leading to quality excellence, quality maintenance and quality improvement.
- Properly planned education and training makes each employee to understand the work to be performed by him. Training puts the education into practice.
- The education and training program should be structured for three levels on the lines of ISO 9004, as explained below:

(a) *Training for executives and managerial personnel*

- Understanding of quality system together with the tools and techniques needed for participation in the operation of the system.
- Understand the criteria to evaluate the effectiveness of the system.
- To make use of employees to achieve the quality targets.

(b) *Training for technical personnel*

Training should be imparted to technical persons in the following fields:
- Process engineering and Product engineering.
- On-line and Off-line quality control techniques.
- Statistical quality control techniques.
- Process capability studies.
- Quality improvement methods.
- Problem identification, problem analysis and corrective action.
- Material and equipment procurement, etc.

(c) *Training to work-force (shop floor) and production supervisors.*

This training should include
- Operation of machines, tools and instruments.

- Reading and understanding the documents provided.
- Relationship of their duties to quality and work place safety etc.

(3) Motivation and Incentive Programs

- Quality systems have clearly recognized the importance of *people* in achieving product quality on a consistent basis. Until and unless the workforce is motivated, the chances of success are not bright.
- The two main programs viz. *Zero Defect program* and *Quality Circles* (refer page 8–45) which enlist the cooperation, assistance and participation of employees to improve product have built-up motivational and incentive programs in them. (For motivation and incentive programs refer pages 19–20 and 30–31 respectively).

(4) Laboratory for Measuring Equipments

- In order to prove that yours is a quality product, you have to measure and control its *quality characteristics*.
- *Quality Characteristics* refer to product parameters (i.e. dimensions, shape etc.) that can be quantitatively assessed/measured by some equipment such as scale, vernier calliper, micrometer, gauges and comparators etc. The measured quality characteristics of a component are then compared with some *standards* and these standards are the foundation for quality. Standards establish the quality of products.

  Therefore, test methods and measuring equipments are extremely important components of quality system.
- A *Metrology and Material Testing Laboratory* is a very important prerequisite to make the Quality System a success.
- **According to ISO 9001 : 1987**
  (a) Identify the product measurements to be made in terms of accuracy required and select the measuring equipment and the appropriate inspection accordingly.
  (b) Accordingly, identify, calibrate and adjust all inspection, measuring and testing equipments those can affect product quality.
  (c) Establish document and maintain calibration procedures including details of equipments, frequency of checks, check method, acceptance criteria and the action to be taken when the results are not satisfactory.
  (d) Ensure the capability of accuracy and precision of the inspection, measuring and test equipments.
  (e) Ensure that environmental conditions are suitable for calibration, inspection, measurement and test being carried out.
  (f) Ensure the handling and storage of inspection, measuring and test equipments so that their accuracy is maintained.

(5) Planning Scheme for Implementation

- **Quality Planning** (ISO 9003 and 9004) is a written document which must be read and understood by every body from top to bottom in the organization before implementing quality systems.

- For projects relating to new products, services or processes, (ISO 9004), management should prepare, as appropriate, written quality plans consistent with all other requirements of a company's quality management system.

Quality Plan should Define

(a) the quality objectives to be attained;
(b) the specific allocation of responsibilities and authority during the different phases of the project;
(c) the specific procedures, methods and work instructions to be applied;
(d) suitable testing, inspection, examination and audit programmes at appropriate stages (for example, design, development);
(e) a method for changes and modification in a quality plan as projects proceed;
(f) other measures necessary to meet objectives.

- **Development Planning** should include the following because without these the *quality plans* cannot be developed:
  (a) Clear cut definition of project and its objectives.
  (b) Organization of project, team structure, contractors, subcontractors etc.
  (c) Project schedule—the tasks to be performed and their time phases.
  (d) How the project is to be managed.
  (e) Development planning needs updating on the basis of feedback.
- **Verification** of each phase of development is a must. The supplier should get verified the output at the end of each phase.

  The verified development output should be submitted to *Configuration Management* and then accepted for subsequent use.
- *Configuration Management* should provide a mechanism for identifying, controlling and tracking the versions of each item being used, and then the status of products in development or delivered and installed.
- **Audit Inspection** provides management with an early view of the product quality. It allows immediate *corrective action*, if any, on the part of supplier, before the product goes into the market and the customer complaints about it.

  During the course of audit, reporting and follow up of audit-findings are essential to make it success.

Corrective Action

(As per ISO 9000 and ISO 9004)

- The implementation of *corrective action* begins with the detection of a quality problem (e.g. materials, components or products non-confirming to quality standards) and involves taking measures to eliminate or minimize the recurrence of such a problem.
- The supplier shall establish, document and maintain procedures for
  (a) investigating the cause of nonconforming product and the corrective action needed to prevent recurrence;
  (b) analysing all processes, work operations, quality records, service reports and customer complaints to detect and eliminate potential causes of non-conforming product;

(c) initiating preventive actions to deal with problems to a level corresponding to the risks encountered;
(d) applying controls to ensure that corrective actions are taken and they are effective.
(e) implementing and recording changes in procedures resulting from corrective action.

Procedure for Corrective Action

(1) The responsibility and authority for instituting corrective action should be defined as part of the quality system.
(2) The significance of a problem affecting quality should be evaluated in terms of its potential impact on production costs, quality costs, safety, reliability etc.
(3) Investigation of possible causes (cause and effect relationship) resulting in non-conforming products should be carried out.
(4) Analysis of problem to determine root cause should be done before planning preventive measures.
(5) In order to prevent a future recurrence of a nonconformity, it may be necessary to change a manufacturing process, packing, storage process, product specification etc.
(6) When the preventive measures are implemented, their effect should be monitored in order to ensure that desired goals are met.
(7) For work-in-process, remedial action should be instituted as soon as practicable in order to limit the cost of repair, reworking or scrapping. Recall finished goods not confirming to quality standards.
(8) Permanent changes resulting from corrective action should be recorded in work instructions, product specifications or the quality system.

A 1.10 INSTALLATION PROCEDURE OF ISO 9000 QUALITY SYSTEM

- Every organization is interested in improving the quality of its completed work, as it has to compete with the best in the World market. Thus it has become quite essential for a company to have a structured and well defined quality system that identifies, documents, coordinates and maintains the necessary quality to meet the customer demands.
- ISO 9000 Quality System is just a model that stipulates certain time honoured quality management practices as guidelines and minimum requirements.
- Therefore every organization, today, is bent upon installing ISO 9000 Quality System.

This system can be installed in several stages, that have to be sequentially undertaken.

The time involved in installation depends upon the size and complexity of the organization.

The basic steps to be followed for ISO 9000 certification are given below:

(1) Quality Awareness training.
(2) Form task force.
(3) Analyse existing practices and corrective action.
(4) Design and develop standard procedures.
(5) Prepare Documentation.
   - Quality manual

- Quality procedures
- Work instructions

(6) Implement the Quality System.
(7) Quality Auditing.
(8) Preliminary Audit by Third party.
(9) Apply for Accreditation.
(10) Maintain the system.

(1) Quality Awareness Training
(Refer page A-5)

(2) Form Task Force

(a) *Strategic* : Management — Quality Policy/Quality Manual.
(b) *Tactic* : Dept. Heads — Quality Procedures.
(c) *Operational* : Supervisors — Work Instructions/Drawings.

(3) Analyse Existing Practices and Corrective action
(As per ISO 9001 : 1987)

- The supplier shall establish, document and maintain procedures for
  (a) investigating the cause of nonconforming product and the corrective action needed to prevent recurrence;
  (b) analysing (*existing practices* i.e.,) all processes, work operations, concessions, quality records, service reports and customer complaints to detect and eliminate potential causes of nonconforming product;
  (c) initiating preventive actions to deal with problems to a level corresponding to the risks encountered;
  (d) applying controls to ensure that corrective actions are taken and that they are effective;
  (e) implementing and recording changes in procedures resulting from corrective action.

Corrective action also presupposes the repair, reworking, recall or scrapping of unsatisfactory material or items (components/products).

(4) Design and Develop Standard Procedures

Standard procedures of manufacturing will have to be developed to fully meet the customer's quality requirements including functional, safety, aesthetic etc., with adequate attention to economy of manufacture.

(5) Prepare Documentation
(As per ISO 9004 : 1987 and IS 14004 : 1989)

- All the elements, requirements and provisions adopted by a company for its quality management system should be documented in a systematic and orderly manner in the form of written policies and procedures.
- Such documentation should ensure a common understanding of quality policies and procedures that is, quality programmes/plans/manuals/records.

- The quality management system should include adequate provision for the proper identification, distribution, collection and maintenance of all quality documents and records.
- The following are *examples* of the types of quality documents requiring control:

(a)	Drawing	(b)	Specifications
(c)	Blue prints	(d)	Inspection instructions
(e)	Test procedures	(f)	*Work instructions*
(g)	Operation sheets	(h)	*Quality manual*
(i)	Operational procedures	(j)	*Quality (assurance) procedures.*

Quality Manual (As per ISO 9004 : 1987)

- The typical form of the main document used in drawing up and implementing a quality system is a *Quality Manual.*
- The primary *purpose* of a quality manual is to provide an adequate description of the quality management system while serving as a permanent reference for implementation and maintenance of that system.
- Procedures should be laid down for making changes, modifications, revisions or additions to the contents of a quality manual.
- In large companies, the documentation relating to the quality management system may take various forms, such as:
  - (i) corporate quality manual;
  - (ii) divisional quality manuals; and
  - (iii) specialized quality manuals (for example, design, procurement, project, work instructions).

In brief, a quality manual includes the quality policy of the company, organisational structure of the quality assurance department, job description of the quality assurance personnels, relationship of the quality control department with other departments, quality control/inspection procedures and documentation (with a copy of every form in use).

Quality Policies and Procedures (As per ISO 9004 : 1987)

- All the elements, requirements and provisions adopted by a company for its quality management system should be documented in a systematic and orderly manner in the form of written *policies* and *procedures*. Such documentation should ensure a common understanding of quality policies and procedures, that is, quality programmes/plans/manuals/records.
- **Quality procedures** instruct the workforce how the quality objectives mentioned in the quality manual can be obtained. Procedures document inter-documental activities, detailing the working and interaction of different sections of the company, for fulfilling the requirements of quality.

  The *procedures specify* what has to be done, by whom, when, where and how will it be done. A common format and a suitable numbering system has to be devised for all procedures. This enables easy identification of individual sections and individual procedures in each section.

Work Instructions

Work instructions deal with a lower level of activities than the *quality procedures*. While procedures describe who does what, work instructions give specific information about the standards of quality to be achieved. The instructions include what has to be done, the proper sequence of work stages, the materials and equipments to be used, the environmental conditions to be maintained, reference/standards to be adhered to and instructions for special processes, if any, like welding, annealing, soldering etc. The instructions also include the recordings, product/process affected, issue and control and authorization of the concerned signatories.

(6) Implementing the Quality System

- Before implementing the quality system, certain pre-requisites are to be met. Such requirements have been discussed on page A-10.
- Implementing the quality system means putting the system into practice in the organization.
- It will be always better to start the implementation, when the *documentation* is ready for use and success is expected. *Education* and *Training* are essential for a successful quality system. The *follow-up action* on the effectiveness of quality system is done by performing *audits*. The audit reports should be followed up, correcting the procedure/process and providing training at all levels. Whenever changes are made in the procedures, the documents also should be amended and have to be controlled, as a part of implementation.

(7) Quality Auditing (ISO 9004 : 1987)

- *Quality Auditing* is independent and objective evaluation of the outgoing product level, as it would be measured and judged from the viewpoint of the customer, whether that customer be the ultimate user, a dealer, the next department or another plant.
- *Quality Audits may be of the following types*
  (a) Internal audits.
  (b) Customer audits.
  (c) Independent third party audits.
- All elements and aspects pertaining to a quality system should be **internally audited** and evaluated on a regular basis. Audits should be carried out in order to determine whether these are effective in achieving stated quality objectives. For this purpose, an appropriate audit plan should be formulated and established.
- **Audit Plan** format should cover the following:
  (a) Specific activities and areas to be audited;
  (b) Suitability of personnel carrying out audits;
  (c) The basis for carrying out audits (for example, organizational changes, reported deficiencies, routine checks and surveys); and
  (d) Procedures for reporting audit findings, conclusions and recommendations.
- **When Carrying out the Audit**, objective evaluation of quality system elements by competent personnel may include the following activities or areas:
  (a) Organizational structures;

(b) Administrative and operational procedures;
(c) Personnel, equipment and material resources;
(d) Work areas, operations and processes;
(e) Items being produced (to establish degree of conformance to standards and specifications); and
(f) Documentation, reports and record keeping.

- **Personnel Carrying out Audits** of quality system elements should be independent of the specific activities or areas being audited.
- Audit findings, conclusions and recommendations should be submitted in documentary form for consideration by appropriate members of the management.

The following points should be covered in the **reporting and follow-up of Audit findings:**

(a) Specific examples of noncompliance or deficiencies should be documented in the audit report, possible reasons for such deficiencies, where evident, may be included;
(b) Appropriate corrective action may be suggested; and
(c) Implementation and effectiveness of corrective actions suggested in previous audits should be assessed.

(8) Third Party Audit

A third/external party assessment is carried out by an independent body to establish the extent to which an organization meets the requirements of an applicable standards or set of regulations.

- Third party can assess an organization against any quality standard but the concentration here is given on ISO 9000 : 1987 against which assessment can be made. It is an independent audit body which would normally issue a *certificate of registration*, indicating acceptance of the organization as *A Company of Assessed Capability* i.e., witness to the world that this assessed organization complies with all the requirements of ISO quality standards.

(9) Accreditation

The next step for the organisation is to apply for Accreditation.

- The National Accreditation Council for Certification Bodies (NACCB) funded by Department of Trade and Industry (DTI) is responsible for the accreditation and supervision of *Certification Bodies* in U.K. An accredited certification body issues the *Crown and Tick logo* only after certification within its accredited scope. Some bodies have accreditation in a wide range of activities and they assess organizations to ISO standards.
- After, an assessment by an independent audit body is successfully concluded, the *certification body* will issue a certificate, attached to which is a definition of the scope of activities which have been assessed.
- A few *Accredited Certification Bodies* are
  (a) ASTA Certification Services, Prudential Chambers, 23/24 Market Place, Rugby CV 21 3 DT.
  (b) Lloyd's Register Quality Assurance Limited, Norfolk house, Wellesley Road, Croydom CR 9 2 DT.

(c) Bureau Veritas Quality International Limited, 3rd floor, 70 Borough High Street, London SE1 1XF.

- Certification bodies carry out assessments in accordance with documented procedures. Most of the certification bodies are always prepared to issue copies carrying informations regarding registration.

(10) Maintain the System

- The Quality system is to be reviewed periodically by the *management*, by performing *internal audits* and taking corrective actions where necessary based on audit reports, thus streamlining the system.
- The *Certification body* also maintains some system of monitoring to ensure continued compliance with the standard.

  Monitoring the quality system needs to have a system of regular, unannounced audits, reassessment at regular intervals, etc.

A 1.11 INDIAN STANDARD ON QUALITY SYSTEMS

The Bureau of Indian Standards recognized the importance of preparation of Indian Standards on quality systems. Therefore, an Indian Standard manual on quality assurance system, IS 10201 was published in 1982 which describes a basic set of quality elements by which quality management systems could be developed and implemented within an organization. After the publication of International Standards on Quality Systems, BIS adopted these as IS 14000 series of Standards.

(1) IS 13999 : 1988

This standard defines basic and fundamental terms relating to quality concepts, as they apply to products and services, for the preparation and use of quality standards and to facilitate mutual understanding in international communication. The terms defined in this standard have a direct application to all Indian Standards in the series on quality systems (IS 14000).

(2) IS 14000 : 1988

This standard provides the guidelines for the selection and use of series of Indian Standards on quality systems that can be used for internal quality management (IS 14004) as well as external quality assurance purposes (IS 14001), (IS 14002) and (IS 14003). It clarifies the relationship among various quality concepts and specifies the rules for using the three models given in IS 14001, IS 14002 and IS 14003. IS 14000 introduces the notion of degree of demonstration concerning the adequacy of the quality systems and the conformity of the product with the specified requirements. A cross reference list of quality system elements has also been included as an annexure to the Standard.

(3) IS 14001 : 1988

This standard is applicable when conformance to specified need is to be assured by the supplier throughout the whole cycle—from design through to servicing. It is used when the contract specifically requires design effort and the product requirements are stated (or need to be

stated) principally in performance terms. This standard represents the fullest requirements, involving all the quality system elements detailed in IS 14000 at their most stringent.

(4) IS 14002 : 1988

This standard is for use when the specified requirements for products are stated in terms of an already established design or specification. Only the supplier's capabilities in production and installation are to be demonstrated. All the quality system elements listed in IS 14000 : 1990 except 'design' and 'after sales service' are present but some are treated less stringently.

(5) IS 14003 : 1988

This standard applies to situations where only the supplier's capabilities for inspection and tests (conducted on the product as supplied) can be satisfactorily demonstrated. In this standard, only half of the quality system elements of IS 14000 : 1990 are required, and at a lower level of stringency than for IS 14002 : 1990.

(6) IS 14004 : 1991

This standard, together with IS 14000, provides guidance to all organizations on quality management. Each of the quality system elements listed in IS 14000 : 1990 has been explained in 14004.

The standard helps in developing and implementing a quality system as also determining the extent to which each quality element is applicable. It also provides guidance on the technical, demonstrative and human factors affecting the quality of products or services at all stages — from detection of customer's needs to their satisfaction. Throughout this standard, emphasis is placed on the satisfaction of the customer's needs and establishment of functional responsibilities. The object is to minimize the cost of the quality project while maximizing the benefits.

(7) IS 14004 (Part 2) : 1992

Quality and customer satisfaction are important subjects receiving increasing attention worldwide. The creation and maintenance of quality in an organization is dependent upon a systematic approach to quality management aimed at ensuring that customer needs are understood and met. The achievement of quality necessitates a commitment to quality principles at all levels in the organization and continual review and improvement of the established system of quality management based on feedback of the customer's perception of the service provided.

The successful application of quality management to a service provides significant opportunities for

- improved service performance and customer satisfaction,
- improved productivity, efficiency and cost reduction, and
- improved market share.

To achieve these benefits, a quality system for services should also respond to the human aspects involved in the provision of a service by

- managing the social processes involved in a service,
- regarding human interactions as a crucial part of service quality,
- recognizing the importance of a customer's perception of the organization's image, culture and performance,

— developing the skills and capabilities of personnel, and

— motivating personnel to improve quality and to meet customer expectations.

This standard gives guidance for establishing and implementing a quality system within an organization. It is based on the generic principles of internal quality management described in IS 14004 : 1991 and provides a comprehensive overview of a quality system specifically for services.

This standard can be applied in the context of developing a quality system for a newly offered or modified service. It can also be applied directly when implementing a quality system for an existing service. The quality embraces all the processes needed to provide an effective service, from marketing to delivery, and includes the analysis of service provided to customers.

The concepts, principles and quality system elements described are applicable to all forms of service, whether solely of a service character or in combination with the manufacture and supply of a product.

A-2 FACTORS AFFECTING PLANT LAYOUT

— *Plant layout* shows the physical relationships between the plant and its equipment, workers, machines, workbenches etc.

The factors affecting plant layout are

(1) The components/products to be manufactured.

(2) The volume of production and hence the volume of raw material and inprocess inventory to be handled.

(3) The operations needed to be done on each component, sub assemblies and assemblies.

(4) The assembly relationship between the components and subassemblies of each product.

(5) The type, size and capacity of machines required for each operation and to be installed (layout) in the plant.

(6) Location of manufacturing areas for individual components, subassemblies and assemblies.

(7) Movement of material handling equipments.

(8) Characteristics and requirements of auxiliary services (e.g. compressed air, steam, standby electricity etc.) necessary for production to proceed.

A-3 ROLE OF MANAGEMENT

Given below are the roles of management which a manager has to fill :

A. *Interpersonal roles*

1. The figure head role (performing ceremonial and social duties)
2. The leader role
3. The liaison role (particularly with outsiders)

B. *Informational roles*

1. Receiving information about the operation of an enterprise.
2. The disseminator role (passing information to subordinates).
3. The spokesman role (transmitting information outside the organization).

C. *Decision roles*

1. The entrepreneurial role

2. The disturbance - handler role.
3. The resource allocator role.
4. The negotiator role (dealing with various persons and groups of persons)

A-4 PHILOSOPHY OF MANAGEMENT

— Executives (Managers) in a specific firm operate with some type of *philosophy*, regardless of whether they have studied their philosophical heritage.

— Furthermore, they may not consider consciously the broad structure of ideas that influence their decisions, let alone make explicit the elements of this philosophy to others. If they attempt to write down the basic elements, their statements tend to appear vague and general. Even though it may be difficult to verbalize these basic ideas, the attempt to understand the moral issues involved in managerial activities provides a broad framework that gives meaning to day-to-day actions.

— *Philosophies* differ among firms. *One philosophy* might be good for Firm A but not useful to Firm B. In this connection **philosophy of management** refers to those general concepts and integrated attitudes that are fundamental to the cooperation of a social group. These concepts and attitudes evolve into the particular way in which the firm perceives itself.

— Generally, the **philosophy** of a given firm can be learned only through close and continuous association with it. It is uniquely determined for the individual firm and is affected by a group of factors that, together may be called the concept of the firm. The concept of the firm is the total of how the firm got where it is, the place it occupies in the industry, its strengths and weakness, the view points of its managers, and its relationship to social and political institutions.

A-5 FEASIBILITY STUDY

— *Development of a project involves following steps* :

(1) Feasibility study
(2) Analysis
(3) Design
(4) Programming and testing
(5) Implementation
(6) Post implementation support

These are the major sub-divisions of any project and each must be formally acknowledged by the client (or user) before starting out on the development. Authorization will be required at each stage prior to moving on to the next.

— **Feasibility study** is carried out in order to assess the viability of a new project.

A number of difficult questions need to be answered, such as :

* Is the envisaged system worth developing ?
* Will the system improve efficiency ?
* Will the system improve productivity?
* Will the system facilitate a reduction in staff ?
* Will the system provide faster, better management information to enable better business decisions to be taken?
* Will the system ultimately save the enterprise money or make it more profitable?

* What will the system cost to develop and to operate and can it be justified?
* Will the system be acceptable to the staff using it on a day-to-day basis?
* How will the system affect the enterprise's organization?

— In any feasibility assessment, these major policy considerations need to be evaluated as early as possible as they may well have an over-riding influence on the shape of proposed new design.

— The importance of conducting a thorough *feasibility study* and beginning the development process in a slow and carefully controlled way is to be emphasized. This point is reiterated here.

— Typically, it is the project leader's responsibility to carry out a feasibility assessment and he will, in consequence, have to live with the results of his work throughout the lifetime of the project.

— It is well worth making sure, therefore, that all interested people and departments have been involved in the feasibility assessment and that some measure of agreement has been reached as to the general direction of the project. All decision-makers need to be kept informed of progress on a regular basis, and the project initiator needs to keep in touch with the feasibility study on a day-to-day basis. The danger of too much involvement, however, needs to be borne in mind.

— The *objective* of the feasibility assessment is to answer the question 'Is it worth spending money on a systems investigation for this project or is it clearly a non-starter?

— While the overall feasibility assessment will include an *evaluation of* the *technical and social acceptability of the project*, it is usual to find that *financial feasibility* far outweighs these other two considerations.

— *Financial feasibility* must not be interpreted simply as the cost in terms of hardware and manpower resources needed to develop the system. These are one-time costs which while clearly playing an important part in the feasibility assessment, are only part of the total cost of the new system. The impact of the final system on the business must be assessed.

Typical questions that may be asked at this time are :

* Will the new system allow more work to be processed without an increase in costs?
* Will the client be able to reduce overhead costs and still maintain the same level of output?
* Can new product lines be introduced into the system more easily?
* Will better management control be available to enable the client to plan the use of the company's resources better than before?

— A good feasibility assessment needs to be able to answer these basic business questions. In short, the *justification* for any new capital outlay must be that it will *increase the profit* of the enterprise, *improve the quality* of service or products which are the business of the enterprise, or *reduce expenditure*. New system developments will therefore be justified by *cost and benefit criteria* that ensure that projects which give the best return, according to the enterprise's policies, are those which are carried out first.

— The assessment of *technical feasibility* is clearly based on preliminary outline systems design ideas relating to what can be accomplished with existing or imminently available technology. At times of rapid technological change, this is clearly a difficult process and it is not unknown for many systems developments to be started with only a hazy idea of the detailed technology that will be used to secure their implementation.

— The assessment of *social feasibility* is assuming greater importance now than earlier. This is due to the inroads that new systems are making on the work practices of end users and the growing realization among employee organizations of the need to negotiate new technology agreements with employers.

— The culmination of the *feasibility study stage* is the production of the *feasibility study report, which* is presented to the client or user. The structure of a *typical report* is shown in Table A-1, together with an outline of the contents. The project leader will secure commitment to the proposal set out in the feasibility study report from the user or the client, and this commitment and the general agreement reached will be documented. Assuming, then, that the project is to go ahead, the feasibility study stage truly concludes with the preparation of the terms of reference for the next stage – investigation and analysis.

— From the project leader's point of view, the *feasibility study* is probably the most difficult to manage as quantitative measures of progress are difficult to establish and to monitor. The data on which conclusions and recommendations are based is often scanty or speculative. The task of identifying and quantifying benefits in terms that senior management can readily understand and accept is difficult. Costing at this stage can only be considered budgetary and there is always the danger that they become embedded in management's minds so that subsequent phases of the project are judged against these early estimates rather than the more accurate costing derived as the project progresses. The project leader should protect himself from such constraints by including suitable caveats in his feasibility report and getting the necessary authorizing signatures.

TABLE A-1 Feasibility Study Report Structure

STRUCTURE
Identification of Report
Management Summary
Introduction
Existing System Outline
Definition of Management Requirements
Review of Alternative Solutions
Proposed Solution
Development and Implementation
Back-up Resources
Action Plan
Conclusion

CONTENTS

The front page should specify :

* the project title
* the project reference number
* the date of issue
* the authorizing signatory (ies)
* the distribution of the report

— Financial institutions, which provide the bulk of long-term finance for industrial projects, consider debt service coverage ratio (DSCR) as an important index of financial viability. DSCR is defined as

$$\frac{\text{Profit after tax} + \text{Depreciation} + \text{Interest on term loans}}{\text{Interest on term loan} + \text{Loan repayment instalment}}$$

DSCR is calculated for each year of the currency of the loan and for the entire period of the loan. A DSCR of 1.5 or 2.0 is considered satisfactory.

— The *net present value* of a project is equal to the sum of the present value of all the cash flows (outflows and inflows) associated with the project. A project is acceptable if its net present value exceeds zero.

— The *net present value method* assumes that the intermediate cash inflows of the project are reinvested at a rate of return equal to the firm's cost of capital.

— The *net present value criterion* has a sound rationale underlying it: When the net present value is maximised, you reach the highest consumption frontier.

— There are two measures of *benefit cost ratio*. The first measure is:

$$\frac{\text{Present value of benefits}}{\text{Initial investment}}$$

The second measure is :

$$\frac{\text{Present value of benefits} - \text{Initial investment}}{\text{Initial investment}}$$

— A project is acceptable if the benefit cost ratio, as per the first measure, exceeds 1. (An equivalent decision rule is: Accept a project if its benefit cost ratio as per the second measure, exceeds 0).

— The *Internal rate of return* of a project is the discount rate which makes net present value equal to zero. A project is acceptable is its internal rate of return exceeds the cost of capital.

— There are two possible *economic interpretations* of internal rate of return (i) Internal rate of return represents the rate of return on unrecovered investment balance in the project. (ii) Internal rate of return is the rate of return earned on the initial investment made in the project.

— If the cash flow stream of a project has multiple changes of sign there may be more than one internal rate of return.

— The *annual capital charge* of an investment is the cost on an annual basis of the initial outlay and operating costs associated with that investment. This method is helpful in choosing between alternatives which provide similar services but have differing patterns of costs associated with them.

— A *wide variety of measures* are used in practice for appraising investments. These include measures suggested by capital budgeting literature and several non-standard measures.

— The *most commonly used method* for evaluating small-sized investments is the payback method. For larger investments, accounting rate of return, and, in more recent years, discounted cash flow methods, are commonly employed.

Types of Appraisal

Broadly, four types of appraisal may be conducted while evaluating an investment project.

* Market appraisal
* Technical appraisal

* Financial appraisal
* Economic appraisal

Market Appraisal

Market appraisal is concerned primarily with two questions:

* What would be the aggregate demand of the proposed product/service in future?
* What would be the market share of the *project under appraisal*?

To answer the above questions the market analyst requires a wide variety of information and appropriate forecasting methods. The kinds of information required are:

— Consumption trends in the past and the present consumption level
— Past and present supply position
— Production possibilities and constraints
— Imports and exports
— Structure of competition
— Cost structure
— Elasticity of demand
— Consumer behaviour, intentions, motivations, attitudes, preferences, and requirements
— Distribution channels and marketing policies in use
— Administrative, technical, and legal constraints

Technical Appraisal

Appraisal of the technical and engineering aspects of a project needs to be done continually when a project is formulated. Technical appraisal seeks to determine whether the prerequisites for the successful commissioning of the project have been considered and reasonably good choices have been made with respect to lactation, size, process, etc. The important questions raised in technical appraisal are:

— Whether the preliminary tests and studies have been done or provided for?
— Whether the availability of raw materials, power, and other inputs have been established?
— Whether the selected scale of operation is optimal?
— Whether the production process chosen is suitable?
— Whether the equipment and machines chosen are appropriate?
— Whether the auxiliary equipments and supplementary engineering works have been provided for?
— Whether provision has been made for treatment of effluents?
— Whether the proposed layout of the site, buildings, and plant is sound?
— Whether work schedules have been realistically drawn up?
— Whether the technology proposed to be employed is appropriate from the social point of view?

Financial Appraisal

Financial appraisal seeks to ascertain whether the proposed project will be financially viable in the sense of being able to meet the burden of servicing debt and whether the proposed project will satisfy the return expectations of those who provide capital. The aspects looked into while conducting financial appraisal are:

— Investment outlay and cost of project

- Means of financing
- Cost of capital
- Projected profitability
- Break-even point
- Cash flows of the project
- Investment worthwhileness judged in terms of various criteria of merit
- Projected financial position and flows
- Level of risk

A-7 PROJECT FINANCING

The term *project financing* describes a variety of financing arrangements for large, individual investment projects. Often a separate legal entity is formed to own the project. Suppliers of capital then look at the earnings stream of the project for repayment of their loan or for the return on their equity investment. Often, the projects involve energy: not only large explorations of gas, oil, and coal but also tankers, port facilities, refineries, and pipelines. Other projects include mineral extraction operations, aluminium plants, fertilizer plants, and very importantly power plants. An example of the latter is a cogeneration project.

Projects of this sort require huge amounts of capital, often beyond the reach of a single company. Many times a consortium of companies is formed to spread risk and to finance the project. Part of the capital comes from equity participations by the companies, and the rest comes from lenders or lessors.

If the loan or lease is on a nonrecourse basis, the lender or lessor pays exclusive attention to the size of the equity participation and to the economic feasibility of the project. In other words, the lender or lessor can look only to the project for payout, so the larger the equity cushion and the greater the confidence that can be placed in the projections, the better the project. In another type of arrangement, each sponsor may guarantee its share of the project's obligation. Under these circumstances, the lender or lessor places emphasis on the credit worthiness of the sponsors as well as the economic feasibility of the project.

For the sponsors of the project there are several types of sharing rules. In a *take-or-pay* arrangement, each sponsor agrees to purchase a specific percentage of the output of the project and to pay that percentage of the operating costs of the project plus debt-servicing charges.

This obligation exists whether or not output actually occurs. When pipelines are involved, the type of sharing rule is frequently a *throughput* arrangement. Here each sponsor is required to ship through the facility a certain amount or percentage, of product. If the total shipped is insufficient to cover the expenses of running the facility, sponsors are assessed additional amounts to cover the shortfall. The amount of assessment is proportional to their participation.

The maturity of the loan or lease corresponds to the likely ability of the project to general cash over time. Although the financing need not be long term, in most cases it extends over a period of eight or more years.

In this type of arrangement, the lender or lessor has limited recourse to the project's sponsors in the sense of being assured of minimum cash flows.

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