Laboratory Manual

IC ENGINE & AUTOMOBILE LAB

for

B. Tech.
Mechanical Engineering

Department of Mechanical Engineering

Rukmani & Sons

Brij Bhooshan Education Web Portal
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Prepared by

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LABORATORY OBJECTIVE

IC engine and automobile lab deals with the techniques to control the environments of the living and non-living subjects and thus provide them comforts to enable them to perform better and have longer lives.

For performing this, it is very essential that an engineer should be well conversant with fundamental principles, concepts, devices and systems based on, IC engine and automobile.

By conducting the experiments in this laboratory as per this manual, following objectives will be fulfilled:

- Theoretical concepts of internal combustion engine by performing practical
- Carry out fault finding in engines, suspension and cooling systems
- Undergo the repair and maintenance of such systems
- Conduct the trials on automobile equipment
- Get acquainted with the latest know-how of the automobile field
- Get knowledge about technologies such as sensors used in automobiles

ABOUT THE LABORATORY

This lab mainly contains suspension system, braking system, differential and other working models of automobile.

This laboratory contains the following setups and models:

1. Types of carburetors
2. Two stroke petrol engine
3. Hydraulic braking system
4. Synchromesh gear box
5. Fuel supply system
6. Lighting system
7. Ignition system
8. Steering with hub and wheels

GUIDELINES FOR TEACHERS/TECHNICAL ASSISTANTS

1. Know the laboratory: The teacher is expected to understand the layout of laboratory, specifications of equipments/instruments/materials, procedure of experiments, method of working in groups, planning time etc.
2. Ensure that required equipments are in working condition before start of experiment and also keep the operating or instruction/user manuals of equipments/instruments and this laboratory manual available.
3. On the first day of the lab, inform the students about the importance of subject/laboratory, various equipments/instruments that will be used in the lab etc. Also instruct them how to make the practical record file for this lab.
4. Explain the theoretical concepts, relevant to the experiment, to the students before start of each practical.
5. Demonstrate the experiment(s) clearly to the students group-wise.
6. Instruct the students to perform the practical. While taking reading/observation, each student must get a chance to perform or observe the experiment.
7. If the experimental setup has variations in the specifications of the equipment, the teachers are advised to make the necessary changes.
8. Teacher shall assess the performance of students by observation or by asking viva related questions to the students to tap their achievements regarding related knowledge/skills so that students can prepare accordingly.
9. The teacher must check carefully and sign the practical record file of the students periodically.
10. Teacher shall ensure that the industrial/site/plant visits recommended as per the syllabus of laboratory are covered.
11. Teacher should ensure that the respective skills and competencies are developed in the students after the completion of the practical exercise.
12. Teacher may provide additional knowledge and skills to the students albeit not covered in the manual but are expected from students by the industries.
13. Teacher may suggest the students to refer additional related literature of the technical papers, reference books, seminar proceedings etc.
14. Teacher can organize group discussions/brain storming sessions/seminars to facilitate the exchange of practical knowledge amongst the students.

GENERAL PRECAUTIONS AND SAFETY PROCEDURES

1. Teacher/technical assistant must ensure that all the electrical equipments/ instruments are used and periodically performance tested as per manufacturer's recommendations (permissible electrical and ambient temperature ratings).
2. Before use, the electrical equipment, extension cords, power tools etc. must be inspected for any damage (worn insulation, bent/missing pins, etc.). Any equipment found to be damaged or otherwise unsafe must be removed from service.
3. The mains plug of equipments must only be inserted in a socket outlet provided with a protective earth contact.
4. **WARNING**: The protective earth connection inside or outside the equipments/instruments must NEVER be interrupted or tampered. **IT CAN MAKE THE EQUIPMENT DANGEROUS**.
5. If an instrument shows visible damage or fails to perform the intended measurements, it is likely that the protection has been impaired. In such case the instrument must be made inoperative and the necessary repairs should be carried out.
6. Extension cords or power strips must not be plugged into one another so as to increase the overall reach.
7. Report all problems with building electrical systems to the teacher/technical assistant/maintenance for corrective action.
8. In case of any electrical hazard/fire reach out for the nearest fire-extinguisher or sand and use it for putting out the fire. Report immediately to the teacher/ technical assistant nearby.
9. For reasons of safety, every student must come to the laboratory in shoes (covering the whole feet).
10. Avoid wearing garments with loose hanging parts. The students should also ensure that floor around the equipment/machine is clear and dry (not oily) to avoid slipping. Please report immediately to the lab staff on seeing any coolant/oil spillage.
11. The student should take the permission and guidance of the lab staff/teacher before operating any equipment/machine. Unauthorized usage of any machine without prior guidance may lead to fatal accidents and injury.
12. The student will not lean on the equipment/machine or take any kind of support of the machine at any point of time.

INSTRUCTIONS FOR STUDENTS

1. Listen carefully to the lecture and instructions given by the teacher about importance of subject/laboratory, curriculum structure, skills to be developed, information about equipment and instruments, procedure, method of continuous assessment, tentative plan of work in laboratory and total amount of work to be done in the semester/session.
2. Read and understand the theory of each experiment to be performed, before coming to the laboratory.
3. Understand the purpose of experiment and its practical implications. Observe carefully the demonstration of the experiment. When you perform it, organize the work in your group and make a record of all observations.
4. In case of absence, the student must perform the experiment(s) on the next turn or in his/her spare time with permission from the teacher/lab assistant.
5. Student should not hesitate to ask any difficulty faced during conduct of practical/exercise.
6. The student shall study all the questions given in the laboratory manual or asked by the teacher and know the answers to these questions properly.
7. The required instruments/tools will be issued from the laboratory store. They must be returned to the store on the same day at the end of lab hours.
8. Laboratory reports (practical file) should be submitted in a bound file or on A4 size sheets, properly filed, on the next turn completed in all respects i.e. with experiment(s) written, graphs attached (if applicable) and entries made in the list of contents of the file and get them checked from your laboratory teacher. Laboratory reports have associated grades/marks.
9. Student should not bring any food or drink item to the laboratory.
10. Student should develop habit of group discussion related to the experiments/exercises enabling exchange of knowledge/skills.
11. Student shall gain knowledge and develop required practical skills and competencies as expected by the industries.
12. Student shall develop the habit of evolving more ideas, innovations, skills etc. than included in the scope of the manual.
13. Student shall refer technical magazines, proceedings of the seminars; refer websites related to the scope of the subjects and update their knowledge and practical skills.

EXPERIMENT – 1

OBJECTIVE:

To study constructional details and prepare layout of four wheel drive line

EQUIPMENT:

A working or non working model of Layout of an Automobile.

THEORY:

Components of an Automobile

Basic Structure:

This is the unit on which are to be built the remainder of the units to turn it in to a power operated vehicle. It consist of frame, suspension system, axles, wheels and tyres.

Frame: There are two distinct forms of construction

1. The conventional pressed steel frame to which all the mechanical units are attached and on which the body is superimposed.
2. The integral or frameless construction, in which the body structure is so designed as to combine the functions of body and frame, the units normally attached to the frame being attached directly to the body. Frameless construction is possible only in case of a closed car, since the roof, screen pillars; door pillars and rear panel are essential load taking parts of structure.

Suspension System: Functions of suspension systems are

1. To prevent the road shocks from being transmitted to the vehicle components
2. To safeguard the occupants from road shocks
3. To preserve the stability of the vehicle in pitching or rolling, while in motion there are two types of suspension systems
   I. The conventional system, in which the springs are attached to a rigid beam axle
   II. The independent system, in which there is no rigid axle beam and each wheel, is free to move vertically without any reaction on the other wheel.

Axles: The weight carrying portions of the axles , whether it may be front or rear, may be considered as beam supported at the ends , loaded at two intermediate points and subjected to following loads

1. The vertical load at the spring centers due to which the weight of the vehicle.
2. A fore and aft load at the wheel centre due to driving or braking effort
3. Torque reactions due to the drive or brakes.
4. A side thrust at the radius of the tyre due to centrifugal force when rounding a curve.

Wheels: Wire spooked wheels have been used mainly on sports cars, primarily on account of their light weight and quickness in changing the wheel .However the pressed steel wheel has displaced these all ordinary purposes. Such a wheel consist of a central flanged disc pressed in to a rolled section rim retained I n position by welding. Light alloy wheels are currently used in case of luxury and sport cars.

Power Plant:

The power plant provides the motive power for all the various functions which the vehicle or any part of it, may be called upon to perform. The power plant generally consists of an internal combustion engine which may be either of spark-ignition, or of compression ignition type.

Transmission System:

Functions of transmission system are

1. To disconnect the engine from the road wheels when desired
2. To connect the engine to driving wheels without shock
3. To vary the leverage between the engine and the driving wheels
4. To reduce the speed permanently in a fixed ratio
5. To turn drive through a right angle
6. To make a provision such that the driving wheels may rotate at different speeds while taking turns.

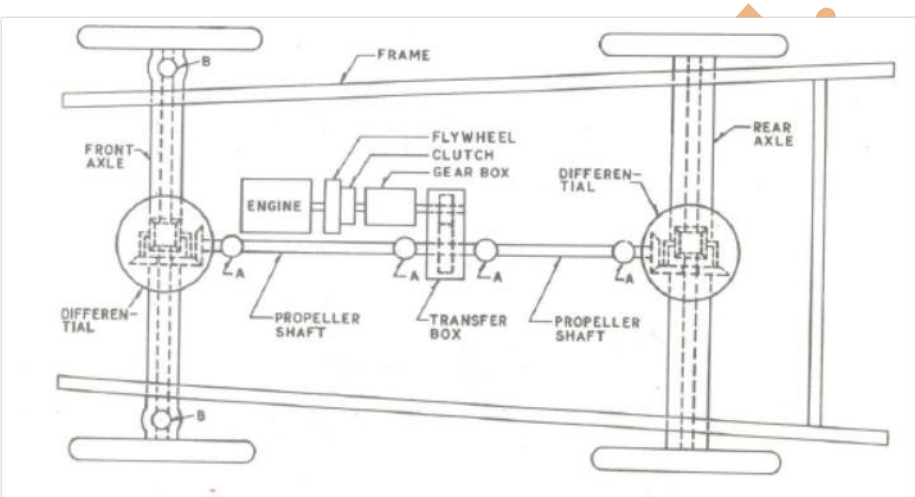
Clutch: Its purpose is to enable the driver to disconnect the drive from the road wheels instantaneously and to engage drive from the engine to the road wheels gradually while moving the vehicle from rest.

Gear Box (Transmission): The gear box or transmission provides the necessary leverage variation between the engine and road wheels.

Bevel pinion and crown wheel: They turn the drive through 90 and also provide a permanent reduction in speed. The permanent reduction is necessitated because of the fact that speed of engine has to be maintained at optimum level at all times, yet a minimum value of torque has to be made available at the road wheels.

Universal joint: They provide for the relative movement between the engine and the driving wheels due to flexing of road springs.

Differential: While taking turns, the driving wheels must run at different speeds. This is done with the help of differential. Instead of using the long propeller shafts and transmitting the power from engine to the rear axle, a number of alternative methods have been used.



EXPERIMENT - 2

OBJECTIVE:

To study construction of single plate and multi plate clutches and draws sketches.

EQUIPMENT:

Models of clutches

THEORY:

Introduction:

The power developed by the engines is delivered to the driving wheels of the automobile by the power train. The transmission is the major part of the power train. In the manual transmission, clutch is a device used to connect and disconnect engine power flow to the transmission the will of the driver. The driver operates the clutch via a clutch pedal inside the vehicle.

When the clutch pedal is depressed, the three main clutch assembly components – flywheel, friction disc and pressure plate are disengaged, interruption of the power flows. As the clutch is release, the pressure plate moves closer to the clutch disc.

Functions of Clutch:

1. To permit the engagement or disengagement of a gear when the vehicle is stationary and engine is running.
2. To transmit the engine power to the road wheels smoothly without shock / jerk to the transmission system.
3. To permit the engaging of gears when the vehicle is in motion without damaging the gear wheels.

WORKING PRINCIPLE:

The working principle of clutch is based on friction .When the two friction surfaces are brought in contact with each other and pressed they are united due to friction between them. If no one is resolved, the other will also resolve. One surface is considered as a driving member and other as driven member. The driving member is kept rotating. When the driven member is brought in contact

with the driving member, it is also starts rotating .When the driven member is separated from the driving member, and it stops revolving. The driving member of clutch is the flywheel mounted on crankshaft, the driven member is a pressure plate mounted on the transmission shaft.

Single Plate Clutch:

This is the common type of clutch used in automobile. It consists of two member flywheel and pressure plate. The flywheel is mounted on engine crankshaft and rotates with it. The pressure plate is bolted to the flywheel through clutch springs and is free to slide on the clutch shaft when the clutch pedal is operated. Single plates clutch has only one clutch plate, mounted on the splines of the clutch shaft. The clutch pedal is used to engage or disengage the clutch.

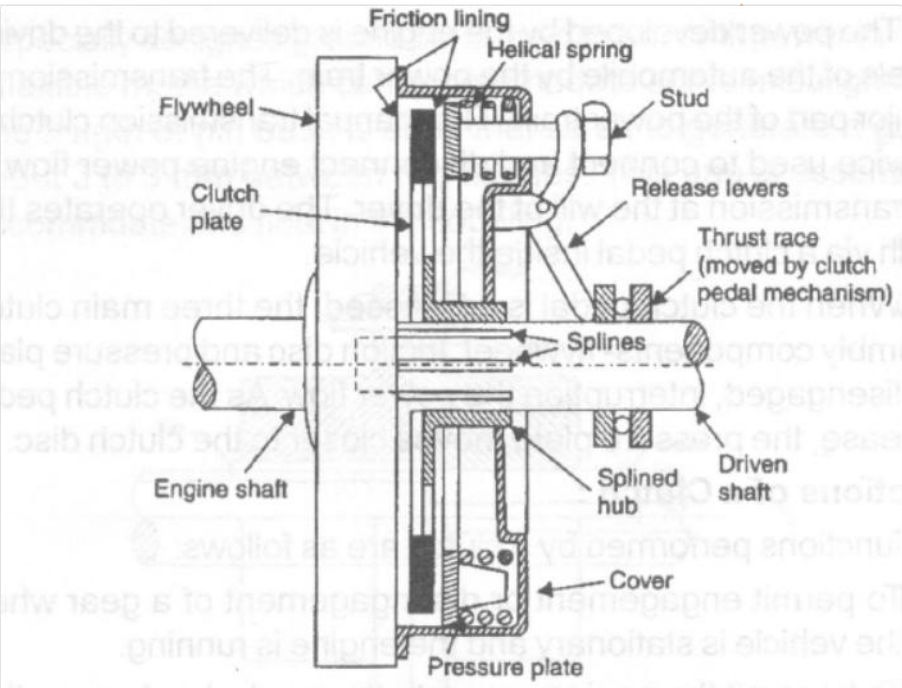


Fig. 2.1 Single Plate Clutch

When the clutch is engaged, the clutch plate is gripped between the flywheel and pressure plate. The friction linings are provided on both sides of the clutch plate. Due to friction between the flywheel, clutch plate and pressure plate, the clutch plate revolves with the flywheel. As the clutch plate revolves, the clutch shaft also revolves, which is connected to the transmission. Hence, the engine power is transmitted through the crankshaft to the clutch shaft. When the clutch pedal is pressed, the pressure plate moves back against the force of the springs and the clutch plate becomes free between the flywheel and the pressure plate. Thus the flywheel keeps rotating as long as the engine is running. As soon as the clutch

pedal is pressed, the clutch is said to be disengaged, otherwise it remains engaged due to the spring forces.

Multiplate Clutches:

A multiplate clutch consists of more than one clutch plate. As the numbers of clutch plates are increased, the friction surface also increases. The increased number of friction surfaces increases the capacity of the clutch to transmit torque. The plates are alternately fitted to the engine shaft and gear box shaft. They are firmly pressed by the strong coil springs and assembled. Each of the alternate plate slides on splines on the pressure plate. A multiplate clutch works in the same way as a single plate clutch while the flywheel is rotating, the pressure plate rotate and press against the friction plate. This causes the clutch plate to rotate, which in turn rotate the clutch shaft. When the pedal is pressed, the flywheel continues to rotate but the clutch plate is released. This happens because they are not fully pressed by the pressure plates. Thus the clutch shaft also stops rotating. A multiplate clutch may be dry or wet. When the clutch is operated in an oil bath, it is called as a wet clutch. When the clutch is operated dry, it is called dry clutch.

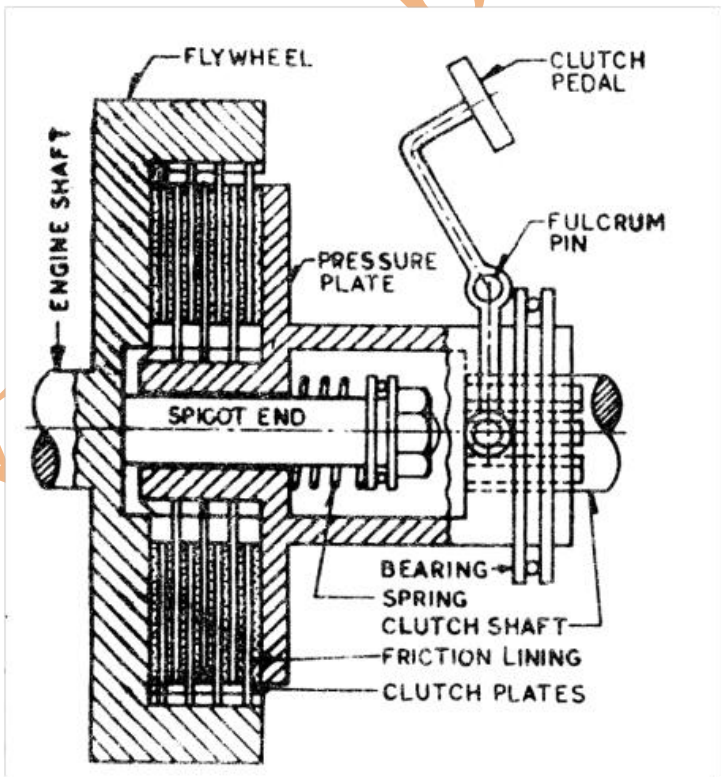


Fig. 2.2 Multi Plate Clutch

EXPERIMENT 3

OBJECTIVE:

To study construction of diaphragm type clutch and draw sketches.

THEORY:

Working Principle and Operation

A simplified sketch of a single plate clutch is given in Fig 3.1. Friction plate is held between the flywheel and the pressure plate. There are springs (the number may vary, depending upon design) arranged circumferentially. which provide axial force to keep the clutch in engaged position. The friction plate is mounted on a hub which is sphned from inside and is thus free to slide over the gear box shaft. Friction facing is attached to the friction plate both sides to provide two annular friction surfaces for the transmission of power. A pedal is provided to pull the pressure plate against the spring force whenever it is required to be disengaged. Ordinarily it remains in engaged position as is shown in Fig. 3.1.

When the clutch pedal is pressed, the pressure plate is moved to the right against the force of the springs. This is achieving by means of a suitable linkage and a thrust bearing. With this movement of the pressure plate, the friction plate is released and the clutch is disengaged.

In actual practice the construction of the clutch differs. The pressure plate, the springs, the release levers and the cover form a sub assembly, called the cover assembly which can be mounted directly to the engine block, of course, placing the clutch plate in between the flywheel and the pressure plate with the clutch shaft inserted in this arrangement.

Advantages:

1. With the single plate clutch, gear changing is easier than with the cone clutch, because the pedal movement is less in this case.
2. It does not suffer from disadvantages of cone clutch i.e. bmdings of cones etc. and hence it is more reliable

Disadvantages

As compared to cone clutch, the springs have to be more stiff and this means greater force require to be applied by the driver while disengaging.

In the assembled position releases lever rest against the centre opening of the cover pressing there is an eyebolt nut which, causes the strut to pull the pressure plate against the springs, thus holding together the assembly. When the cover is bolted onto the flywheel, the pressure plate is further pushed back against the springs, causing them to be compressed further, which relaxes the release levers. Anti rattle springs serve to prevent the undesirable noise due to release levers when the clutch is in the engaged position.

Diaphragm Spring Type Single Plate Clutch

The construction of this type of clutch is similar to that of the single plate type of clutch described above except that here diaphragm springs (also called Belleville springs) are used instead if the ordinary coil springs. In the free condition, the diaphragm spring is of conical form but when assembled, it is constrained to an approximately flat condition because of which it exerts a load upon the pressure plate.

A diaphragm spring type clutch is shown in Fig. 3.2 where shows the clutch in the engaged position and in the disengaged position.

It is seen from the above figures That the diaphragm spring is supported on a fulcrum retaining ring so that any section through the spring can be regarded as a simple lever. The pressure plate E is movable axially, but it is fixed radically with respect to the cover. This is done by providing a series of equally spaced lugs cast upon the back surface of the pressure plate. The drive from the engine flywheel is transmitted through the cover, pressure plate and the friction plate to the gear box input shaft.

The clutch is disengaged by pressing the clutch pedal which actuates the release fingers by means of a release ring. This pivots the spring about its fulcrum, relieving the spring load on the outside diameter, thereby disconnecting the drive.

In this clutch, three straps of spring steel are placed equilaterally so that then outer ends are riveted to the cover, while their centers are riveted to the pressure plate. Drive is transmitted from the cover to the pressure plate via the straps along lines of action through the strap rivet centers. Spring flexure of the straps permits the axial movement of the pressure plate relative to the cover.

Advantages of the diaphragm spring type clutch

This type of clutch has now virtually superseded the earlier coil spring design in many countries in clutch sizes ranging upto 270 mm, in diameter, although in case of heavy vehicles, the coil spring type clutches are still being used because of the difficulty to provide sufficient clamping force by a single diaphragm spring. The diaphragm spring however, offers certain distinct advantages.

1. It is more compact means of storing energy. Thus compact design results in smaller clutch housing.
2. As the diaphragm spring is comparatively less affected by the centrifugal forces, it can withstand higher rotational speeds. On the other hand, coil springs have tendency to distort in the transverse direction at higher speeds.
3. In case of coil springs, load deflection curve is linear. Therefore, with the wear of the clutch facing the springs has less deflection due to which they would apply less force against the clutch plate. On the other hand, in case of diaphragm spring, the load deflection curve is not linear therefore, in this case, as the clutch facing wears, force on the plate gradually increases, which means that even in the worn out condition, the spring force is not less than its value in case of new clutch. Further, it is also seen that the load deflection curve depends upon the ratios h/t where h is the free dish height and t is the thickness of the spring. Therefore, in this case with suitable design, the load deflection curve can be improved to give lower release loads.
4. The diaphragm acts as both clamping spring and release levers. Therefore, many extra parts like struts, eye bolts, levers etc. are eliminated in the diaphragm spring, because of which the loss of efficiency due to friction wear of these parts also does not occur, which results in the elimination of squeaks and rattles.

EXPERIMENT 4

OBJECTIVE:

To study and prepare layouts of sliding mesh and constant mesh gear boxes.

EQUIPMENT:

A working or a non working model of any gear box such as constant mesh, sliding mesh

THEORY:

There are three reasons to have a transmission (gear box and its associated units) in the power train or drive train. These are:

1. The transmission provides the torque needed to move the vehicle under a variety of road and load conditions. It does this by changing the gear ratio between the engine crankshaft and vehicle drive wheels.
2. It can be shifted into reverse so the vehicle can move backward.
3. It can be shifted into neutral for starting the engine and running it without turning the drive wheels. There are two basic types of transmissions: manual and automatic. Manual transmissions are shifted manually by hand. Automatic transmission shift automatically, with no help from the driver.

Sliding Mesh Gear Box:

It is the simplest type of gear box. The arrangement of gears is shown in fig. in neutral position. The gear housing and bearings are not shown. The clutch gear is rigidly fixed to the clutch shaft.

It remains always connected to the drive gear of the countershaft. Three other gears are also rigidly fixed to the countershaft (lay shaft). They are the second speed gear, first speed gear and reverse speed gear. Two gears are mounted on the splined main shaft which can be slided by the slider yoke when the shaft lever is operated. These gears are the second speed gear and first and reverse speed gear. They can be connected to the corresponding gears of the countershaft. Reverse idler gear is mounted on another shaft and always remains connected to the reverse gear of the countershaft.

Constant Mesh Gear Box:

Fig shows a constant mesh gear box. It consists of a clutch shaft, a countershaft and a main shaft. Gears (2), (3), (5) ,(7) and (9) are fixed to the main countershaft but do not slide alone it. Gear Wheels (4),(6) and (8) are not fixed to the main shaft. Therefore these gears can revolve freely around it. Gear (4) of the main shaft is in constant mesh with gear (3) of the counter shaft. Similarly, gear (6) is in constant mesh with gear (5), and gear (8) with gear (7). All the gears are shown in neutral position.

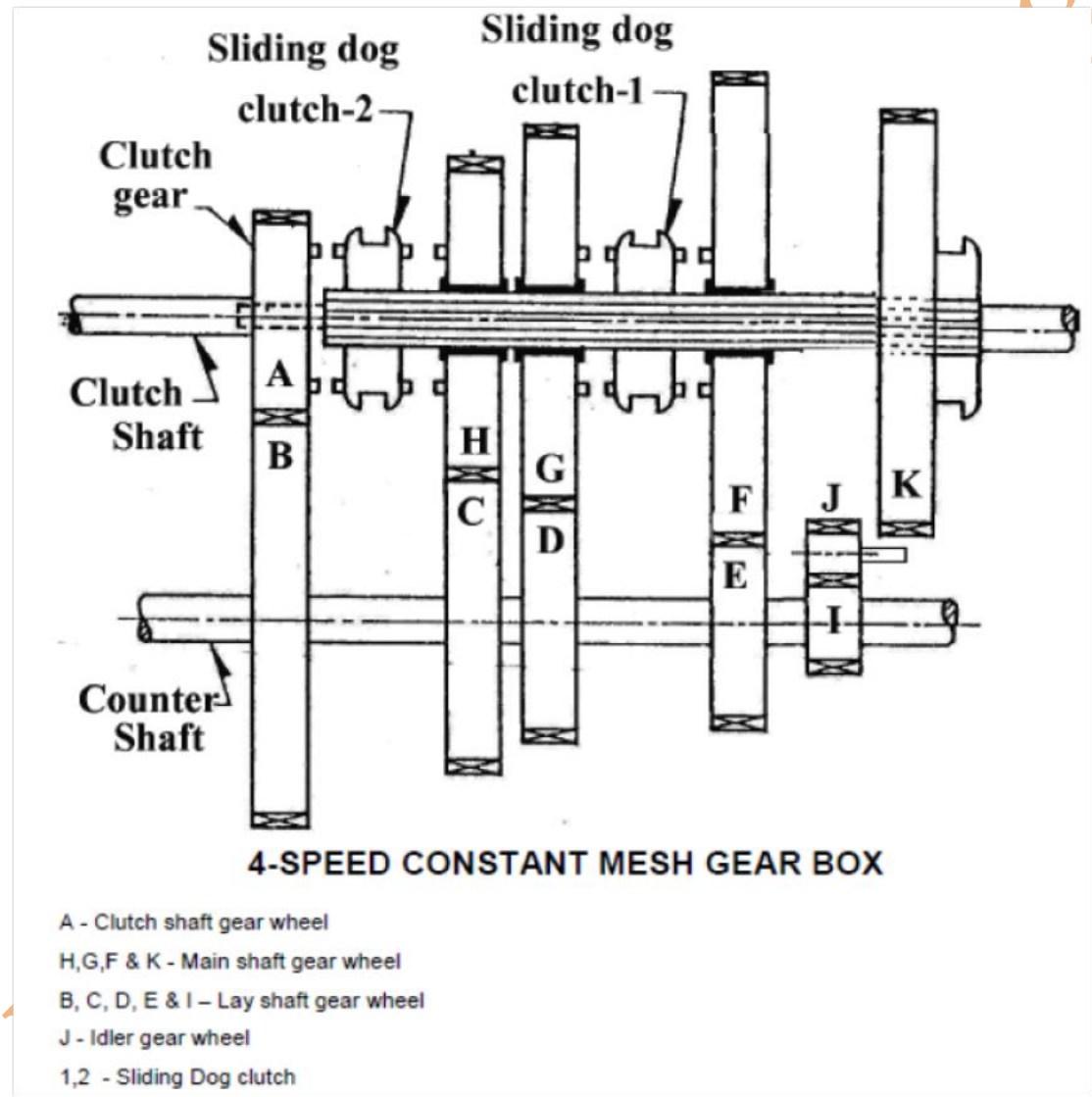


Fig. 4.1

To find out gear ratio using formula:
Gear ratio = No.of gear driving in teeth/ No.of gear driven in teeth.

EXPERIMENT-5

OBJECTIVE:

To study construction of different types of Automobile Wheels and Tyres & draw sketches.

EQUIPMENT:

A working or a non working model of Automobile Wheels and Tyres.

THEORY:

Disc Wheel

This type of wheel consists of two parts, a steel run which is base to receive the tyre and a pressed steel disc. The rim and the disc may be, permanently attached or attachable, depending upon design. A typical steel disc wheel is shown in Fig 5.1. in which the pressed steel disc is welded to the rim.

When the bead of the tyre is rests in the rim, it becomes possible to fit in position of the rim without the well it would not be possible to mount or remove the tyre from the wheel. The seat of the rim where the tyre rests usually has a 5 degree or 15 deg taper (not shown) so that as the tyre is inflated, the beads are forced up the taper to give a wedge fit. With tubeless Tyres, the taper helps to build a good seal.

The steel disc performs the functions of the spokes. The wheel hub is fitted on the axle. Some slots are generally provided in the wheel disc to a how the air to pass to the inner side for better cooling of the brake drum inside. Since these holes tend to weaken the disc, the holes in modern wheels are swaged which means that some portion of the disc around each hole is turned inward smoothly to compensate for the loss of strength due to holes. A separate cover is also provided on the wheel disc. A hole in the run serves to accommodate tube valve.

A wheel may be inset, zero set or outset, depending upon the position of the rim in relation to attachment face of the disc. In the inset wheel the centre line of the rim is located inboard of the attachment face of the disc. Inset is distance the distance from the attachment face of the disc to the centre line of the rim. A zero set wheel is the one in which the rim centre line coincides with the attachment face of the disc while in the outset wheel the centre line of the rim is located outboard of the attachment face of the disc. A wheel whose disc can be mounted on either face to provide inset or outset, thus decreasing or increasing the wheel track is called reversible wheel. Wheel constructed in two parts, which when

securely fastened together combine to form a rim having two fixed flanges is called a divided wheel rim.

Wire Wheel

Unlike the disc wheel the wire wheel has a separate hub which is attached to the rim through the number of wire spokes. The spokes carry the weight, transmit the driving and braking torques and withstand the side forces while cornering, in tension. spokes are long, thin wires and as such these can not take compressive or bending stress. All types of loads are sustained by the spokes in Tension .The spokes are mounted in a complicated criss-cross fashion installed in the three planes. The component of vehicle weight in the direction of spokes above The hub is sustained by these spokes in tension. Similarly, the driving and the braking torques are taken up by the tension in the spokes hi the desired direction as shown by fig respectively. The side forces on cornering are taken up by the spokes forming triangular arrangement. Thus it is seen that the spokes have to be mounted on the wheel. The initial tension of the spokes can be adjusted by means of screw nipples which also serve to secure the spokes to the rim. The hub is provided with internal splines to correspond to the splines provided on the axle shaft. A wing nut screws the hub on the axle shaft. The advantages of this type of wheel are light weight and high strength, and above all it provides much better cooling of the brake drum. it is also easy to change the wheel when required, because only one nut has to be opened. However, wire wheels are expensive due to their intricate construction. The rim of a wired wheel is not capable to fit tubeless tyres.

Light alloy cast or forged wheel

The latest trend in case of automobile wheels is the use of wheels made from aluminum or magnesium alloys cast wheels are generally used for cars while forged wheels are preferred for wheels of heavier vehicles. The main advantage of light-alloy wheels is their reduced weight which reduces unsprung weight. A magnesium alloy wheel weighs about 50 per cent of a steel wheel and about 70 per cent of an aluminium alloy wheel for similar strength. Moreover, light alloys have better conductivity of heat which helps the wheels to dissipate heat generated by the tyres or brakes and thereby run cooler. Further, wider rims improve stability on cornering. Through cast or forged wheels have to be machined. Yet this helps to maintain clo.se tolerances and also produce better appearance. Magnesium alloys have high impact and fatigue strength so that they can stand vibrations and shock loading better. However, being tune to corrosion. These have to be given some protective coating. Aluminum alloys do not have high resistance to vibration and shock as in case of magnesium alloys,

but these are relatively easier to cast or forge and also less tune to corrosion. Generally, amminum alloys are used for cars sports and racing cars usually have magnesium alloy wheels. Higher cost is the only disadvantage of light alloy wheels.

Wheel styling being a modern trend in automotive industry, wheel division of Dunlop Limited has designed a range of wheels of cast aluminium alloy and designated this range as Formula D This range also includes composite wheels, i.e. the wheels with cast aluminum body alloy and steel rims.

Tyre

A tyre is a cushion provided with an automobile wheel. It consists of mainly the outer cover i.e. the tyre and the Tube inside. The tyre tube assembly is mounted over the wheel rim. It is the air inside the tube that carriers the entire load and provides the cusion.
The tyre performs the following functions

1. Supports the vehicle load
2. Provider cushion against shocks
3. Transmits driving and braking force to the road
4. Provides cornering power for smooth steering.

Tyre Properties

Non Skidding: This is one of the most important tyre properties. The Tread pattern on The Tyre must be suitably designed to permit least skidding even on wet roads.

Uniform Wear: To maintain the non skidding property, it is very essential that the wear of the tyre treat must be uniform. The ribbed tread pattern helps to achieve this.

Load Carrying Capacity: The tyre is subjected to alternating .stresses during each revolution of the wheel. The tyre material and design must be able to ensure that the tyre sustains the stresses.

Cushioning: The Tyre should be able to absorb high frequency vibrations set up by the road surface and thus provide cushioning effect.

Power Consumption: The automotive tyre should absorb some power which is due to friction between the tread rubber and road surface and also due to hysterics loss on account of the tyre being continuously fixed and released. This power comes from the engine and should be least. It is seen that the synthetic

tyres consume more power while rolling than the ones made out of natural rubber.

Tyre noise: The tyre noise must be in the form of definite pattern a sequel or a loud roar. In ah these cases, it is desirable that the noise should be minimum.

Balancing: Balancing is very important consideration for tyres. The Tyre being a rotating part of the automobile it must be balanced statically as well as dynamically. The absence of balancing gives rise to peculiar oscillations called wheel tramp and wheel wobble.

Types of Tyres

The use of solid tyres in automobiles is almost obsolete and only the pneumatic tyres are used universally. These pneumatic tyres are of two types viz. the conventional tyre with a tube and the tubeless tyre.

Conventional Tube Tyre: Fig gives in a simplified form the cross section of such a tyre. It consists of two main parts, viz. the carcass and the tread. The carcass is the basic structure taking mainly the various loads and consists of a number of plies wound in a particular fashion from the cords of rayon or any other suitable material. Each cord in each ply is covered with resilient rubber compounds and all the plies are insulated against each other. The Term ply rating which is often used in tyre industry does not indicate exact number of plies in the tyre. It is only a relative index of tyre strength and load carrying capacity. A four ply rating tyre, may have only two plies. In order to prevent the tyre from being thrown off the rim, the plies are attached to two rings of high tension steel wire. These rings are made to fit snugly against wheel rim thereby anchoring the tyre to the rim. These rings are called beads.

The tread is the part of the tyre which contacts the road surface when the wheel rolls. It is generally made of synthetic rubber and the design of the tyre tread depend on various tyre properties viz the grip, the noise and the wear. The tread is moulded into a series of grooves and ribs. The ribs prove the traction edges required for gripping the road surface while the grooves provide passage for quick escape of any foreign matter such as water etc. Traction edges and sipes are provided on the ribs. Sipes are the small grows moulded into the ribs of the tyre tread, these increase the traction ability' of the tyre by increasing number of traction edges. As the tyre flexes on the road surface, the sipes open to provide extra gripping action. The sipes appear to be shallow but in fact these travel the entire depth of the tread. The design of the tyre tread has a direct effect on the tyre life, its handling characteristics, quality of ride comfort, noise, and traction.

Between the head and the tread the outer rubber covering of the carcass is called side wall. The sidewalls are designed to flex and bend without cracking when subjected to continuous deflection while running. In other words, the sidewall material must have high fatigue strength. At the inner edges, beads are formed by reinforcing with steel wires. This provides the tyre with strong .shoulders for bearing against the wheel rim. All plies are tied to the beads which prevent any change of shape.

Inside the tyre, there is a tube which contains the air under pressure. The tube being very thin and flexible, takes up the shape of the tyre cover when inflated. A valve stem is attached to the tube for inflating or deflating the same.

Tubeless Tyre: This type of tyre does not need a separate tube' instead the air under pressure is filled in the tyre for which purpose a non-return valve is fitted to the rim (fig 6). The inner construction of the tyre is almost same as that of the tyre, except that it is lined on inside with a special air-retaining liner.

The tube less tyres possess following advantages over the conventional tubed tyres.

1. Lesser upsprung weight — being lighter, unsprung weight is reduced, and ultimately reduces wheel bouncing.
2. Better cooling - In case of the tyres, heat in the compressed air has to pass through the tube material, i.e. rubber, which is not a good conductor of heat. Since there is no rube in the tubeless tyres, hence heat passes to the atmosphere directly resulting better cooling thereby increasing the tyre life.
3. Slower leakage of air - since the inner liner in the tubeless tyres is not stretched like the tube, it retains the air better resulting in its slower leakage.
4. Simpler assembly - Only the tyre has to be fitted over the rim. There is no danger of the tube being punctured during assembly.
5. Improved safety — In case of any tiny hole being caused in the tyre, the same can be repaired simply by plugging, whereas in case of the conventional tyres it takes quite some time.

Carcass Types

Carcass or skeleton of the tyre is of 3 types

1. Cross ply or bias ply
2. Radial Ely
3. Belted bias type

The tyre is named after the particular type of carcass it contains as this is the main structure taking the stresses while in operation.

Cross Ply Type: In tins type, the ply cords are woven at an angle (30deg — 40deg) to the tyre axis. There are two layers which run in opposite directions. However, the cords are not woven like wrap and weft of ordinary cloth because that would lead to rubbing of the two layers and thus produce heat which would damage the tyre material (fig 1).

Radial Ply Type: In this ply cords run in the radial direction i.e. in the direction of the tyre axis. Over this basic structure, run a number of breaker strips in the circumferential direction. The material for the breaker strips must be flexible but inex tensible. so that no change of circumference takes place with change of the amount of inflation. Without the breaker strips, radial plies would give very soft ride, but there will not be auv lateral stability. The extensible breaker strip behaves like a girder in its own plane and provides the directional stability (fig 2).

Belted Bias Type: This is a combination of cross ply & cross ply tyres. The basic construction is the bias ply over which run a number of breaker belts. The belts improve the characteristics of the bias-ply tyre to a large extent. (1) the stresses in the carcass are restricted and the tread area is stabilized by belts. This results in reduction of tread-scrubbling and thus appreciable increase in tyre life (2) the breaker belts hold the tread flatter against the road surface, thus causing increase of traction and safety. (3) the belts increase the resistance of the tyre a gains: puncture.

EXPERIMENT-6

OBJECTIVE:

Study and experiment on Suspension system.

EQUIPMENT:

A model of suspension system.

THEORY:

Need of Suspension System:

1. To prevent the road shocks from being transmitted to the vehicle components.
2. To safeguard the occupants from road shocks.
3. To preserve the stability of the vehicle in pitching or rolling, while in motion.

Types of Suspension:

1. Leaf spring suspension system
2. Coil Spring Suspension system
3. Mc-Persion strut suspension system
4. Torsion bar suspension system

Suspension Springs:

1. Steel springs
   (a) Leaf spring
   (b) tapered leaf spring
   (c) Coil spring
   (d) torsion bar
2. Rubber springs
   (a) Compression spring
   (b) Compression Shear-spring
   (c) Steel-reinforced spring
   (d) Progressive spring
   (e) Face shear spring
   (f) Torsional shear spring
3. Plastic spring
4. Air spring

5. Hydraulic spring

Constructional Details and Characteristics of Leaf Spring:

The most commonly used leaf spring is the semi-elliptic type, consisting of one main leaf, which usually has its ends formed into eyes for connection with the spring brackets, and a number of shorter leaves, the length of which gradually and uniformly decreases from the main leaf. The various leaves are held together by a centre bolt.

Constructional Details and Characteristics of Coil Spring:

Coil springs can store about twice as much energy per unit volume as that of leaf springs. Thus for the same job coil springs need weight only about half that of leaf springs. But leaf springs serve both the purposes. Cushion the shocks and to guide or control cushioned motion.

Constructional Details and Characteristics of Torsion Bar Spring:

A rod or tube acting in torsion can work as a torsion-bar spring. The torsion-bar spring is a bar of spring steel that is anchored to the frame at one end while the other end is freely supported and connected to a lever arm. The lever-arm is pin-jointed to the axle spindle or steering head. The action of torsion-bar springs is essentially same as that of coil spring.

Rubber Suspension:

The advantages of using rubber as a means of suspension are:

1. It can store greater energy per unit weight than the steel. For this reason rubber springing system can be made more compact.
2. The rubber has excellent vibration damping properties.
3. The absence of squeaking which is always present in steel springs.
4. The number of bearings is reduced considerably for the rubber suspension system. This means longer life.
5. Rubber is more reliable. A rubber suspension cannot suddenly fail like the metal springs.

Air Suspension:

The advantages of air suspension system are:

1. A variable space for wheel deflection is put to optimum use by virtue of the automatic control devices.

2. Because the vehicle attitude is also constant, changes in headlamp alignment due to varying loads are avoided.
3. The spring rate varies much less between the laden and unlades conditions, as compared with that of conventional steel springs. This reduces the dynamic loading.
4. The improved standard of ride comfort and noise reduction attained with air springs reduces both driver and passenger fatigue.

Shock Absorbers:

Shock absorbers are necessary because springs do not "settle down" fast enough. After a spring has been compressed and released, it continues to shorten and lengthen, or oscillate for a time.

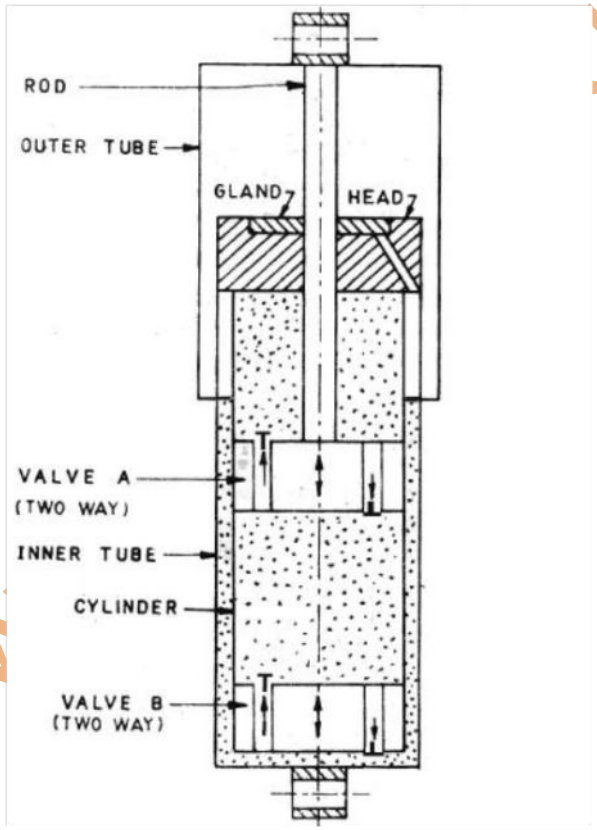


Fig. 5.1 Shock Absorber

This is what happens if the spring at the wheel is not controlled. When the wheel hits a bump, the spring compresses. Then the spring expands after the wheel passes the bump. The expansion of the spring causes the car body and frame to be thrown upward. But, having over expanded, the sprin shortens again. This action causes the wheel to move up and momentarily leave the road at the same time that the car body and frame drops down. The action is repeated until the oscillations gradually die out Such spring action on a car would produce a very

bumpy and uncomfortable ride. It could also be dangerous, because a bouncing wheel makes the car difficult to control. Therefore, a dampening device is needed to control the spring oscillations. This device is the shock absorber.

The shock absorber is the direct-acting tubular or telescope type. In operation, the shock absorbers lengthen and shorten as the wheels meet irregularities in the road. As they do this, a piston inside the shock absorber moves in a cylinder filled with fluid. Therefore the fluid is put under high pressure and forced to flow through the openings slowly. This slows the piston motion and retains sprinaction.

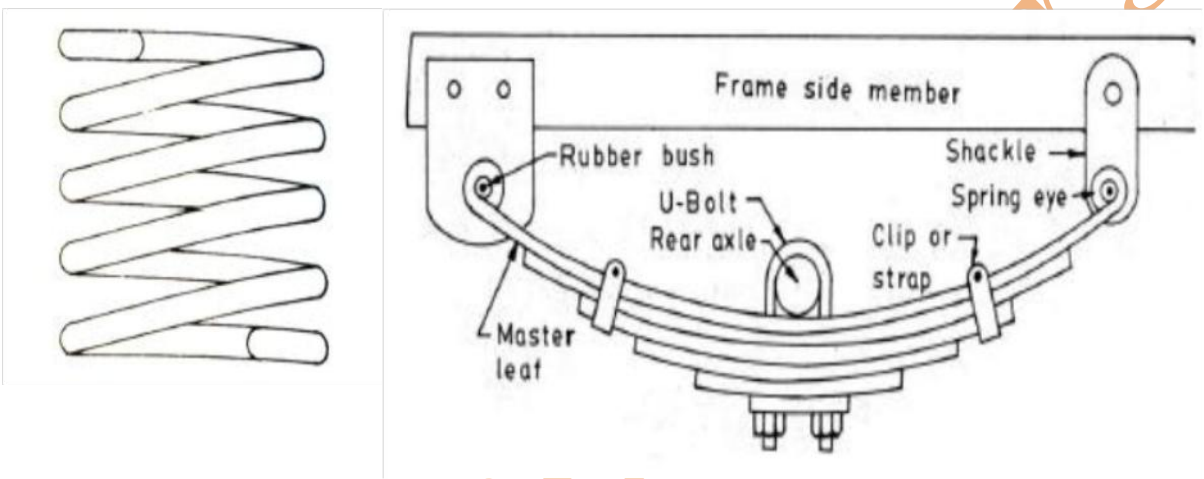


Fig. 5.2 Coil, and, Leaf Spring Absorber

EXPERIMENT-7

OBJECTIVE:

To study construction of steering system for manual/power arrangement and draw sketches.

EQUIPMENT:

A working or a non working model of steering mechanism.

THEORY:

The steering system allows the driver to control the direction of the automobile by means of two major components. : the steering gears, which multiply the driver's effort at the steering wheel; and the steering linkage, which connects the gear box to the front wheels. How well the system works depends on proper alignment of the front wheels for directional control and ease of steering.

1. To convert rotary movement of the steering wheel into angular motion of the front road wheels.
2. To provide directional stability to the vehicle.
3. To minimize wear of tyres.
4. To turn vehicle at driver's will.
5. To provide perfect rolling motion of the road wheels at all times.
6. To multiply the effort of the driver by leverage so that turning of wheels is easy.
7. To facilitate straight ahead recovery after completing a turn.
8. To absorb road shocks thus preventing them to get transmitted to the hands of the driver.
9. To swing the wheels to the left or right.

To achieve correct steering, two types of steering mechanisms are used.

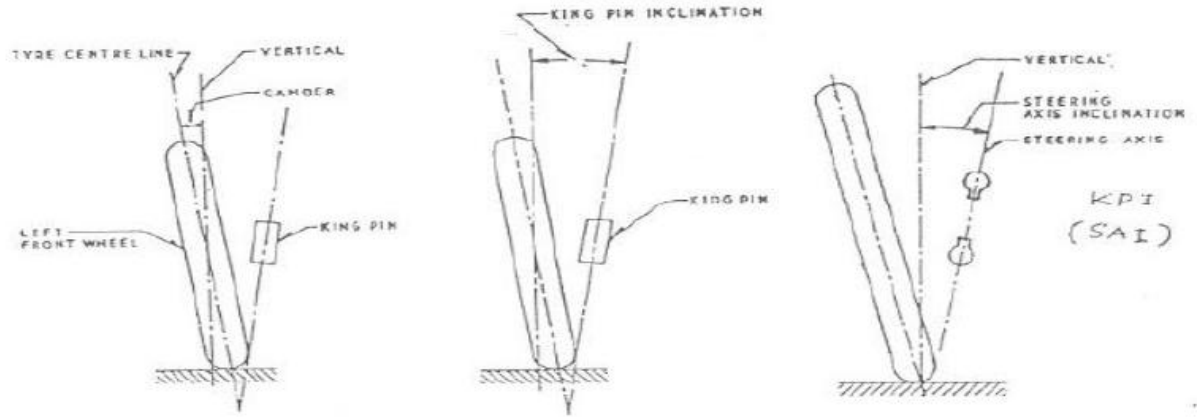
1. Davis Steering Mechanism
2. Ackermann Steering Mechanism

The main difference between these two is that the Davis mechanism has sliding pairs, where as the Ackermann mechanism has only turning pairs. The sliding pair has more friction than the turning pair and hence Davis mechanism will wear out after certain time. Therefore Ackermann mechanism is preferred to the

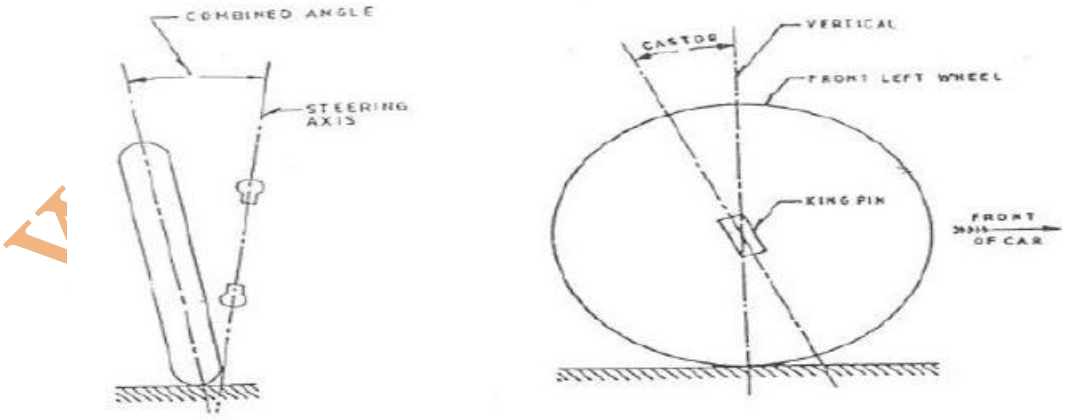
Davis mechanism. It consists of a track rod AB connected to the links KA and LB, which are integral with the stub axles. When the vehicle is in straight ahead position these links make equal angles with the centre line of the car. Ackermann Principle: In order to achieve the instantaneous centre, the inner wheel must turn through a greater angle than the outer. This difference in movement of the inner and outer wheels is obtained by inclining the links KA and LB. The effect of this will be clear from fig. If the track rod AB moves, say through x distance, measured parallel to the axle beam, link KA will move through a greater angle than link LB. The inclination of these links is such that lines drawn through them will intersect theoretically at the centre line of the car. This arrangement is known as Ackermann principle or linkage and can also be applied if the track rod is placed in front of the axle.

STEERING GEOMETRY PARAMETERS:

Camber: Tilt of the wheel plane from the longitudinal plane.



Castor: Tilt of the king pin with reference to the transverse vertical plane.



Combined angle Castor

Kingpin Inclination: King Pin inclination is the tilt of the king pin from the longitudinal vertical plane.

Toe in or Toe out: Toe in is the amount by which the front wheels are set closer together at the front than at the rear when the vehicle is stationary. On the other hand, the wheel may be set closer at the rear than at the front in which case the difference of the distances between the front wheels at the front and at the rear is called toe out.

Steering Gear Box:

The steering gear converts the rotary motion of the steering wheel into straight line motion of the linkage. There are two basic types of steering gears, the pitman-arm type and the rack and pinion type. Either type can be used in a manual steering system or a power steering system. The pitman type has a gear box at the lower end of the steering shaft. The rack and pinion type has a small gear (a pinion) at the lower end of the steering shaft. The action is the same in either system. When the steering wheel and shaft are turned by the driver, the rotary motion is changed into straight line motion. This causes the front wheels to pivot or swing from one side to the other to steer the car. One job of the steering gear is to provide mechanical advantage. In a machine or manual device, this is the ratio of the output force to the input force applied to it. This means that a relatively small applied force can produce a much greater force at the other end of the device.

1. Worm and Wheel
2. Cam and Double Roller
3. Worm and Nut
4. Recirculating Ball type
5. Rack and Pinion

EXPERIMENT-8

OBJECTIVE:

To study construction of hydraulic braking (disc/drum) systems and functioning of master & wheel cylinders and draw sketches.

EQUIPMENT:

A working or a non working model of Braking system.

THEORY:

Functions of Brake:

There are two distinct functions of the brake:

1. To stop or slow down the vehicle in the shortest possible distances in emergencies.
2. To control the vehicle to be retained when descending a hill.

Classification of Brakes:

1. From construction point of view
   (a) Drum brakes
   (b) Disc brakes
2. By method of actuation
   (a) Mechanical brakes
   (b) Hydraulic brakes
   (c) Electric brakes
   (d) Vacuum brakes
   (e) Air brakes

HYDRAULIC BRAKE SYSTEM:

These types of brakes consist of master cylinder, which contains hydraulic brake fluid. Master cylinder is operated by the brake pedal and is further connected to the wheel cylinder in each wheel through pipelines, unions and flexible lines. The system is so designed that even when the brakes are in the released position, a small pressure of about 50kpa is maintained in the pipelines to ensure that the cups of the wheel cylinder are kept expanded. This prevents the air entering the wheel cylinders when the brakes are released.

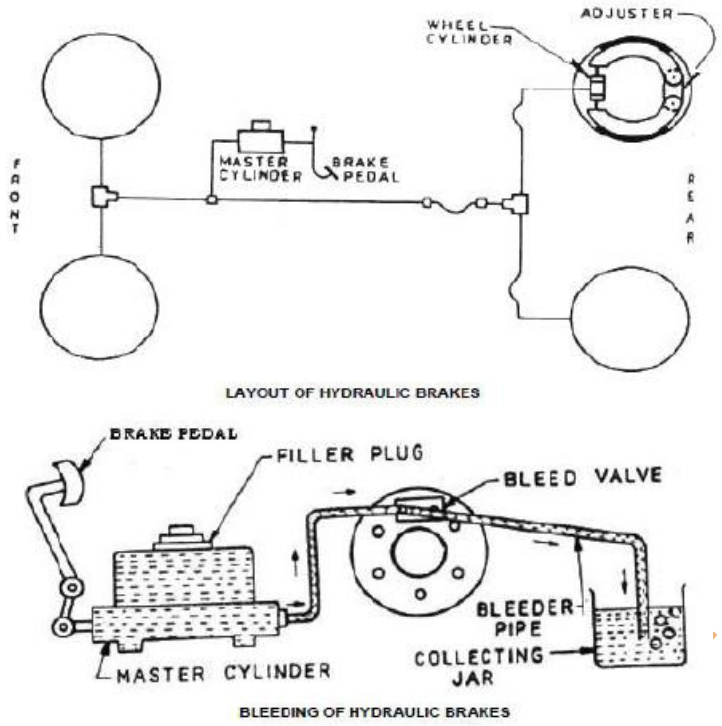


Fig. 8.1 Hydraulic Break

Besides this pressure also serves the following purposes:

1. It keeps the free travel of the pedal minimum by opposing the brake shoe retraction springs.
2. During bleeding, it does not allow the fluid pumped into the line to return, thus quickly purging air from the system.

Master Cylinder:

It consists of fluid reservoir and compression chamber in which piston operates. The fluid in the reservoir compensates for any change in the fluid volume in the pipelines due to temperature variations and to some extent due to leakage. To prevent leakage there are rubber seals on both sides of the piston in the compression chamber. The fluid always surrounds the reduced diameter region of the piston. A rubber boot covers the push rod and of the master cylinder to prevent the dirt entering inside. Towards the brake lines side of the compression chamber, there is fluid check valve with a rubber cupinside. It serves to retain the residual pressure in the brake lines even when the brakes released.

There are a number of holes in the piston head on the primary (high pressure) seal side. Two holes connect at the reservoir to the compression chamber. The smaller one out of these is about 0.7 mm diameter and is called the bypass or compression port. The second hole is called the intake or recuperation port.

Besides, there is a vent in the cap, to keep the brake fluid always at atmospheric pressure.

The push rod is operated with the foot brake pedal through the linkage. As the pedal is pressed, push rod moves to left against the force of the spring, till it covers the bypass port. Further movement of the push rod causes building up of pressure in the compression chamber. Finally, when sufficient pressure has built up, the inner rubber cup of the fluid check valve is deflected, forcing the fluid under pressure in the lines. This fluid enters the wheel cylinder or the caliper and moves the pistons thereby applying the brakes. When the brakes are released, the spring pressure in the master cylinder moves the piston to the right extreme position. This same force of the spring keeps the fluid check valve pressed on its seat for sometime and thereby delays the return of fluid from the lines into the compression chamber again. Some delay is also caused by the inertia of the fluid in the lines. This produces a vacuum in the compression chamber and unless this is destroyed immediately, there are all chances of air leakage into the system. Even a very small amount of air will render the brakes unless, the air being compressible. Having intake port as shown in figure solves this problem. As soon as some vacuum is formed, the atmospheric pressure in the fluid reservoir forces the fluid through intake port and holes in the piston, which deflects the rubber, cup and enters the compression chamber, destroying the vacuum. But by the time, the vacuum is destroyed; the fluid from the lines comes back into the reservoir by lifting the fluid check valve off its seat. This extra fluid now has to be accommodated somehow, because compression chamber is already full. If this is not done, the pressure in the lines will not be relievedfully and there are chances of brake shoe rubbing with the drum. Once this happens, there will be more heat generated at the drum, which when transmitted to the wheel cylinders would cause the fluid to expand and exert still more pressure, causing the shoes to move still further towards the drum. In this way, a vicious circle will start, causing the brakes to jam ultimately.

This is avoided by means of bypass port. The extra fluid coming from the lines passes to the fluid reservoir, where pressure is maintained atmospheric by providing an air vent. Wheel Cylinder: The construction is very simple. The brake fluid under pressure forces the piston apart, thereby applying the brakes.

Antilock Braking:

The most efficient braking takes place when the wheels are still moving. If the brakes lock the wheels so that the tires skid, kinetic friction results, and braking is much less effective. To prevent skidding and provide maximum effective

braking, several antilock devices have been developed. Some provide skid control at the rear wheels only. Others provide control at all four wheels.

Control means that as long as the wheels are rotating, the antilock device permits normal application of the brakes. But if the brakes are applied so hard that the wheels tend to stop turning and a skid starts to develop, the device comes into operation. It partly releases the brakes so that the wheels continue to rotate. However, braking continues, but it is held to just below the point where a skid would start. The result is maximum braking.

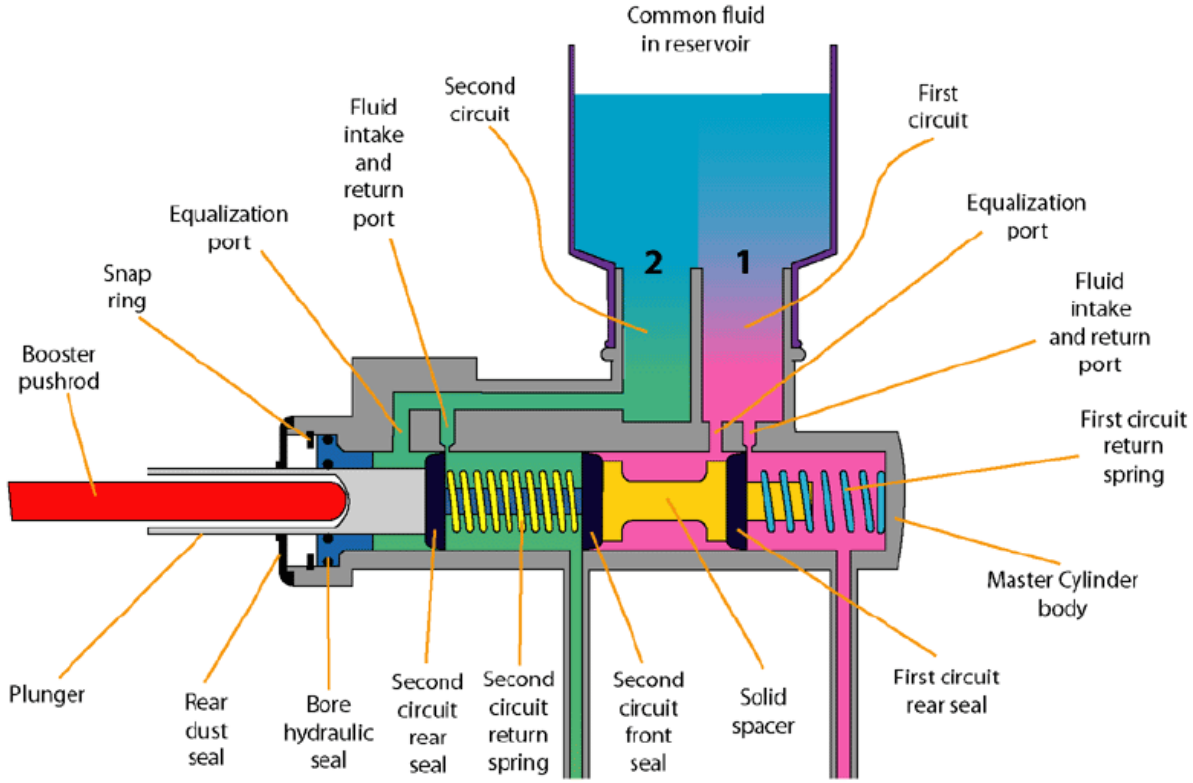


Fig. 8.2 Antilock Braking