Laboratory Manual

REFRIGERATION & AIR CONDITIONING LAB

for

B. Tech.
Mechanical Engineering

Department of Mechanical Engineering

Brij Bhooshan Education Web Portal
Web: www.brijrbedu.org

LABORATORY MANUAL

REFRIGERATION & AIR CONDITIONING LAB

for

B. Tech.
Mechanical Engineering

Prepared by

A team of
Rukmani & Sons

E-mail: enquiry@brijrbedu.org
Website: http://www.brijrbedu.org

TABLE OF CONTENTS

PART III: Annexure		
15	References	35

LABORATORY OBJECTIVE

Refrigeration and air-conditioning 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 refrigeration and air-conditioning.

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

- Solidification of theoretical concepts of refrigeration and air-conditioning by performing practical
- Determine the performance of the refrigeration and air-conditioning systems through various performance parameters
- Carry out fault finding in refrigeration and air-conditioning systems
- Undergo the repair and maintenance of such systems
- Conduct the trials on refrigeration and air-conditioning equipment
- Get acquainted with the latest know-how of the refrigeration field
- Development of logical method of analysis and interpretation

ABOUT THE LABORATORY

The vapor compression refrigeration system is the mainstay of the refrigeration and air conditioning laboratory.

This laboratory contains the following setups and equipments:

1. Vapour Compression Refrigeration Test Rig having Hermetically Sealed Compressor
2. Air Conditioning Test rig
3. Duct type air conditioning test rig.
4. Ice Plant Test rig
5. Window air conditioner
6. Models of different types of evaporators
7. Models of Different type of expansion devices
8. Domestic Refrigerator

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:

Experiment on refrigeration test rig and calculation of various performance parameters.

PRE-REQUISITES:

Students are required to have understanding of the following basics to enable better understanding of the practical:

1. Knowledge of refrigeration cycle.
2. Basic understanding of coefficient of performance (COP) of cycle and tonnage capacity.
3. Knowledge of calculations related to COP and tonnage capacity.

Test Rig Specification

Compressor	ISI hermetically sealed.
Condenser	Air Cooled Condenser.
Evaporator	Calorimeter type. Inner chamber is made up of stainless steel. The immersion type cooling coil is provided inside the calorimeter chamber.
Refrigerant	Freon, R-22
Control Panel	➢ Glass tube rotameter to measure the flow of liquid refrigerant. ➢ Expansion device (capillary tube & expansion valve). ➢ Drier. ➢ Thermostat for heating and cooling. ➢ Pressure gauges. ➢ Main switch, digital type voltmeter, ampere meter, energy meter. ➢ Digital temperature Indicator fitted with RTD thermocouple.
Voltage	Single phase, 220 V, 50 Hz AC supply.

THEORY:

The coefficient of performance of refrigeration plant is given by the ratio of heat absorbed, by the refrigerant when passing through the evaporator or the system, to the working input to the compressor to compress the refrigeration. Co-efficient of refrigeration cycle is given by the ratio of net refrigeration effect to the power required to run the compressor.

$$COP_{(cycle)} = \text{Net refrigerant effect in unit time / Power input in unit time}$$
$$= m\ C_p\ \Delta T / kWh$$

where

C_p = Specific heat of refrigerant
ΔT = Temperature difference ($T_1 - T_3$)
kWh = Kilowatt hours energy meter reading (1 kWh = 3600 Joule)

$$= m\ C_p\ \Delta T / 3.88$$

PROCEDURE:

Switch on the compressor and let it run for considerable period of time. Fill the measured amount of water in cooling chamber. Measure initial temperature of water. Note down the temperature of water after 20 minutes, note down the power consumed by the compressor.

OBSERVATIONS:

S. no.	Energy meter reading (kWh)			Mass of water (Kg)	Temperature of chilling water final ΔT (°C)
	Initial (a)	Final (b)	C = (b – a)		
1					
2					
3					
4					
5					

RESULT:

The COP and tonnage capacity are calculated for different cases. And is found out to be ……

PRECAUTIONS:

1. Keep the instrument clean and away from dust.
2. Move the equipment carefully.
3. Take the readings carefully under steady-state conditions.

EXPERIMENT – 2

OBJECTIVE:

To study different types of expansion devices used in refrigeration system.

PREREQUISITES:

Students are required to have understanding of the following basics to enable better understanding of the practical:

"Expansion Device", is the term usually used in industry, for any device that meters or regulates the flow of liquid refrigerant to an evaporator. It has two purposes:

1. To reduce the pressure of the liquid refrigerant.
2. To regulate the flow of refrigerant to the evaporator.

It, thus divides the high-pressure side from the low-pressure side of the system.

HAND EXPANSION VALVE:

A hand expansion valve is a hand operated needle valve. The rate of liquid flow through the valve depends on the pressure differential across the valve orifice and on the degree of valve opening, the latter being manually adjustable.

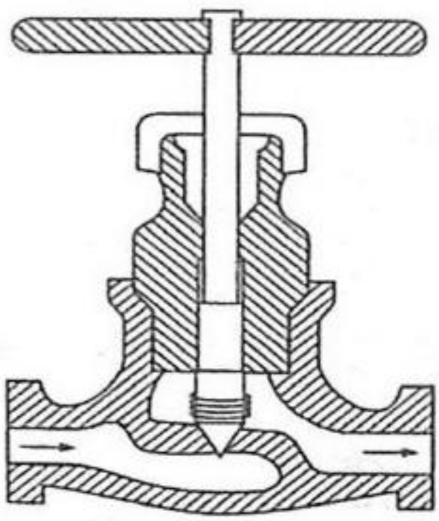


Fig. 1 Hand expansion valve.

This is suitable for use only on large systems where an operator is on duty and where the load on the system is relatively constant (e.g., ice making plants and cold storages).
The main advantages of a hand expansion valve are its simplicity and low initial cost. Also, because of its simple construction there is very little that can get out of order. The principle disadvantage is that an operator must be available at all times to make the necessary adjustment to meet the changing load conditions.

AUTOMATIC EXPANSION VALVE

The automatic expansion valve is a pressure-reducing device. It is activated by the evaporator pressure which it keeps constant since the pressure of the refrigerant in the evaporator determines evaporator temperature.

Fig. 2 shows a schematic sketch of an automatic expansion valve. It is a diaphragm-or bellows operated valve with the evaporator pressure acting on the lower side of the diaphragm and atmospheric pressure plus adjustable spring pressure acting on the upper side. As the compressor operates to remove the gas from the evaporator, reducing the pressure in the evaporator and under the diaphragm, the adjusting spring pressure pushes diaphragm down. This motion is transmitted through push rods (or by needle valve seat) to the valve needle, opening it enough to allow more refrigerant to flow to the evaporator. As more Refrigerant in liquid enters the evaporator, the pressure increases forcing the diaphragm upward and allowing the valve to close. A properly sized valve will pass enough liquid refrigerant to maintain constant temperature and pressure conditions.

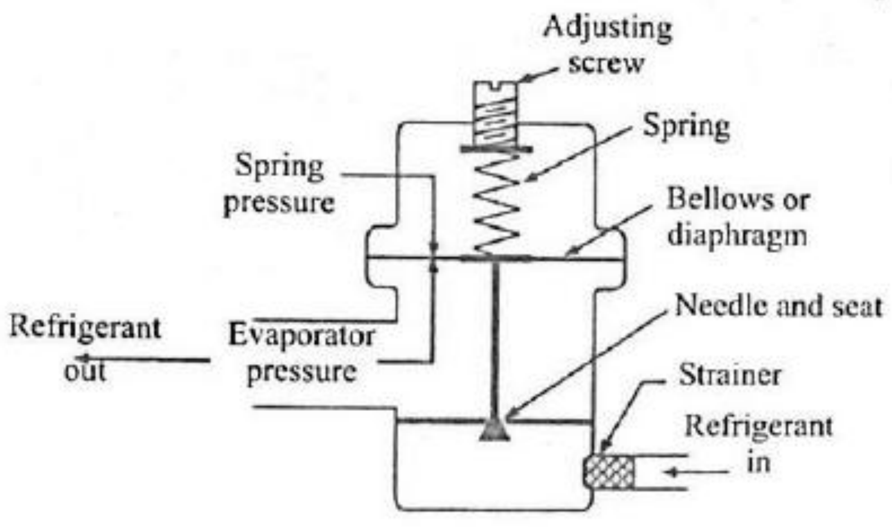


Fig. 2. Automatic expansion valve.

An automatic expansion valve must be set to prevent over feeding on low-load conditions and therefore cannot feed enough on high-load conditions. If the heat load drops off quickly, the evaporator pressure drops suddenly, opening the valve wide again in trying to raise evaporator pressure to the pressure setting of the valve. As a result the liquid refrigerant can flood back to the compressor and cause much damages. If the heat load increases suddenly, the evaporator pressure will increase rapidly, forcing the diaphragm up and allowing the valve to close. This `starves' the evaporator until the compressor can reduce the pressure and allow more refrigerant to pass into the evaporator.

The automatic expansion valves find their greatest use in the systems with relatively constant loads and in systems with only one evaporator coil.

THERMOSTATIC EXPANSION VALVE

A thermostatic expansion valve is a throttling device which works automatically., maintaining proper and correct liquid flow as per the requirements of the load on the evaporator.

This valve finds a wide application because of its adaptability to any type of dry expansion application, automatic operation, high efficiency and ability to prevent liquid flood backs.

A thermostatic expansion valve performs the following functions:

(i) Reduces the pressure of liquid from the condenser pressure to evaporator pressure.
(ii) Keeps the evaporator fully active.
(iii) Modulates the flow of liquid to the evaporator according to the load requirement of the evaporator so as to prevent flood back of liquid refrigerant to the compressor.

Fig. 3 shows a thermostatic expansion valve. The following are the important parts of the valve:

1. Power element with a feeler bulb
2. Valve seat and needle
3. Adjustment spring
4. Bellows or diaphragm.

The remote bulb charged with fluid which is open on one side of the diaphragm through a capacity tube is clamped firmly to the evaporator outlet. The temperature of the saturated liquid in vapour mixture is the same as the temperature of the superheat gas leaving the evaporator at the location. The pressure of the liquid in the bulb (P_3) tends to open the valve. This pressure is balanced by pressure due to spring (P_2) plus pressure in the evaporator (P_1).

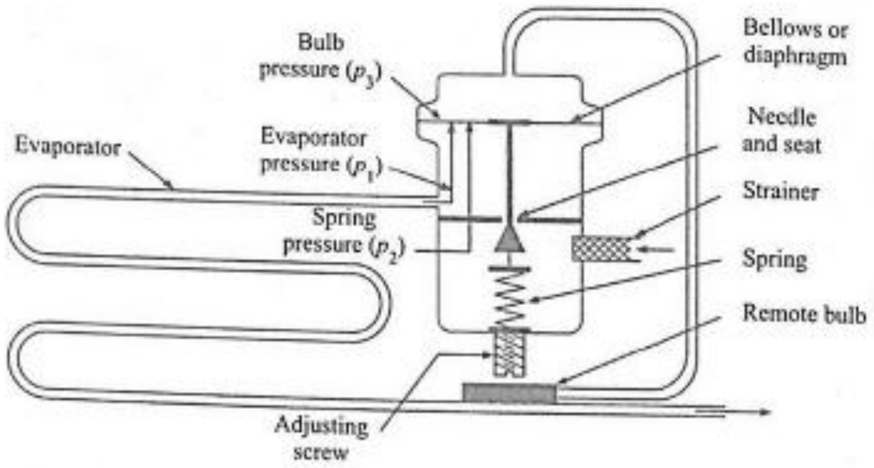


Fig. 3. Thermostatic expansion valve.

The performance characteristics of thermostatic-expansion valves are most suitable for application in air-conditioning and refrigerant plants. When the cooling load 'increases', the refrigerant evaporates at a faster rate in the evaporator than the compressor can suck. As a result the pressure and degree of superheat in the evaporator increase. The increase in superheat causes the valve to open more and to allow more refrigerant to enter the evaporator. At the same time, the increase in suction pressure also enables the compressor to delivery increased refrigerating capacity. When the cooling load 'decreases' the refrigerant evaporates at a slower rate than the compressor can suck. As a result, the evaporator pressure drops and the degree of superheat decreases. The valve tends to close and the compressor delivers less refrigerating capacity at a decreased suction pressure. Thus the thermostatic-expansion valve, as opposed to the automatic expansion valve, is capable of meeting varying load requirement.

Most thermostatic expansion valves are set for 5°C of superheat and are usually rated in tonnes of refrigeration.

CAPILLARY TUBE

A capillary tube is a fixed restriction-type device. It is the simplest of the refrigerant flow controls, consisting merely of a fixed length (from 0.5 m to 5 m) of small diameter (0.5 mm to 2.25 mm) tubing installed between the condenser and the evaporator, usually in place of the conventional liquid line.

The pressure drop through the capillary tube is due to the following two factors:

(i) Friction, due to fluid viscosity, resulting in 'frictional pressure drop'.

(ii) Acceleration, due to the flashing, of the liquid refrigerant into vapour resulting 'momentum pressure drop'.

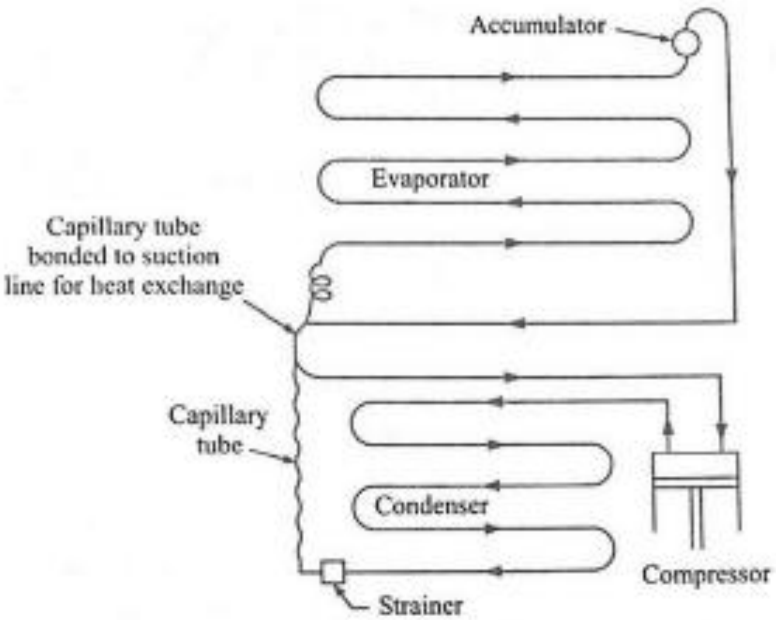


Fig. 4. Capillary tube.

The cumulative pressure drop must be equal to the difference in pressures at the two ends of the tube. The flow through the capillary tube will, therefore, adjust so that the pressure drop through the tube just equals the difference in pressures between the condenser and evaporator. For a given state of the refrigerant, the pressure drop is directly proportional to the length and inversely proportional to the bore diameter of the tube.

To obtain the desired flow and pressure drop a number of combinations of length and bore are possible for a capillary tube. However, once a capillary tube has been selected, it will be suitable only for design pressure drop. It cannot satisfy the flow requirements with changing condenser and evaporator pressures. Even then the capillary tube is most commonly used in small refrigerators, window type air-conditioners, water-coolers, etc.

Advantages:

Capillary tube claims the following advantages:

1. Simplicity.
2. Low cost.
3. Absence of moving parts.
4. It is found most advantageous with on-off control because of its unloading characteristics.

Thus when the compressor stops, allows high and low pressures to equalize, thereby enabling the compressor motor to re-start on no load. Accordingly, smaller low starting torque motors can be used.

EXPERIMENT – 3

OBJECTIVE:

To study different types of evaporators used in refrigeration system.

PREREQUISITES:

Students are required to have understanding of the following basics to enable better understanding of the practical:

1. Basic concepts of Thermodynamics and Heat Transfer.

INTRODUCTION

An evaporator is any heat transfer surface in which a volatile liquid is vapourised for the purpose of removing heat from a refrigerated space or product and also cooling its own coils. Evaporator is also called chiller, freezer or cooling coil depending upon its application. An evaporator must fulfil following three main requirements:

(i) It must have enough surface to absorb the required heat without excessive temperature difference between the refrigerant and the substance to be cooled.

(ii) It must provide sufficient space for the liquid refrigerant and also adequate space for the refrigerant vapour to separate from the liquid.

(iii) It must provide space for circulation of the refrigerant without excessive pressure drop between the intel and outlet.

Classification of Evaporators

Evaporators may be classified as follows:

(a) On the basis of operating conditions:
  1. Flooded type evaporators.
  2. Dry or direct expansion type evaporators.

(b) On the basis of construction of the surfaces:
  1. Bare-tube evaporator
  2. Plate-surface evaporator
  3. Finned-tube evaporator.

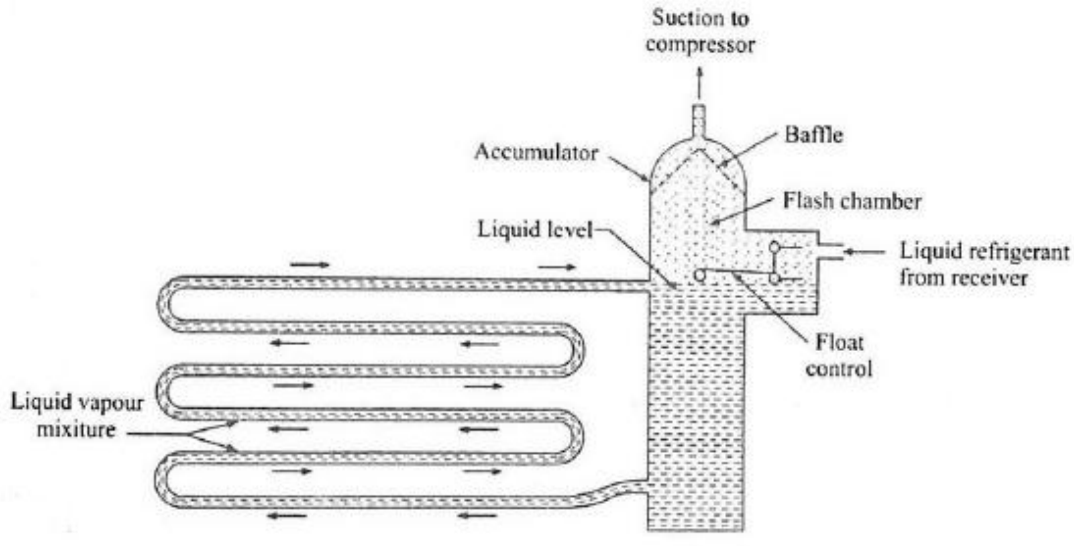
The above mentioned evaporators are discussed in the following articles.

Flooded Type Evaporators

A flooded or overfeed evaporator is one wherein the amount of liquid refrigerant circulated through the evaporator is considerably in excess of that which can be vaporised. Here a constant refrigerant liquid level is maintained. A float valve is used as the throttling device which maintains a constant liquid level in the evaporator. Due to the heat supplied by the substance to be cooled, the liquid refrigerant is vaporised and so the liquid level falls down. The float valve opens to admit more liquid and thus maintains a constant liquid level. As a result the evaporator is always filled with liquid to the level determined by the float adjustment and the inside surface is wetted with the liquid. Thus this type is called flooded evaporator. To prevent liquid carry over to compressor, accumulator is generally used with a flooded evaporator. Accumulator also serves as the chamber for the liquid level float valve. The evaporator coil is connected to the accumulator and the liquid flow from the accumulator to the evaporator coil is generally by gravity. The vapour formed by the vaporising of the liquid in the coil being lighter, rises up and passes on to the top of the accumulator from where it enters the suction line. Sometime liquid eliminators are provided in the accumulator top to prevent the possible carryover of the liquid particles from the accumulator to the suction line.

These evaporators give high rate of heat transfer as the whole surface of the evaporator coil remains in contact with liquid refrigerant. These are bulky in construction and require large amount of refrigerant for their working.

The flooded evaporators are used in large installations, especially in chemical and food processing industries.

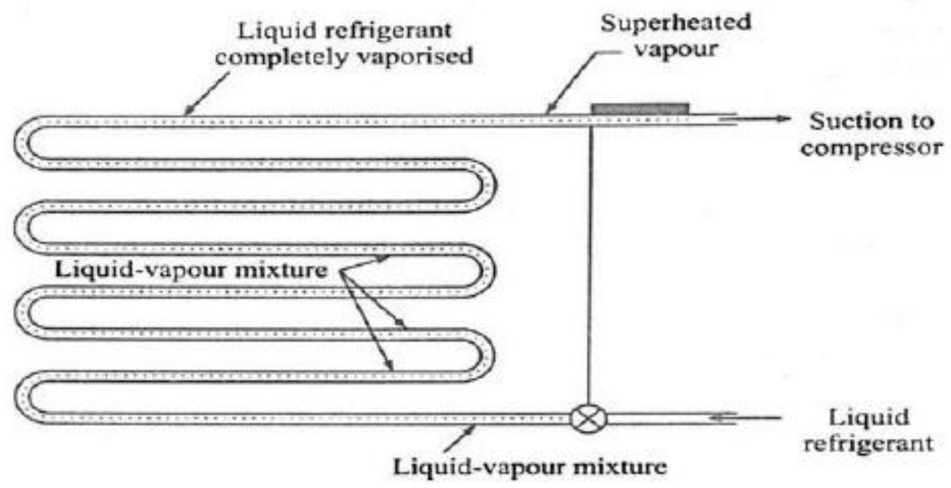


Flooded type evaporator.

Dry Expansion Evaporator

In a dry expansion evaporator the amount of liquid refrigerant fed into the evaporator is limited to that which can be completely vaporised by the time it reaches the end of the evaporator. The expansion device feeds the evaporator at such a rate that whole of the refrigerant gets gradually vaporised by the time it reaches the end of the coil. Feeler bulb of the expansion valve controls the rate of flow through the orifice of the flow control.

Such an evaporator is one of the most widely used devices for producing refrigeration and is used on systems having capacity below 150 tonnes of refrigeration.



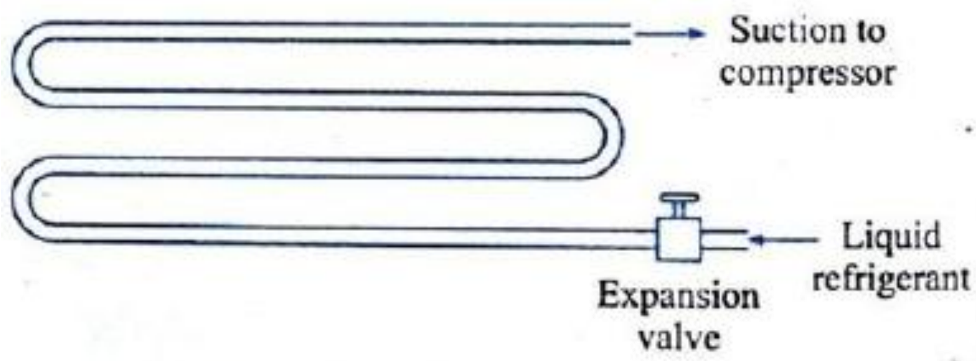
Dry expansion evaporator.

Bare Tube Evaporator

These evaporators are usually constructed of either steel pipe or copper tubing. Copper tubing is used in small evaporators using Freon as refrigerant whereas steel pipe is employed with large evaporators using ammonia as refrigerant. Bare-tube coils are available in a number of sizes, shapes and designs, and are usually bare tube evaporator and are usually custom made to the individual application.

Its use is limited to applications where the box temperatures are under 0°C and in liquid cooling, because the accumulation of ice or frost on these evaporators has less effect on the heat transfer than on those equipped with fins.

Since these, evaporators are easier to clean. They are also extensively used in household refrigerators.



Bare tube evaporator.

Plate Surface Evaporator

These evaporators are made in different designs. In some cases tubing is attached to the plates whereas in other cases two sheets may be pressed together to provide a path for refrigerant flow between them. • Such evaporators are used in domestic refrigerators or frozen food industry.

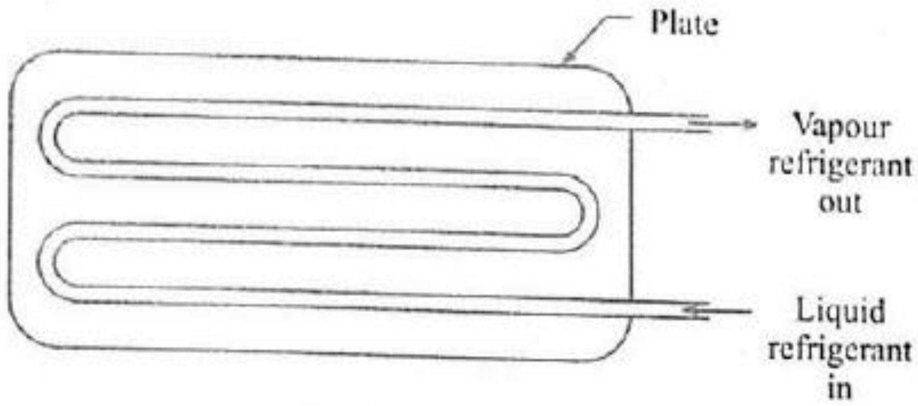
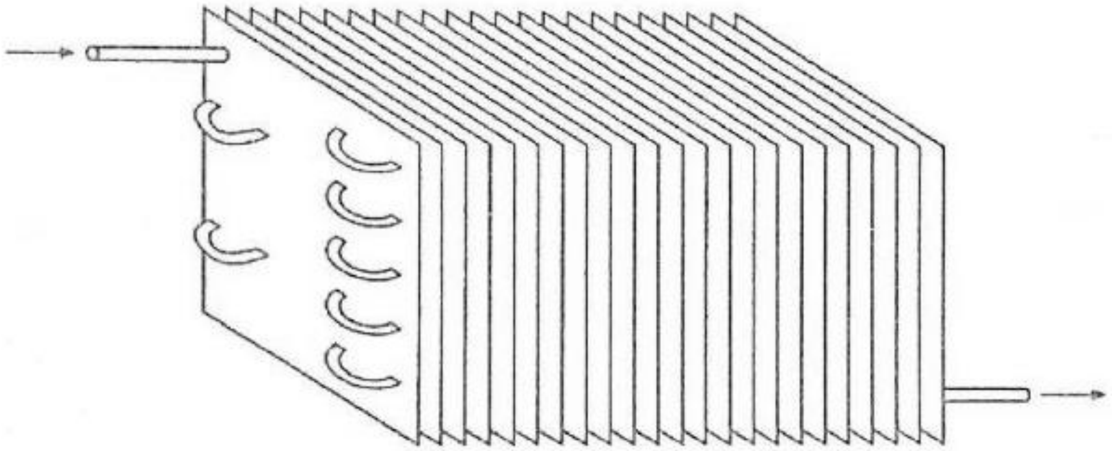


Plate surface evaporator.

Finned Tube Evaporator

Finned coils are bare-tube coils upon which metal plates or fins have been installed. The fins increase the surface area of evaporator which means increased hear transfer and capacity. The size and spacing of fins depends upon the type of application. Such evaporators have always a direct expansion feed of liquid refrigerant.

Finned tube evaporators are best suited for window type air-conditioners and other air cooling application where temperature is maintained above I °C. For such an application the capacity of evaporator is further increased by adding a fan to the finned evaporator.



Finned tube evaporator.

EXPERIMENT – 4

OBJECTIVE:

To study basic components of air-conditioning system.

PREREQUISITES:

Students are required to have understanding of the following basics to enable better understanding of the practical:

1. Basic concepts of Thermodynamics, Heat Transfer and psychrometry.

The purpose of an air conditioner is to maintain a comfortable indoor environment.
The comfort is determined by a combination of 3 factors:

- Temperature.
- Humidity.
- Air Distribution.

For this reason, the main purposes of air conditioners are to:

- Control room temperatures (cooling/heating).
- Control room humidity levels (drying, humidifying).
- Optimise air flow (circulation, distribution).
- Clean the air (filtration).

An Air Conditioner Consists of Four Main Sections:

Refrigerant circuit components: Circulation of the refrigerant and radiation of heat. (Compressor, evaporator, condenser, capillary tube, etc.).

Ventilation System: Distribution of air (indoor) Heat dissipation (outdoor). (Fan, filter, duct etc.).

Electrical parts: Climate control (Starting relay, over load protector, thermostat, and motor).

Other: Unit casing, etc.

Refrigerant circuit components

Compressor: Compresses the refrigerant from low pressure (low temperature) to high pressure (high temperature). This conversion raises the boiling point to higher temperature levels, facilitating elimination of the heat brought by the outdoor air.

Condenser: This component receives gas at high pressure and high temperature from the compressor. In air-cooled condensers, the metallic surfaces cool the gas which changes status and turns to liquid. In the case of water-cooled condensers, it is the circulation of the water that produces the same cooling effect.

Evaporator: After expansion refrigerant enters in to evaporator it absorbs heat from the surrounding air and produces cooled air.

Expansion Device: A narrowing of a tube connected along the line between the condenser and the evaporator with diameters ranging from 1 to 2 mm. and lengths ranging between 1 and 2 m.

Ventilation System:

Fan: following two types of fans may be used for the transmission of air:

1. Centrifugal fan:
   Centrifugal fan may have following three types of blades:
   a. Radial or straight blades.
   b. Forward curved blades.
   c. Backward curved blades.
2. Axial flow fan:
   Axial fans are divided into following three groups:
   a. Propeller fan.
   b. Tube axial fan.
   c. Vane axial fan.

Electrical System:

1. *Starting Relay:* It is used to provide necessary starting torque required to start the motor.
2. *Overload Protector:* It is used to protect the compressor motor winding from damage due to excessive current, in the event of overloading due to some fault.
3. *Thermostat:* A thermostat is used to control the temperature in the refrigerator. The bulb of the thermostat is clamped to the evaporator.

EXPERIMENT – 5

OBJECTIVE:

Experiment on air-conditioning test rig & calculation of various performance parameters.

PREREQUISITES:

Students are required to have understanding of the following basics to enable better understanding of the practical:

1. Basic concepts of Thermodynamics, Heat Transfer and psychrometry.
2. Understanding of refrigeration cycle.

Test Rig Specification:

Compressor	ISI, hermetically sealed, reciprocating compressor
Condenser	Fin tube type air cooled condenser with variable speed fan
Evaporator	Fin & Tube (copper) type
Refrigerant	Freon, R-22
Fan Blower Set	Standard Make
Control Panel	➢ Suction pressure gauge for low pressure measurement ➢ Discharge pressure gauge for High pressure measurement ➢ Expansion Device ➢ Filter/Drier ➢ High pressure cutout ➢ Main switch, digital type voltmeter, ampere meter, energy meter. ➢ Digital temperature Indicator fitted with RTD thermocouple.
Voltage	Single phase, 220 V, 50 Hz AC supply.

THEORY:

The performance of Air-Conditioning system is expressed in terms of COP. The COP of air conditioning system is given by:

$$C.O.P. = HR/Power\ Input$$

where,

HR is heat removed = $m.C_P.\Delta T$

m = mass of air supplied /sec

C_p = specific heat of air
$\Delta T = T_1 - T_2$
T_1 = surrounding air temperature.
T_2 = duct air temperature.
$m = V_a/V_{sa}$
V_a = quantity of air supplied m^3/sec
V_{sa} = area of duct × velocity of air

$$= L \times B\sqrt{2(P_{stag} - P_{stat})/\rho}$$

P_{stag} = Stagnation or Total Pressure
P_{stat} = Static Pressure
Power Input: measured from energy meter.

PROCEDURE:

Switch on the power supply to system i.e. start the compressor simultaneously start fan blower motor also. Now compressed refrigerant passing through the condenser and after condensing. It goes to evaporator, where due to cooling effect air, which is sucked by blower cools.

After few minute the air at the outlet of air duct will become cool at that time. And also measure the static and total pressure by using V-tube manometer and pilot tube.

OBSERVATION TABLE:

S.No.	T_1	T_2	P_{stag}	P_{stat}	Energy meter reading (kWh)		
					Initial (a)	Final (b)	C = (b – a)
1							
2							
3							
4							

CALCULATIONS:

RESULT:

PRECAUTIONS:

1. Run the system for quite some time before taking readings.

2. Note down number of revolutions of energy meter carefully with the help of stop watch.
3. Insure considerable cooled air output from air duct.
4. The system should not switch OFF immediately after once switched ON.
5. The control valve of pressure and compound gauge should open partly; when it is required to measure pressure otherwise valves must be closed.
6. Do not twist any pipe line and handle all switches valves very carefully only as and when required.

EXPERIMENT – 6

OBJECTIVE:

Experiment on Ice-plant.

PREREQUISITES:

Students are required to have understanding of the following basics to enable better understanding of the practical:

1. Basic concepts of Thermodynamics, Heat Transfer and psychrometry.
2. Understanding of refrigeration cycle.

Test Rig Specification:

Compressor	ISI hermetically sealed reciprocating type.
Condenser	Air Cooled- Standard make.
Ice Plant Tank	Mild Steel (Thermally Insulated)
Cooling Coil	Water Immersed type
Ice Cans	Made of G.I. Sheet.
Primary refrigerant	Freon, R-22
Secondary Refrigerant	Brine.
Control Panel	➢ Expansion device (Thermostatic Expansion Valve). ➢ Drier. ➢ Pressure gauges. ➢ Main switch, digital type voltmeter, ampere meter, energy meter. ➢ Digital temperature Indicator fitted with RTD thermocouple.
Voltage	Single phase, 220 V, 50 Hz AC supply.

THEORY:

The ratio of heat removed to work input is called the co-efficient of performance of a refrigerating machine.

$$COP = \text{Heat output} / \text{Power input}$$

$$= m.\ C_p \Delta T / Kwh$$

where

m = Mass of water is ice cane in kg.
C_p = Specific heat of water = 4.18
ΔT = Temperature (in K) drop of ice cane water in unit time.
kWh = Power consumed by the compressor in unit time.

PROCEDURE:

Fill the water in ice canes. The measured quantity of water should be filled. And keep the ice canes in brine tank and close the door. Switch on the power supply to compressor, at the time of starting note down the initial temperature of ice cane water and energy meter reading. Also switch on the stop on the stop watch take the readings of ice cane temperature and energy meter at the interval of 5 minutes. Take enough set of readings for considerable difference in temperature. Finally, Switch off the compressor and drain the ice can water.

OBSERVATION TABLE:

S.No.	Mass of Water (Kg)	Temperature			Energy Meter reading		Time (sec)
		Initial (T_1)	Final (T_2)	ΔT	Initial	Final	
1							
2							
3							
4							

CALCULATIONS:

RESULT:

PRECAUTIONS:

1. Run the system for quite some time before taking readings.
2. Note down number of revolutions of energy meter carefully with the help of stop watch.
3. Do not open the door of Ice Box.
4. Measure time precisely.
5. Once experiment is over, drain water from Ice canes.
6. Do not twist any pipe line and handle all switches valves very carefully only as and when required.

EXPERIMENT – 7

OBJECTIVE:

Study of window air conditioner.

PREREQUISITES:

Students are required to have understanding of the following basics to enable better understanding of the practical:

1. Basic concepts of Thermodynamics, Heat Transfer and psychrometry.

Window air conditioner is sometimes referred to as room air conditioner as well. It is the simplest form of an air conditioning system and is mounted on windows or walls. It is a single unit that is assembled in a casing where all the components are located.

This unit has a double shaft fan motor with fans mounted on both sides of the motor. One at the evaporator side and the other at the condenser side.

The evaporator side is located facing the room for cooling of the space and the condenser side outdoor for heat rejection. There is an insulated partition separating this two sides within the same casing.

THEORY:

Front Panel

The front panel is the one that is seen by the user from inside the room where it is installed and has a user interfaced control be it electronically or mechanically. Older unit usually are of mechanical control type with rotary knobs to control the temperature and fan speed of the air conditioner. The newer units come with electronic control system where the functions are controlled using remote control and touch panel with digital display. The front panel has adjustable horizontal and vertical (some models) louvers where the direction of air flow are adjustable to suit the comfort of the users. The fresh intake of air called VENT (ventilation) is provided at the panel in the event that user would like to have a certain amount of fresh air from the outside.

Indoor Side Components

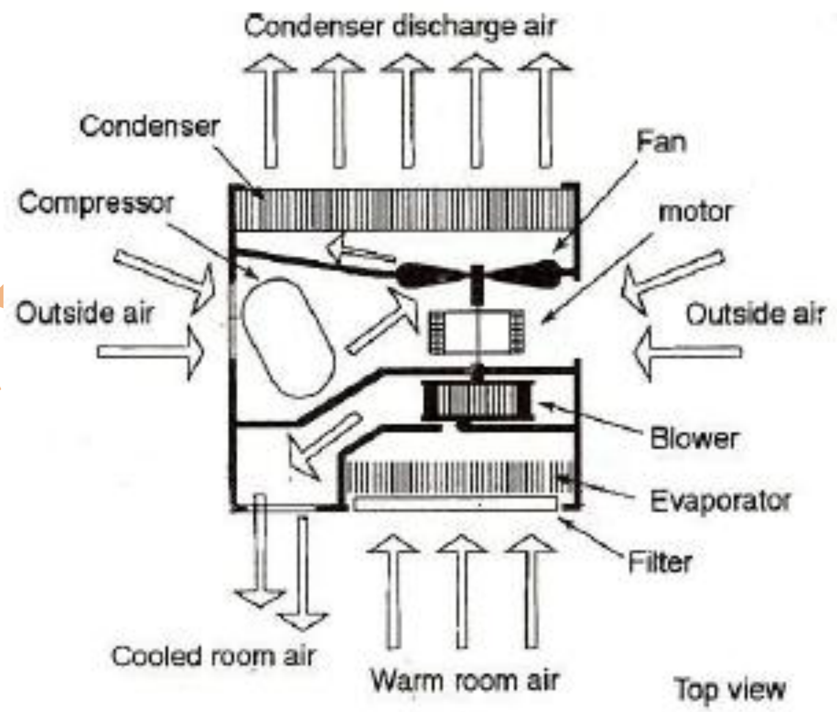
The indoor parts of a window air conditioner include:

Cooling Coil with an air filter mounted on it. The cooling coil is where the heat exchange happens between the refrigerant in the system and the air in the room.
Fan Blower is a centrifugal evaporator blower to discharge the cool air to the room.
Capillary Tube is used as an expansion device. It can be noisy during operation if installed too near the evaporator.
Operation Panel is used to control the temperature and speed of the blower fan. A thermostat is used to sense the return air temperature and another one to monitor the temperature of the coil. Type of control can be mechanical or electronic type.
Filter Drier is used to remove the moisture from the refrigerant.
Drain Pan is used to contain the water that condensate from the cooling coil and is discharged out to the outdoor by gravity.

Outdoor Side Components

The outdoor side parts include:

Compressor is used to compress the refrigerant.
Condenser Coil is used to reject heat from the refrigerant to the outside air.
Propeller Fan is used in air-cooled condenser to help move the air molecules over the surface of the condensing coil.
Fan Motor is located here. It has a double shaft where the indoor blower and outdoor propeller fan are connected together.



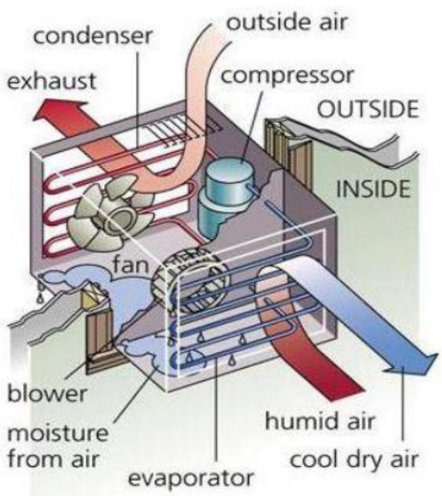
Operations

During operation, a thermostat is mounted on the return air of the unit. This temperature is used to control the on or off of the compressor. Once the room temperature has been achieved, the compressor cuts off. Usually, it has to be off for at least 3 minutes before turning on again to prevent it from being damaged. For mechanical control type, there is usually a caution to turn on the unit after the unit has turned off for at least 3 minutes. For electronic control, there is usually a timer to automatically control the cut-in and cut-out of compressor.

The evaporator blower fan will suck the air from the room to be conditioned through the air filter and the cooling coil. Air that has been conditioned is then discharge to deliver the cool and dehumidified air back to the room. This air mixes with the room air to bring down the temperature and humidity level of the room. The introduction of fresh air from outside the room is done through the damper which is then mixed with the return air from the room before passing it over the air filter and the cooling coil. The air filter which is mounted in front of the evaporator acts as a filter to keep the cooling coil clean to obtain good heat-transfer from the coil. Hence, regular washing and cleaning of the air filter is a good practice to ensure efficient operation of the air conditioner.

Heat Pump Window Air Conditioner

In temperate countries, heating of the room is required. A heat pump window air conditioner unit is able to cool the room during summer and heat the room during winter. A reversing valve (also known as 4-Way-Valve) is used to accomplish this. During heating operation, it reverses the flow of the refrigerant which results in the evaporator to act as a condenser and the condenser as evaporator.



EXPERIMENT – 8

OBJECTIVE:

Study of hermetically sealed compressor.

PREREQUISITES:

Students are required to have understanding of the following basics to enable better understanding of the practical:
Compressor function in refrigeration cycle, types of compressor, hermetically sealed compressor.

Hermetically Sealed Compressor:

A hermetic or sealed type compressor are directly connected on electric motor, the motor and compressor operates on the same shaft and are enclosed in common casing. Compact units of this type are used almost exclusively in domestic refrigeration and also in home cold storage plants, drinking fountains, ice cream and food displayed cabinets. They are made to operate on either the reciprocating or rotary principle and may be mounted with the shaft in either in the vertical or horizontal position. The rpm is same for compressor and motor. The one- piece housing provides for quietness and minimum of vibration. In addition, the seal and compiling are eliminated. The motor operates in an ideal atmosphere. As it is entirely enclosed no airborne dust can reach it. Important sub-systems in hermetically sealed compressor are as under.

a. ***Suction & discharge of refrigerant:*** Service valves are used for suction, discharge refrigerant to compressor. It is also used to connect pressure gauge. For filling refrigerant to compressor initially, charging valve is also present.
b. ***Cooling:*** suction gas at 10 to 15 degree C cools the motor and shell. Also the compressor has oil-cooling tube, which cools the lubricating oil in compressor & placed in the form of a loop at the bottom. Refrigerant & cooling through this tube takes heat from lubricant & dissipate in oil cooler placed just above the tubing.
c. ***Anti slug device:*** An anti slug device consisting basically of two assemblies. One is the centrifuge, press fitted on the crankshaft, rotates at the speed of compressor. The refrigerant is drawn in through the h in the top. Any liquid or oil is expelled through the slots on the side by centrifugal force & the gas being lighten is drawn through the slots in the hub. The second assembly collects the gas and directs it to the cylinder heads.

d. ***Power transmission mechanism:*** a 230-v electric power supply is given to the stator through relay. The rotor which has crank shaft generally rotates. The crankshaft through e reciprocates. The refrigerant is sucked & discharged through suction read & flapper valve plate.

e. ***Lubrication system:*** The lubricating oil along with refrigerant is discharged during compression. Lubricating oil travels on high-pressure side up to capillary tube only and from here major lubricating oil return back to compressor. Oil separated by oil separator is collected at lower part of the compressor in sump from where it is led to piston - cylinder assembly and other moving parts by splash lubrication. Care should be taken to use the standard, directed lubricating oil only for particular type of refrigerant, otherwise it may form sludge, wax when mixed with the refrigerant.

1. Take out the oil from the dome of the compressor through suction or charging line.
2. Cut the welding of dome with the help of hacksaw and separate the two halves of the dome.
3. Clean the dome properly.
4. Take out the compressor motor assembly from the dome by removing spring attached to the dome.
5. Remove the suction and discharge mufflers and study their function.
6. Open the valve assembly.
7. Note the construction of suction valve.
8. Note the construction of discharge valve and retainer and spring for discharge valve.
9. Study the working of both valves.
10. Rotate the crankshaft and note how the motion is transferred from crankshaft to the piston.
11. Also note the type of crankshaft used.
12. Dismantle the crankshaft and connecting rod.
13. Also separate the piston from the connecting rod by taking out the piston pin.
14. Note whether the piston rings are available or not.
15. Note the material of each part and their functions.
16. See if there is any defect with any part and note it.
17. Remove the defect by repairing or changing the part if required.
18. See if there is any defect in electric motor with the help of a multi meter and note it.
19. Get it rectified from the electrician if there is any defect. Now assemble the parts in correct sequence using the proper size gaskets.

REFERENCES

1. Refrigeration and Air conditioning, C.P Arora, Tata-McGraw Hill, 2009
2. Refrigeration and Air conditioning, W.F. Stoecker & J.W. Jones, McGraw-Hill
3. Principles of Refrigeration, Roy.J Dossat, Pearson Education 2009
4. Refrigeration and Air conditioning by P.L. Ballaney
5. Experimental Methods for Engineers by Jack P. Holman, McGraw Hill, 1999.
6. Mechanical Experiments and Workshop Practice, G. S. Sawhney, I K International Publishing House Pvt. Ltd, 2010