U.C.P.ENGG.SCHOOL,BERHAMPUR-10

DEPARTMENT OF MECHANICAL ENGINEERING

REFRIGERATION AND AIR CONDITIONING

LAB MANUAL

Vision & Mission

Vision of the Institute:

To be a leading technical institute that provides excellent education to create human resources of high standard for the society and industry.

Mission of the Institute:

1. To develop state of the art facilities for technical education.
2. To create a well experienced faculty that understands need of the society and industry.
3. To provide resources that make faculty and students keep abreast of industry.

Vision of the Department of Mechanical Engineering:

To produce human resources of high standard in mechanical engineering who can contribute favorably to the technological and socioeconomic development of the nation.

Mission of the Department of Mechanical Engineering:

1. Develop state of the art facilities related to mechanical engineering.
2. Make the students competitive for employment or higher studies in highly esteemed organizations/institutions.
3. Encourage to solve problems of society implementing technical knowledge.

EXPERIMENT NO.-1

AIM OF THE EXPERIMENT: To study the construction features of Domestic Refrigerator

APPARATUS REQUIRED:

Sl.no.	EQUIPMENT	SPECIFICATION	QUANTITY
01	Domestic Refrigerator		1

THEORY :

A vapor compression refrigeration system is now days used for all purpose of refrigeration. It uses a refrigerant sealed in air tight and leak proof mechanism. The refrigerant is circulated through the system and undergoes a number of changes in its state while passing through various parts of the system. The refrigerant (R-12) absorbs heat from one place and releases it to other place.

MECHANISM OF DOMESTIC REFRIGERATOR: A domestic refrigerator consists of 5 essential parts.

1. **COMPRESSOR :**
   The low pressure and temp. Vapor refrigerant from evaporator is drawn into the compressor through the inlet or suction valve, where it is compressed to a high pressure and temp..This high pressure and temperature vapour refrigerant is discharged into the condenser through the delivery valve.
2. **CONDENSOR:**
   The condenser or cooler consists of coils or pipes in which the high pressure and temp. vapor refrigerant is cooled and condensed. The refrigerant while passing through the condenser, gives up its latent heat to the surrounding condensing medium which is normally air or water.
3. **RECEIVER:**
   The condensed liquid refrigerant from the condenser is stored in a vessel is known as receiver from where it is supplied to the evaporator through the expansion valve.
4. **EXPANSION VALVE:**
   It is also called throttle valve or refrigerant control valve. The function of the expansion valve is to allow the liquid refrigerant under high pressure and low temp. to pass at a controlled rate after reducing its pressure and temp.
5. **EVAPORTAOR:**
   An evaporator consists of coils of pipe in which the liquid vapour refrigerant at low pressure and temp. is evaporated and changed into vapor refrigerant at low pressure and temp. During evaporating the liquid vapor refrigerant absorbs its latent heat of vaporization from the medium which is used to be cooled.

WORKING PRINCIPLE:

The low pressure vapor in dry state drawn from the evaporator during the suction stroke of the compressor. During compression, the pressure and temp.is increased. When the high pressure refrigerant vapor enters the condenser, heat flows from condenser to cooling medium, thus allowing the vaporized refrigerant to return to the liquid state.

After condensation, the liquid refrigerant is stored in the liquid receiver. Then it is passed through the expansion valve, where the pressure is reduced sufficiently to allow the vaporization of the liquid at a low temp. The low pressure refrigerant vapor after expansion enters the evaporator where heat is absorbed by it and the cycle is completed.

CONCLUSION:

We successfully studied about the construction features of domestic refrigerator

EXPERIMENT NO.-2

AIM OF THE EXPERIMENT: To study the construction features of water cooler.

APPARATUS REQUIRED:

Sl no	Equipment	Specification	Quantity
01	Model of water cooler		1

THEORY :

The purpose of water cooler is to make water available at a constant temp. irrespective of ambient temp. .

They are meant to produce cold water at about 7^0 C to 13 ^{0}C (280K to 286K) for quenching the thirst of the people working in hot environment.

The temp. of the cold water is controlled with the help of a thermostatic switch set with in7^0 C to 13 ^{0}C range.

There are two types of water cooler.

1. Storage type water cooler
2. Instantaneous type water cooler

STORAGE TYPE WATER COOLER:

- The evaporator coil is soldered onto the wall of the storage tank of the cooler.
- The tank may be galvanized steel or stainless steel sheets. The water level inthe tank is maintained by float valve.
- In this type of water cooler, the machine will run for a long period to bringdown the temp. Of the mass of the water in storage tank.
- When the water is drawn from the cooler and an equal amount of fresh wateris allowed in the tank, the temp. will rise up slowly and the machine starts again.

INSTANTANEOUS TYPE WATER COOLER:

- In this type of water cooler the evaporator consists of two separate cylindrical woundcoil made up of copper or stainless steel tube.
- The evaporating refrigerant is in one of the coil and the water to be cooled is in theother coil.
- The water cooled by the refrigerant in evaporator by conduction.
- These water cooler are further classified as (a) Bottle type (b) Pressure type (c)

Self-contained remote type .

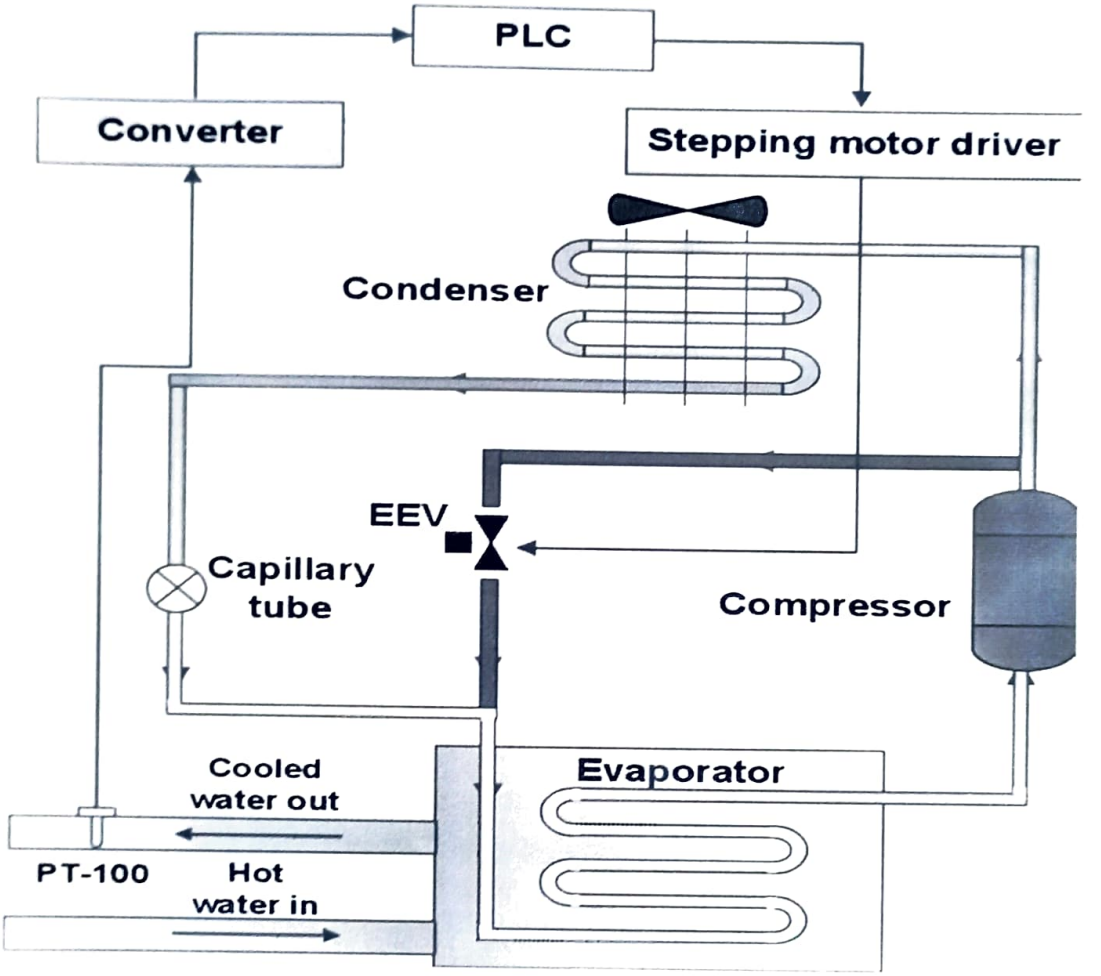


Fig. Schematic diagram of water cooler

CONCLUSION : We have successfully studied about water cooler.

EXPERIMENT NO.-3

AIM OF THE EXPERIMENT: To study the construction features of window air conditioner

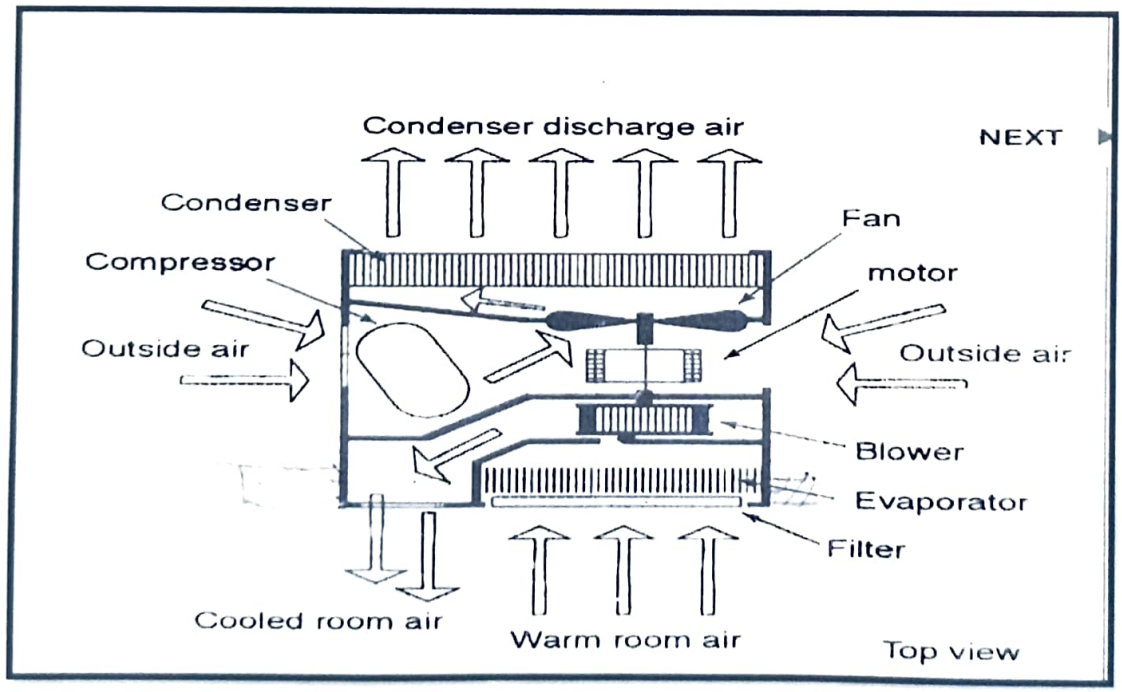
APPARATUS REQUIRED: Window air conditioning trainer.

THEORY: 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 refrigeration 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 these two sides within the same casing.

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 a 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 refrigeratn 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.

CONCLUSION: We have successfully studied the construction of window air conditioner

EXPERIMENT NO.-4

AIM OF THE EXPERIMENT:

To study the construction features of split air conditioner

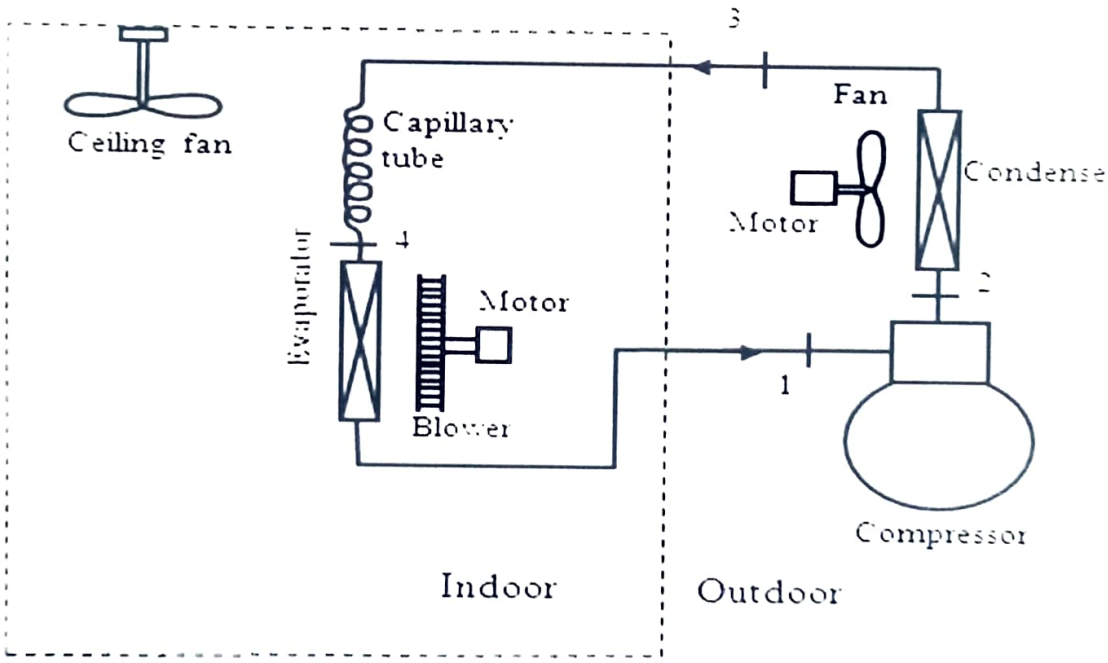
APPARATUS REQUIRED:

Sl No	Equipment	Specification	Quantity
01	Split A.C	1 Ton Cap.	1

THEORY

Split air-conditioner:

A split air conditioner is a suitable alternative to wall, window, or centralized air conditioner systems. Often called mini-split, ductless split, or duct-free air conditioning, this system can adequately cool a standard-sized house without requiring extensive installation costs and efforts.



A split air conditioner is made up of two primary parts that a very familiar: the evaporator and the compressor. Both of these elements exist is more common central air units and wall air conditioners. The difference with a mini-split system is that they are separated into two different, distant components, one being outdoors and one being indoors. The outdoor section is a compressor that initiates the cooling process, while the indoor componet.

The two sections are connected with a set of electrical wires and tubing, also called lines, used to transport air between the two sections. It's these lines that allow the split AC to be considered ductless, and the fact that the wires and tubing are so small and discreet compared to large ducts is where the "mini" split name comes from.

Function

The compressor is controlled by an internal thermostat. As the thermostat detects warm air, it activates the outdoor compressor. The compressor circulates a refrigerant gas, increasing the pressure and temperature of the refrigerant as it compresses it through a series of pipes. The refrigerant then moves to the condenser for further processing.

In the condenser, a cooling system removes heat from the high-pressure gas and the gas changes phase and becomes a liquid. This chilled liquid is pushed through tubing indoors until it reaches the evaporator system.

Inside the home, the evaporator fan collects warm air and passes it through a chamber containing the chilled liquid refrigerant. The fan system blows this air, which has now been cooled, back into the room, lowering the overall temperature of the space. If the thermostat still detects air that is warmer than desirable, the process continues, and the refrigerant and any excess heat that remains in the system are passed back outdoors to the compressor in order to begin the cycle again.

Benefits of Split Air Systems

Less Energy Loss

A Split air conditioner is compact and isolated between two localized component sections, so there is very little opportunity for heat and other energy to escape the system. Centralized air conditioning systems waste enormous amounts of energy due to heat exchange in the air conditioner duct system. However, this problem is virtually eliminated in a split air conditioner system.

Less Heat Loss

Split air conditioner systems are preferable to window and wall air conditioning units as well. Although the latter are small and easy to install, they do not

provide reliable cooling to a large space or to multiple rooms. Even with thoroughly sealed windows and walls, these air conditioner units allow for heat to enter the space, partially negating the effects of the system.

Targeted Heating and Cooling

Additionally, it's possible to have more than one indoor evaporator and fan. You could have one in each room or area of your home and run them each independently with only one outdoor compressor. This combines the efficiency and customization of a space heater or fan with the convenience of central air.

CONCLUSION :

We have successfully studied the split air conditioner

EXPERIMENT NO.-5

AIM OF THE EXPERIMENT:

To determine the capacity and cop of vapor compression Refrigerator test rig

APPARATUS REQUIRED :

SL NO	EQUIPMENT	SPECIFICATION	QUANTITY
01	VCRS Test Rig	Vapor Compression test rig.	1

THEORY:

The vapor compression refrigeration system is now a days used for all purpose of refrigeration. It uses a refrigerant sealed in air tight an leak proof mechanism through the system and the refrigerant is circulated through the system and under goes a number of changes in its state. While passing through various parts of the system, the refrigerant absorbs heat from one place to another.

CONSTRUCTION:

A simple vapor compression refrigeration system mainly consists of a compressor, condenser, receiver, expansion valve and evaporator. The compressor consists of an arrangement in which an electric motor is provided. The condenser is made in a coil shaped receipt refrigerant. A storage tank in which the liquid vapor refrigerant at a pressure is evaporated.

WORKING PROCEDURE

The low pressure vapor in dry state drawn from the evaporator during the suction stroke of the compressor. During compression, the pressure and temperature is increased. When the high pressure refrigerant vapor enters into the condenser, heat flows from condenser to cooling medium, thus allowing the vaporized refrigerant to return to the liquid state.

After condensation, the liquid refrigerant is stored in the liquid receiver. Then it is passed through the expansion valve, where the pressure is reduced sufficiently to allow the vaporization of the liquid at a low temp. The low pressure refrigerant vapor after expansion enters the evaporator where heat is absorbed by it and the cycle is completed.

TABULATION :

SL NO	Pressure in PSI		Temperature (°C)				Mass flow rate (Kg/min)
	P_1	P_2	T_1	T_2	T_3	T_4	

CALCULATION :

T_1 P_1 = Compressor inlet temp and pressure.

T_2 P_2 = Compressor outlet temp and pressure.

T_3 P_3 = Condenser outlet temp and pressure.

T_4 = Evaporator temperature.

$$\text{Relative COP} = \frac{(\text{COP})\text{actual}}{(\text{COP})\text{theoritical}}$$

$(COP)_{actual}$= **Q/W**

Q = Heat extracted in the evaporator in KJ

= $m_w X C_{pw} X (T_{4\ initial} - T_{4\ final})$

Where m_w= Mass of water taken in the evaporator in Kg

C_{pw}= Sp. Heat of water = 4.187 KJ/Kg K

W = Work input in KJ.W can be directly found from the energy meter reading after 30 min. of running. We get the meter reading after 30 min is 0.2 Kwh = 0.2 K X J/S

COP_{Actual}= Q/W

$$(COP)_{theoretical} = \frac{h1-h4}{h2-h1}$$

From Pressure gauge we get P_1 =

P_2 =

1 bar = 14.5 psi1 psi = 1/14.5 bar By using these two pressure we can get h_1 h_2 $h_3 = h_4$ from P-h chart is as follows. PSI = Pound per Square Inch

CONCLUSION:

We successfully studied about the refrigeration tutor and found the value of COP.

EXPERIMENT NO.-6

AIM OF THE EXPERIMENT: To Deterimine capacity and COP of water cooler.

APPARATUS USED: Water cooler trainer.

THEORY: Temperature–entropy diagram

That results in a mixture of liquid and vapour at a lower temperature and pressure as shown at point 4.The cold liquid-vapour mixture then travels through the evaporator coil or tubes and is completely vaporized by cooling the warm air (from the space being refrigerated) being blown by a fan across the evaporator coil or tubes. The resulting refrigerant vapour returns to the compressor inlet at point 1 to complete the thermodynamic cycle.

The above discussion is based on the ideal vapour-compression refrigeration cycle, and does not take into account real-world effects like frictional pressure drop in the system, slight thermodynamic irreversibility during the compression of the refrigerant vapour, or non-ideal gas behaviour (if any).

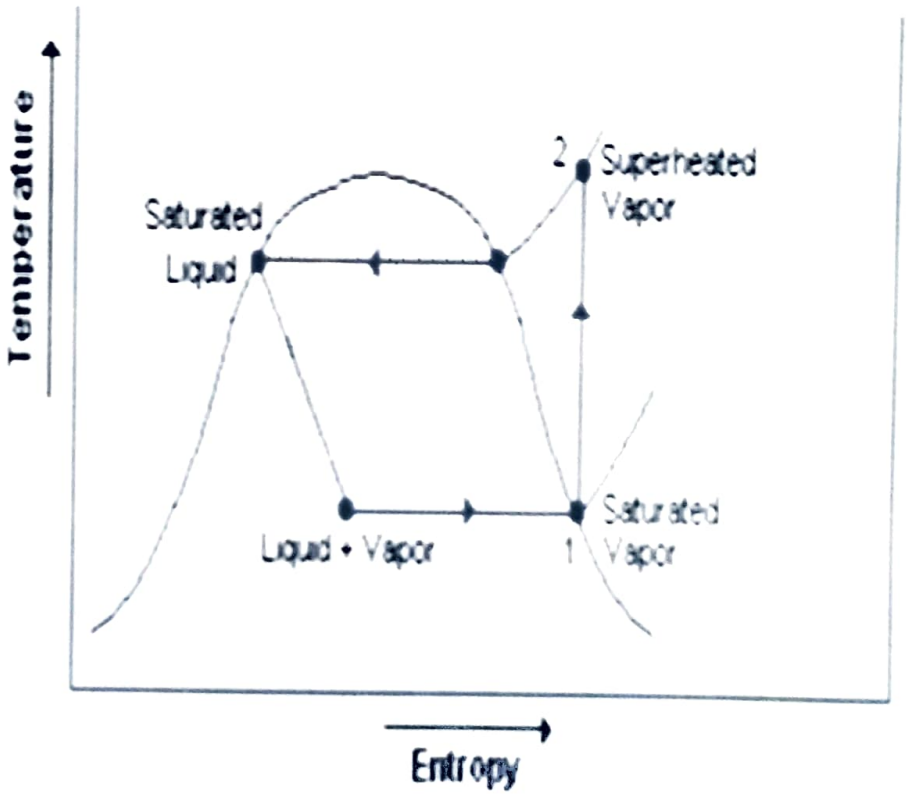


Figure: T-S diagram of vapour compression refrigeration system

OBSERVATION TABLE

S.NO	P1	P2	T1	T2	T3	T4	MR
1.							
2.							
3.							

Coefficient of performance: - The coefficient of performance is defined as the ratio of heat extracted in the evaporator to the work done on the refrigerant

C.O.P. = Q/W

Using points (P1,T1) ; (P2,T2) ;T3 and T4 locate points 1,2,3,4 on the p-h chart for R-22 and obtain the enthalpy values H1, H2, H3, H4

THEORETICAL C.O.P.= H1-H4/H2-H1

Result: The C.O.P. of the system is.....

EXPERIMENT NO.-7

AIM OF THE EXPERIMENT: - To Determine Capacity and cop of window air-conditioner

APPARATUS REQUIRED: - Compressor, Condenser, Evaporator, Capillary Tube, Ammeter, Voltmeter.

THEORY: -

Air conditioning equipment is used to maintain controlled atmospheric conditions as per required. The controlled atmospheric conditions may be required for human comfort or manufacturing processes of engineering goods. Air conditioning systems are classified in two groups.

1. Packed Units

2. Central Unit

A packed unit is self-contained unit, because complete unit including compressor, evaporator, condenser, fan motor etc. are kept in a common enclosure. Capacity of packed or window AC is 1 to 1.5 T.R. This AC is mounted with the room which is required for controlled atmosphere.

A window AC mainly consists of following sub-assemblies:

1. System assembly includes compressor, condenser, evaporator, expansion device, and filter.

2. Motor with blower & fan assembly includes, a double ended shaft motor, a fan and a motor and suitable bracket for it.

3. Cabinet and air distributing assembly – it includes a cabinet as enclosure for whole system, an air distributing system.

4. Control panel assembly – it includes the switched those required to control the entire AC system as per the requirement, IC temperature, humidity etc.

The AC Test Rig is designed and fabricated, to determine the performance and to study its working principle. The AC test Rig consist a 1.5 T sealed compressor unit, a finned condenser(heating coil) and evaporator (cooling coil), a double ended (shaft) motor to run fan and blower simultaneously and fitted on a wooden stand and properly covered by grill.

A duct is assembled along with blower unit as a carrier of comfort air, the velocity of the air passing through the coil is measured by using a pilot tube fitted in duct itself an tube manometer which is fitted on control panel. The control panel is fitted over compressor and fan blower assembly. Control panel consist of 1 phase energy meter to measure power consumed by compressor, a Rota meter to measure flow rate of refrigerant pressure gauge to measure pressure of discharge side compound vacuum gauge to measure suction side pressure, a digital temperature indicator to measure temperature at various places. The desired temperature find out by changing position of selector switch with it. A voltmeter andammeter is also fitted on control panel.

Specifications of AC Test Rig:

Compressor	: Hermetically sealed compressor 1.5 T.R. with starting and running capacitor.
Refrigerant	: R – 22
Pressure gauge	: 0.300 PSI
Suction gauge	: - 30-0-150 PSI
Rota meter	: 0-5 L L PM
Fan blower motor	: 1 / 30 HP 1- 0
Condenser & evaporator	: Double row finned.

Window type air conditioner

The performance of an air-conditioning system is expressed in terms of co-efficient of performance. And COP is the ratio of net refrigerating effect and power supplied to do the work

i.e. COP = Rn / W

Where Rn = heat removed by system = m. Cp⊗T

m = mass of air supplied / minute.

Cp = Specific heat of air

⊘T = Difference in temperatures.

T1 – T2

T1 = Surrounding temperature

T2 = Air duct temperature

Mass of circulated air can be calculated by

$m = Va / Vsa$

Where Va = Quantity of air supplied m3 / min.

Vsa = Area of duct x velocity of the air.

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

ρ = mass density of air

P (stag) = Stagnation or total pressure.

P (stat) = Static pressure

W = Power input time and measured by energy meter reading.

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. 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.

Temperature sensor details: -

1. T1 = Temperature Sensor : Fixed at Compressor Discharge Line
2. T2 = Temperature Sensor : Fixed after Condenser
3. T3 = Temperature Sensor : Fixed after Capillary Tube
4. T4 = Temperature Sensor : Inside Cooling Tank
5. T5 = Temperature Sensor : Fixed at Compressor Suction Line.

Observation Table

S No	T1	T2	P stag	P stat	P Total	No. of revolution	W = Total power consumed

Sample Calculation

COP = m. Cp⊗T / KWh = 20 x 4.187 x (12) / 245 x 3.9

And C O P = m. Cp⊗T / W

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.

Result: -

EXPERIMENT NO.-10

AIM OF THE EXPERIMENT:

Complete charging of domestic refrigerator and its leak test.

PRIOR KNOWLEDGE:

Different types of commonly used refrigerants along with their properties (i.e. physical, chemical and thermodynamic), the effect of undercharge or overcharge of refrigerant, the effect of non condensable on the performance of the system.

DESCRIPTION:

It is well known that the moisture, air and other non-condensable are very harmful for the refrigeration system. The moisture present may choke capillary tube and also if moisture is combined with hydrochloric and hydrofluoric acids they are having ill effects on the system. The presence of air and non-condensable increases the head pressure of the system. As the head pressure goes higher, the compressor motor draws more current. Also higher head pressure reduces the refrigeration capacity of the unit appreciably. The temperature rise of the compressor accelerates the chemical action inside the system.From above points it is clear that moisture, air and non-condensable should be removed from the refrigeration system to the maximum possible extent. Hence before system can be charged with a refrigerant it should be thoroughly evacuated and dehydrated by drawing a high vacuum. If this is not done at the initial stage itself, a clean system can near be attained. After the completion of erection the plant should be checked and the refrigerant should be charged into the system. During working also there is chance of leakage in a refrigeration system. Finding a leakage is the job of patience. The approach should be to find leak rather then concluding that there are no leaks on a cursory check. Apart from the cost of charging refrigerant into a leaky system, a shortage of refrigerant can cause real danger to the plant.Therefore leak testing should be done periodically without fail in all seriousness and with full concentration.

LEAK TEST METHODS:

Different leak testing methods one employed for different types of refrigerants.

1. AMMONIA, R12, R22:

i) SULPHUR TEST METHOD: Burning sulphur stick shows a dense white smoke if ammonia is present. The burning sulphur stick is passed around all the joints and suspected leaky points for the appearance of smoke. This test is applicable for tracing minute leaks only.

ii) SOAP BUBBLE TEST: This test may not be very effective to trace very minute ammonia

leak as it is soluble in water. Fortunately, ammonia is having plungent odor, a heavy leak can be easily detectable.

iii) LITMUS TEST: Wet litmus paper (Phenolpthalene paper) which turns red in contact with ammonia can also be used to detect leaks.

2. HALOGENATED REFRIGERANTS:

Soap solution, Halogen leak detector, Halide torch and Electronic leak detectors are the methods used to trace leaks in halogenated refrigerants

i) HALOGEN TORCH:A halogen torch can detect minute leaks, which are not possible to trace with soap solution. The presence of trace of refrigerant can change the light blue colour of the detector flame to green or deep blue. The end of the explorer tube of the detector is carefully passed over the joints and suspected leakage points. If there is a leak, the refrigerant can be drained in with the suction effect at the end of the explorer tube to the hot copper or brass portion of the burning torch. The refrigerant reacts with the metal to form copper chloride, which produces the color change in the flame.

A well maintained halogen torch is claimed to detect leaks of the order of about 15 gram per year.

ii) Electronic Leak Detector: This is an electrical instrument. In this also an explorer tube is used to suck the refrigerant from the leaky points to an instrument. A vibrator is provided to suck the refrigerant through the explorer tube. A filter is also provided at the tip of the tube to prevent atmospheric dirt entering the instrument. A heating element in the tube heats the refrigerant drawn in and the refrigerant creates a variation in the current flow of the instrument. The extent of variation of the current is an indication of the amount of leak. The current variation is read on the dial of the instrument. The change of current actuates a relay which operates an indicating light.

These detectors are capable of detecting refrigerant leaks of the order of about 0.3 gm per year. The electronic leak detector is a very sensitive instrument and should be handled and stored carefully.

CHARGING PROCEDURE FOR REFRIGERANT:

The vacuum pump mounted on the charging kit is of rotary type. Also metering system is provided so that we can charge sufficient quantity of refrigerant.

PURGING:

Many times during the operation of the system, the air leaks inside the system. It is necessary to remove the air for maintaining the efficiency of the system. Owing to the presence of air in

a system, the high-side pressure and load on condenser increase. The method of removing air from the system is known as purging. During purging, the compressor discharge valve is intermittently opened for few seconds at a time. Air and few grams of refrigerant vapor escape under high-pressure. A noticeable pressure and temperature drop in the system occurs and normal operating pressure is established. The refrigerant is added from outside if excessive purging is occurred.

CONCLUSION:

The refrigeration system must be free from non-condensable and correct quantity of refrigerant must be there in the system for good performance. At the time of charging of refrigerant the lubricating oil of required grade must be added to the compressor.