EXPERIMENT No: 1

AIM:
Study on parts of refrigerator.

THEORY:

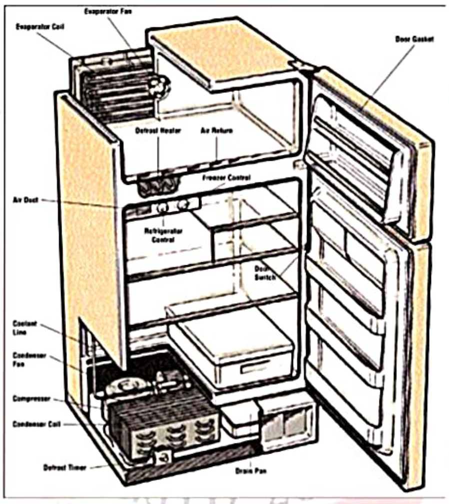

Figure 1: Vapor Compression Test Rig

A vapour compression refrigeration system is an improved type of air refrigeration system in which a suitable working substance, termed as refrigerant is used. It condenses and evaporates at temperatures and pressures close to the atmospheric conditions.
The refrigerant used does not leave the system but is circulated throughout the system alternately condensing and evaporating. The vapour compression refrigeration system is now days used for all-purpose refrigeration. It is used for all industrial purpose from a small domestic refrigerator to a big air conditioning plant.

The vapour compression refrigeration cycle is based on the following factor:
1. Refrigerant flow rate.
2. Type of refrigerant used.
3. Kind of application viz air-conditioning, refrigeration, dehumidification etc.
4. The operation design parameters.
5. The system equipments/ components proposed to be used in the system.

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The vapour compression refrigeration cycle is based on a circulating fluid media, viz, a refrigerant having special properties of vaporizing at temperatures lower than the ambient and condensing back to the liquid form, at slightly higher than ambient conditions by controlling the saturation temperature and pressure. Thus, when the refrigerant evaporates or boils at temperatures lower than ambient, it extracts or removes heat from the load and lower the temperature consequently providing cooling.
The super-heated vapour pressure is increased to a level by the compressor to reach a saturation pressure so that heat added to vapour is dissipated/ rejected into the atmosphere, using operational ambient conditions, with cooling medias the liquid from and recycled again to form the refrigeration cycle.
The components used are:
1. Evaporator
2. Compressor
3. Condenser and receiver
4. Throttling device

The refrigeration cycle can be explained schematically in the two diagrams i.e.. Pressure enthalpy diagram Temperature entropy diagram.

The working of vapour compression refrigeration cycle and function of each above component is given below.

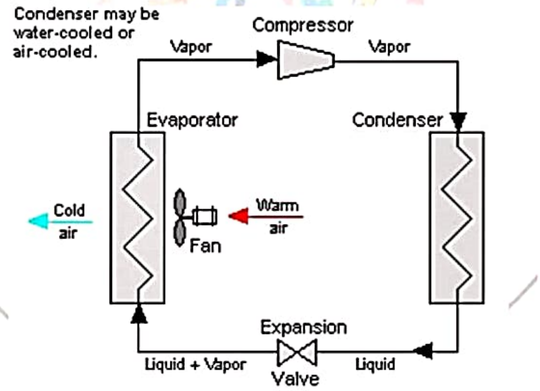
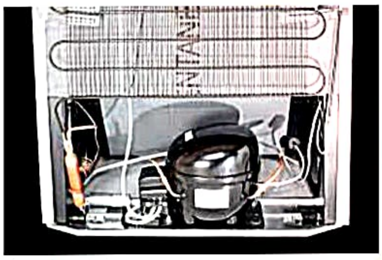


Figure 2: Components of vapour refrigeration system

Evaporator:
The liquid refrigerant from the condenser at high pressure is fed through a throttling device to an evaporator at a low pressure. On absorbing the heat to be extracted from Media to be cooled, the liquid refrigerant boils actively in the evaporator and changes state. The refrigerant gains latent heat to vaporize at saturation temperature/ pressure and further absorbs sensible heat from media to be cooled and gets fully vaporized and super heated.

Compressor:
The low temperature, pressure, superheated vapour from the evaporator is conveyed through suction line and compressed by the compressor to a high pressure, without any change of gaseous state and the same is discharge into condenser. During this process heat is added to the refrigerant and known as heat of compression ratio to raise the pressure of refrigerant to such a level that the saturation temperature of the discharge refrigerant is higher than the temperature of the available cooling medium, to enable the super heated refrigerant to condense at normal ambient condition. Different types of compressors are reciprocating, rotary and centrifugal and are used for different applications.



Condenser:
The heat added in the evaporator and compressor to the refrigerant is rejected in condenser at high temperature/ high pressure. This super heated refrigerant vapour enters the condenser to dissipate its heat in three stages. First on entry the refrigerant loses its super heat, it then loses its latent heat at which the refrigerant is liquefied at saturation temperature pressure. This liquid loses its sensible heat, further and the refrigerant leaves the condenser as a sub cooled liquid. The heat transfer from refrigerant to cooling medium (air or water) takes place in the condenser. The sub-cooled liquid from condenser is collected in a receiver (wherever provided) and is then fed through the throttling device by liquid line to the evaporator.

There are several methods of dissipating the rejected heat into the atmosphere by condenser. These are water-cooled, air cooled or evaporative cooled condensers.
In the water-cooled condenser there are several types viz. Shell and tube, shell and coil, tube in tube etc. In Evaporative cooled condenser, both air and water are used. Air-cooled condensers are prime surface type, finned type or plate type. The selecting of the type depends upon the application and availability of soft water.

Throttling device:
The high-pressure liquid from the condenser is fed to evaporator through device, which should be designed to pass maximum possible liquid refrigerant to obtain a good refrigeration effect. The liquid

line should be properly sized to have minimum pressure drop.

The throttling device is a pressure-reducing device and a regulator for controlling the refrigerant flow. It also reduces the pressure from the discharge pressure to the evaporator pressure without any change of state of the pressure refrigerant.

The types of throttling devices are:

1.Capillary tubes 2. Hand expansion valves 3. Thermostatic expansion valve

The most commonly used throttling device is the capillary tube for application upto approx. 10 refrigeration tons. The capillary is a copper tube having a small dia-orifice and is selected, based on the system design, the refrigerant flow rate, the operating parameters (such as suction and discharge pressures), type of refrigerant, capable of compensating any variations/ fluctuations in load by allowing only liquid refrigerant to flow to the evaporator.

CONCLUSION:
Various components of the vapour compression system have been studied

AIM:
Study on compression system.

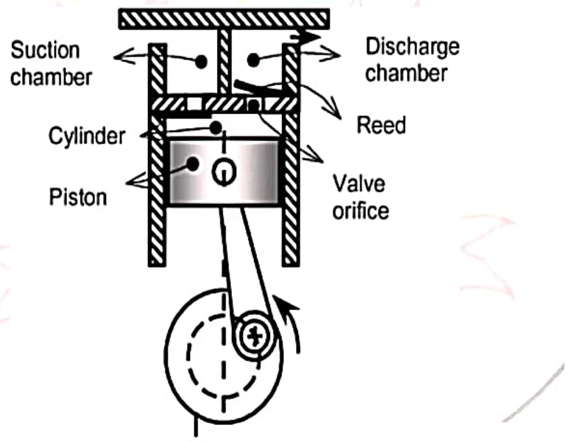
APPARATUS USED:
Model of Reciprocating, Centrifugal and Rotary compressor

THEORY:

1. **Reciprocating compressor:**

The compressors in which the vapour refrigerant is compressed by reciprocating motion of the piston are called reciprocating compressors. These compressors are used for refrigerant which have comparatively low volume per Kg and a large differential press. Such as NH_3(R-717), R-12, R-22. The reciprocating compressors are available in sizes as small as ½ KW which are used in small domestic refrigeration and up to about 150 KW for large capacity.

The single acting compressors usually have their cylinder arranged vertically radially or in 'V' or 'W' form. The double acting compressors usually have their cylinder arranged horizontal.



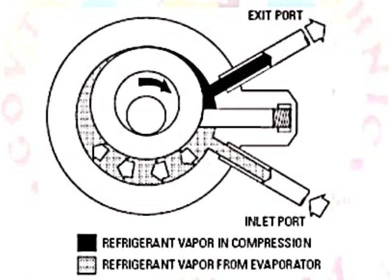
When the piston moves downwards, the refrigerant left in the clearance space expands. Thus, the volume of the cylinder increase and the pressure inside the cylinder decreases. When the pressure become slightly less then the valve gets opened and the vapour refrigerant flows into the cylinder. This flow continuous until the piston reaches the bottom of the stroke. At bottom of the stroke, the suction valve closes because of spring action. Now, when the piston moves upwards, the volume of the piston moves upwards, the volume of the cylinder decreases and the pressure inside the cylinder increases. When the pressure inside the cylinder becomes greater than that on the top of the discharge valve, the discharge valve gets opened & the vapour refrigerant is discharged into the condenser and the cycle is repeated.

2. **Rotary compressor:**

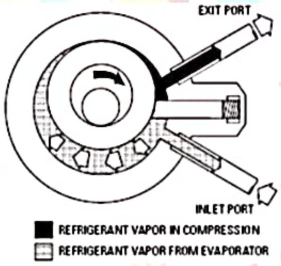
In rotary compressor, the vapour refrigerant from the evaporator is compressed due to movement of blades. The rotary compressors are positive displacement type compressor. Since, the clearance in rotary compressors is negligible; therefore, they have high η_{vol}. These may be used for refrigerants like R-12, R-22, and R-144 & NH_3.
The two types of rotary compressors are: -

a. **Single stationary blade type**
b. **Rotating blade type**

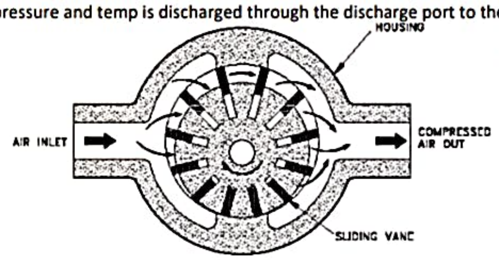
Single stationary blade type consists of a stationary cylinder, a roller and a shaft. The shaft has an eccentric on which the roller is mounted. A blade is set into the slot of a cylinder in such a manner that it always maintains contacts with a sloter by means of a spring. The blade moves in and out of the slot to follow the rotor when it rotates. Since the blade separates the suction and discharge parts, therefore it is often called a sealing blade. When the shaft rotates, the roller also rotates the roller rotates so that it always touches the cylinder wall.



Rotating Blade type consists of a cylinder and a slotted rotor containing a number of blades. The centre of the rotor is eccentric with the centre of the cylinder. The blades are forced against the cylinder wall by the centrifugal action during the rotation of the motor. The low pressure and temperature vapour refrigerant from the evaporator is drawn through the suction port. As the rotor turns, the suction



Rotating Blade type consists of a cylinder and a slotted rotor containing a number of blades. The centre of the rotor is eccentric with the centre of the cylinder. The blades are forced against the cylinder wall by the centrifugal action during the rotation of the motor. The low pressure and temperature vapour refrigerant from the evaporator is drawn through the suction port. As the rotor turns, the suction vapour refrigerant entrapped between the two adjacent blades is compressed. The compressed refrigerant at high pressure and temp is discharged through the discharge port to the condenser.



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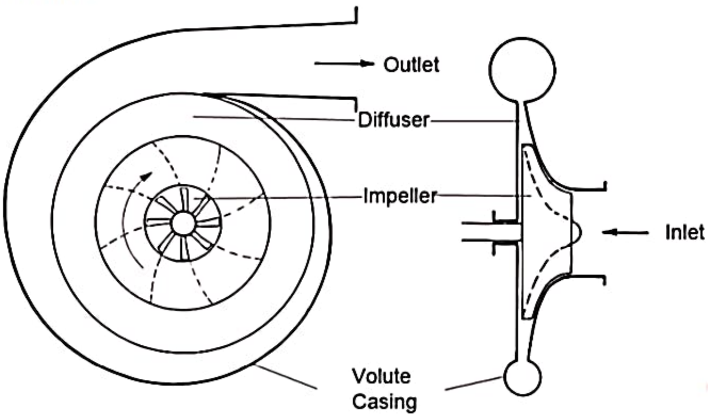
3. Centrifugal Compressor

The centrifugal compressor increases the pressure of low pressure vapour refrigerant to a high pressure by centrifugal force. The centrifugal compressor is generally used for refrigerants that require large displacement and low condensing pressure, such as R-12. However, the refrigerant R-12 is also employed for large capacity applications and low-temperature applications.

A single stage centrifugal compressor, in its simplest form, consists of an impeller to which a number of curved vanes are fitted symmetrically. The impeller rotates in an air volute casing with inlet and outlet points. The impeller draws in low pressure vapour refrigerant from the evaporator. When the impeller rotates, it pushes the vapour refrigerant from the centre of the impeller to its periphery by centrifugal force. The high speed of the impeller leaves the vapour refrigerant at a high velocity at the vane tips of the impeller. The kinetic energy thus attained at the impeller outlet is converted into pressure energy when the high velocity vapour refrigerant passes over the diffuser. The diffuser is normally a vane less type as it permits more efficient part load operation which is quite and it further converts the kinetic energy into pressure energy before it leaves the refrigerant to the evaporator.



CONCLUSION:

Various compression systems were studied.

PRACTICAL 6: TO DETERMINE C.O.P. AND APPARATUS DEW POINT OF AN AIR CONDITIONING TEST RIG.

Objective:

- To determine C.O.P. of air-conditioning test rig.
- To determine apparatus dew point of air-conditioning test rig.

Theory:

Previously the air conditioning for human comfort was considered luxury in most of the countries but now a days it is a necessity. Therefore air conditioning industry is growing fastly throughout the world. Due to increase in population and industrialization the uncomfort may be due to the inadequate supply of oxygen or unbearable temperature. Full air conditioning does the automatic control of an atmospheric environment either for comfort of human being or animals or for the proper performance of some industrial or scientific processes. The purpose of air conditioning is to supply sufficient volume of clean air containing a specific amount of water vapour and at a temperature capable of maintaining predetermined atmospheric conditions.

In brief the air conditioning the space signifies.

1. Temperature Control: You can enjoy a perfect constant temperature because of the control of not only cooling but also heating.
2. Humidity Control: The room can be humidified or dehumidified.
3. Air Filtering, Cleaning and Purification: The room is cleaned by removing dust and dirt from the air.
4. Air movement and Circulation: Air which is cleaned and controlled in temperature and humidity is distributed throughout the room. As a result, room air can be maintained evenly.

Description of Setup:

The equipment consists of a hermetically sealed compressor, air cooled condenser, blower for air circulation through a duct mounted on a frame, an evaporator is placed in the duct, also there are heaters of suitable capacity in the duct. The refrigerant used in the system is R22. The mass flow rate of air through duct can be varied by arrangement provided on the blower unit. The humidity of air is increased by introducing steam generated in small boiler. The relative humidity of air at inlet and outlet can be measured by noting dry / wet bulb temperatures. The duct is insulated from outside to avoid heat loss. The control panel consists of switches, voltmeter, ammeter etc. as well as energy meter for measuring the power consumption of compressor. The refrigeration circuit and duct are mounted on a fabricated frame.

Technical Specifications:

1. Compressor : Hermetically sealed type.
2. Condenser : Air cooled type, cooling fan driven by motor.
3. Rotameter : Eureka make, range 6.1-61 LPH, calibrated for R22
4. Thermostatic Expansion valve : Danfos make no
5. Evaporator : Evaporator fitted in the duct size 10" x 10" x 3 row.
6. Blower unit : To force air through the duct 1HP 3 phase motor.
7. Heater fitted in the duct after the evaporator: 2kw
8. Steam generator to generate steam with suitable piping for introducing steam in the duct- 8 litre capacity, with 2 kw heater.

a) Pressure gauges for measurement of pressures.
b) HP & LP cut outs:
c) Energy meter for compressor with EMC ____ R/kwh.

Experimental Procedure:

The demonstration of the following processes can be done on the test rig.

1. Cooling process.

5. Evaporator : Evaporator fitted in the duct size 10" x 10" x 3 row.
6. Blower unit : To force air through the duct 1HP 3 phase motor.
7. Heater fitted in the duct after the evaporator: 2kw
8. Steam generator to generate steam with suitable piping for introducing steam in the duct- 8 litre capacity, with 2 kw heater.

a) Pressure gauges for measurement of pressures.
b) HP & LP cut outs:
c) Energy meter for compressor with EMC_____ R/kwh.

Experimental Procedure:

The demonstration of the following processes can be done on the test rig.

1. Cooling process.
2. Heating process.
3. Cooling with dehumidification process.
4. Heating with humidification. Process.

Cooling Process: (Sensible cooling)

It is cooling with out subtraction of moisture is termed as sensible cooling. The cooling can be achieved by parsing the air over cooling coil like evaporating coil of refrigeration cycle.

Heating Process:

Heating of air without addition of moisture is termed sensible heating. The heating can be achieved by passing air over heater in the duct. The process is represented as below in psychometric chart:

Cooling with Dehumidification:

In this process cooling along with humidification is carried out it is represented as below:

Heating with Humidification:

It is represented as given below.

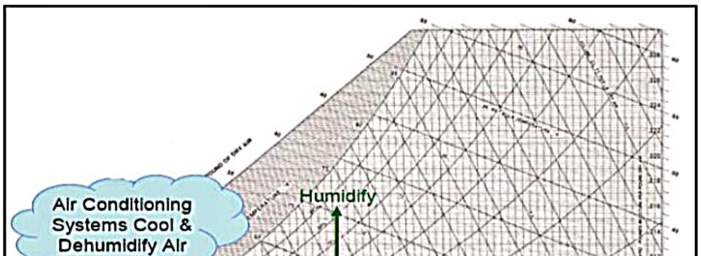
for starting the test rig. Put 'ON" the air condenser fan and run it for 2-3 minutes.

1. Then start blower with suction full open.
2. Now put 'ON' the compressor switch, so that refrigeration cycle may produce refrigeration effect.
3. Run the plant for achieving steady temperature at condenser and Evaporator.
4. Measure the air velocity in the duct by using anemometer.
5. Note down the following observations.

Observation Table:

Conducting Trials and Measured Reading:

1. Condenser pressure = __________kg/cm²
2. Evaporator pressure = __________kg/ cm²
3. (a) Temperature of gas at inlet to condenser T_{ci} = ______________°C
   (b) Temperature of gas at outlet to condenser T_{co} = ______________ °C
   (c) Temperature of gas at inlet to evaporator T_{ei} = ______________ °C
   (d) Temperature of gas at outlet = to evaporator T_{eo} = __________ °C
4 (a) Refrigerant flow rate = ___________LPH.
   (b) Dry bulb temperature of inlet air DBT1 = ________ °C
   (c) Wet bulb temperature of inlet air WBT1= ________ °C
   (d) Dry bulb temp. after evaporator DBT2 = ________ °C
   (e) Wet bulb temp. after evaporator WBT2 = ________ °C
5 Time for 10 revolutions of energy meter = _______sec.
6 Air velocity in duct = ________m/sec
7 Voltmeter reading = ________volts
8 Ammeter reading = _________Amp.



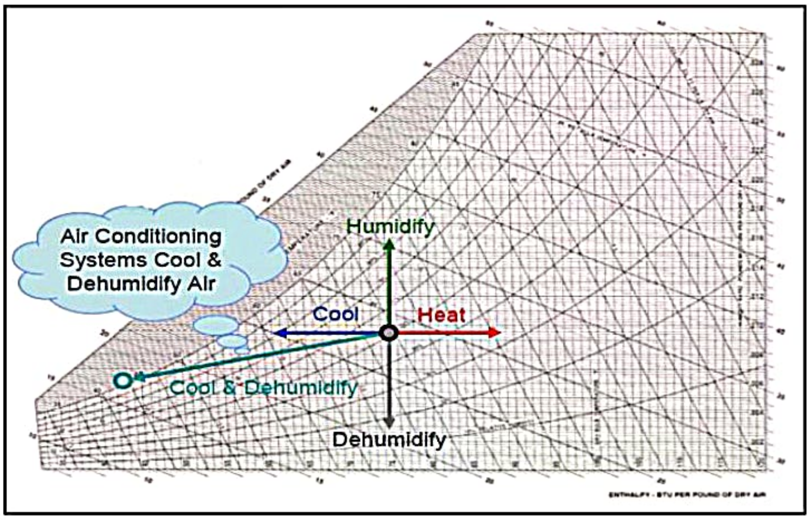


Fig 6.1 - Psychometric Chart

Calculations:

1. Theoretical COP = $\frac{Heo - Hei}{Hci - Heo}$ (Hco = Hei)

2. Actual COP = $\frac{\text{Refrigeration effect produced}}{\text{Work done}}$

3. Refrigeration effect produced = Ma x (h1 – h2).

4. Mass of air (ma) = density x volume of air

5. h1 and h2 can be calculated from psychometric chart

6. Work done by compressor = $\frac{\text{rev} \times 3600}{T \times EMC}$ watt .

7 . Relative COP = $\frac{\text{Actual COP}}{\text{Theoretical COP}}$

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8. Carnot COP = $\frac{TL}{TH - TL}$ T_H & T_L = Saturation temperature of condenser and

Conclusion:

Exercise:

1	Define Air-conditioning. Explain Central air conditioning system.
2	Classify air conditioning systems and enlist factors affecting comfort air conditioning.
3	An air refrigeration open system operating between 100 kPa and 1 MPa is required to produce a cooling effect of 2000 kJ/min. Temperature of the air leaving the cold chamber is (– 5)°C and at leaving the cooler is 30°C. Neglect losses and clearance in the compressor and expander. Determine : (i) Mass of air circulated per min, (ii) Compressor work, expander work, cycle work , (iii) COP and power in kW required.
4	A Refrigerator working on Bell-Coleman cycle takes air into the compressor at 1 bar and –50C. It is compressed in compressor to a 5 bar and cooled to 250C at the same pressure. It is further expanded in the expander to 1 bar and discharged to take cooling load. The isentropic efficiency of the compressor = 85% and the isentropic efficiency of the Expander = 90% find the following: (i) Refrigerating capacity of the system if air circulation is 40kg/min. (ii) KW capacity of motor required to run the compressor (iii) COP of the system. Take $^{\gamma}$ =1.4 Cp =1kJ/kg Cv = 0.7 kJ/kg for air.
5	An air refrigerator working on Bell coleman cycle takes in air at 1 bar and at a temperature of 100 C. The air is compressed to 5 bar abs. The same is cooled to 250 C in the cooler before expanding in the expansion cylinder to cold chamber pressure of 1 bar. The compression and expansion laws followed are $pv^{1.35} = C$ and $pv^{1.3} = C$ respectively. Determine C.O.P of the plant and net refrigeration effect per kg of air. Take Cp = 1.009 kJ/kg K and R = 0.287 kJ/kg K for air.

PRACTICAL 8: TO DETERMINE $(COP)_C$ AND $(COP)_H$ OF HEAT PUMP.

Objective:

- To determine C.O.P. of Heat pump.

Theory:

Now-a-days, energy conservation is becoming very important. Hence engineers have started using heat pump systems for commercial and industrial buildings to save energy. The heat pump is a machine that absorbs heat at one location and transfers it to another location at a different temperature. Heat pump is the modern expression for a refrigeration system In which heat discharged at the condenser is of prime importance. Thus heat pump is device which collects heat from one source and delivers it to another source using refrigeration cycle. The medium being, cooled serves as heat source.

Heat is picked up by the refrigerant, which is pumped to another higher level by the compressor and given to the medium cooling condenser so that it can be used practically. The heat pumps can be operated on low temperature heat energy using winter air, a body of water or the ground as a reservoir and rejecting heat at a higher temperature, not enough to energize heating systems.

Thus the basic heat sources that are normally used are air, water and earth. When heat pumps are installed frequently provision is made for both heating and cooling services to be supplied simultaneously to the separate zones of buildings.

Description of Setup:

Mechanical Heat Pump is a table mounted model which uses water as well as air as a heat source and sink for both cooling and heating purposes. The experiments can be done as water to water heat pump i.e. using water condenser and water evaporator and water to air heat pump i.e. using water condenser and air evaporator.

On the unit, compressor is mounted centrally and both the water and air condensers are mounted on either sides of the compressor. All the components are mounted on the main unit and the schematic layout of the Mechanical Heat Pump Is sell-explanatory.

Technical Specifications:

1. Compressor : hermetically sealed, using R-12 refrigerant.
2. Condenser : Water cooled copper tube, Shell & Coil type.
3. Rotameter : Eureka make, range 6.1-61 LPH, calibrated for R22
4. Thermostatic Expansion valve : Thermostatic expansion valve having 1/2 ton of Refrigerating Capacity.
5. Evaporator: (a) Water circulated copper tube, Shell and Coil type.
   (b) Air circulated copper tube type.
6. Multichannel Digital temperature indicator with thermocouples: 0-3000 C. with 10 C least count
7. Pressure gauges: Two Nos. for delivery and suction for measurement of pressures.
8. HP & LP cutouts: of suitable range.
9. Energy meter for compressor with EMC_____ R/kwh.

Experimental Procedure:

This experiment is performed by using water condenser and water evaporator. -

a) Start the water supply to both condenser and evaporator and adjust the flow rate to predetermine value.
b) See that pressures in both the gauges are equal.
c) Put 'ON' the main switch.
d) Check the valve positions as per given diagram.
e) Now, start the compressor cooling fan first and then start the compressor. Within a short period, clear liquid refrigerant flow will be seen in the rotameter.
f) After sometime the pressure of refrigeration cycle will become stable. Allow the plant to run for at least half an hour.
g) During testing see that water flow rates are constant and not varying.
h) Allow the plant to attain steady state. Check tor steady state by taking the readings periodically.
i) Take all readings as mentioned in the observation table. Complete one set of observations.

By varying the water flow rate of condenser, effect of sub- cooling can be studied. Similarly by varying water flow rate of evaporator, load on the plant can be varied.

a) Start the water supply to both condenser and evaporator and adjust the flow rate to predetermine value.
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Observation Table:

Conducting Trials and Measured Reading:

1. Condenser pressure = __________kg/cm²
2. Evaporator pressure = __________kg/cm²
3. Tempratures

a) Condenser Inlet T_{ci} = __________°C
b) Condenser Outlet T_{co} = __________°C
c) Evaporator Inlet T_{ei} = __________°C
d) Evaporator Outlet T_{eo} = __________°C

4) a) Refrigerant flow rate = __________LPH.
5) Time for 10 revolutions of Compressor energy meter = ________sec.

Condenser Side

1) Water Temperature
a) Inlet = __________°C
a) Outlet = __________°C
2) Water flow rate = ________LPH

Evaporator Side

1) Water Temperature
a) Inlet = ________°C
a) Outlet = ________°C
2) Water flow rate = ________LPH

Calculations:

1. Theoretical COP = $\frac{Heo - Hei}{Hci - Heo}$ (Hco = Hei)

2. Actual COP = $\frac{\text{Heat absorbed in evaporator from water}}{\text{Compressor Work}}$

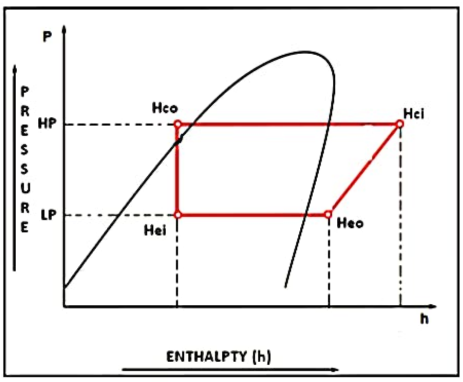

Fig 8.1- Plot the operating cycle on p-h chart

3. Heat absorbed in evaporator from water = m_e x Cp x Te

Where, m_e = Mass flow rate of water in evaporator Kg / hr

Cp = Specific heat of water 1 Kcal / Kg °C

3. Heat absorbed in evaporator from water = m_e x Cp x Te

Where, m_e = Mass flow rate of water in evaporator Kg / hr

Cp = Specific heat of water 1 Kcal / Kg °C

Te = Temp. difference of water in Evaporator

4. Work done by compressor = $\frac{860 \times 10 \times 3600}{Tc \times EMC}$ watt

Where,

Tc = Time for 10 revolutions of energymeter disc sec.

5. Relative COP = $\frac{\text{Actual COP}}{\text{Theoretical COP}}$

6. Carnot COP = $\frac{TL}{TH - TL}$

T_H = Saturation temperature of condenser pressure in °K

T_L = Saturation temperature of evaporator pressure in °K

Conclusion:

Exercise:

1	Explain Heat pump.
2	Differentiate between heat pump and refrigerator.

EXPERIMENT No: 4

Aim: To understand the different psychrometric processes and analyze the same using psychrometric chart.

THEORY: In the design and analysis of air conditioning plants, the fundamental requirement is to identify the various processes being performed on air. Once identified, the processes can be analyzed by applying the laws of conservation of mass and energy. All these processes can be plotted easily on a psychrometric chart. This is very useful for quick visualization and also for identifying the changes taking place in important properties such as temperature, humidity ratio, enthalpy etc. The important processes that air undergoes in a typical air conditioning plant are discussed below.

a) Sensible cooling:

During this process, the moisture content of air remains constant but its temperature decreases as it flows over a cooling coil. For moisture content to remain constant, the surface of the cooling coil should be dry and its surface temperature should be greater than the dew point temperature of air. If the cooling coil is 100% effective, then the exit temperature of air will be equal to the coil temperature. However, in practice, the exit air temperature will be higher than the

cooling coil temperature. Figure 28.1 shows the sensible cooling process O-A on a psychrometric chart. The heat transfer rate during this process is given by:

$$Q_c = m_a(h_O - h_A) = m_a c_{pm}(T_O - T_A) \quad (28.1)$$

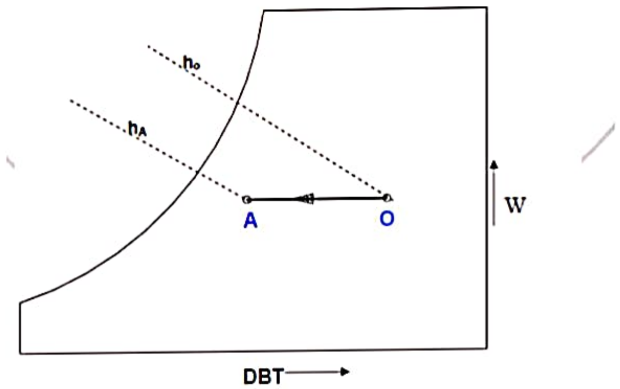

Fig.28.1: Sensible cooling process O-A on psychrometric chart

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b) Sensible heating (Process O-B):

During this process, the moisture content of air remains constant and its temperature increases as it flows over a heating coil. The heat transfer rate during this process is given by:

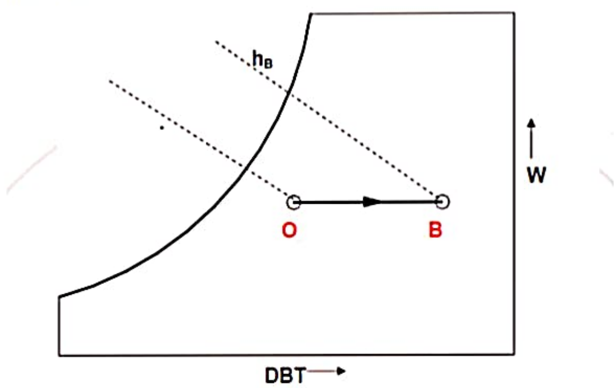


Fig.28.2: Sensible heating process on psychrometric chart

c) Cooling and dehumidification (Process O-C):

When moist air is cooled below its dew-point by bringing it in contact with a cold surface as shown in Fig.28.3, some of the water vapor in the air condenses and leaves the air stream as liquid, as a result both the temperature and humidity ratio of air decreases as shown. This is the process air undergoes in a typical air conditioning system. Although the actual process path will vary depending upon the type of cold surface, the surface temperature, and flow conditions, for simplicity the process line is assumed to be a straight line. The heat and mass transfer rates can be expressed in terms of the initial and final

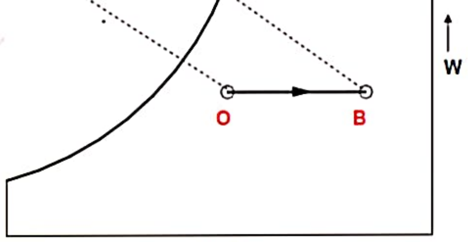


Fig.28.2: Sensible heating process on psychrometric chart

c) Cooling and dehumidification (Process O-C):

When moist air is cooled below its dew-point by bringing it in contact with a cold surface as shown in Fig.28.3, some of the water vapor in the air condenses and leaves the air stream as liquid, as a result both the temperature and humidity ratio of air decreases as shown. This is the process air undergoes in a typical air conditioning system. Although the actual process path will vary depending upon the type of cold surface, the surface temperature, and flow conditions, for simplicity the process line is assumed to be a straight line. The heat and mass transfer rates can be expressed in terms of the initial and final conditions by applying the conservation of mass and conservation of energy equations as given below:

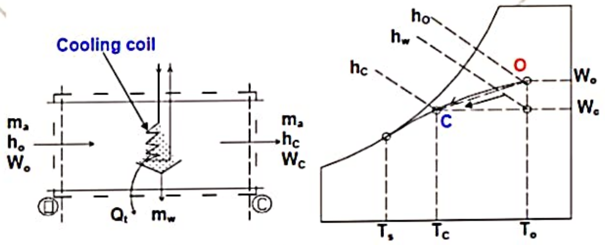


Fig.28.3: Cooling and dehumidification process (O-C)

d) Heating and Humidification (Process O-D):

During winter it is essential to heat and humidify the room air for comfort. As shown in Fig.28.5., this is normally done by first sensibly heating the air and then adding water vapour to the air stream through steam nozzles as shown in the figure.

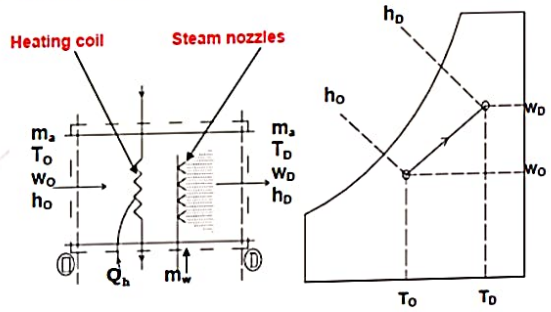


Fig.28.5: Heating and humidification process

e) Cooling & humidification (Process O-E):

As the name implies, during this process, the air temperature drops and its humidity increases. This process is shown in Fig.28.6. As shown in the figure, this can be achieved by spraying cool water in the air stream. The temperature of water should be lower than the dry-bulb temperature of air but higher than its dew-point temperature to avoid condensation (T< T< TDPT w O).

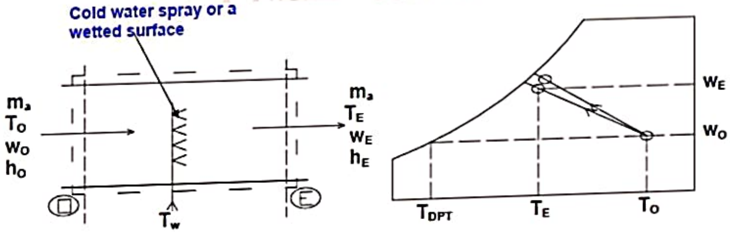


Fig.28.6: Cooling and humdification process

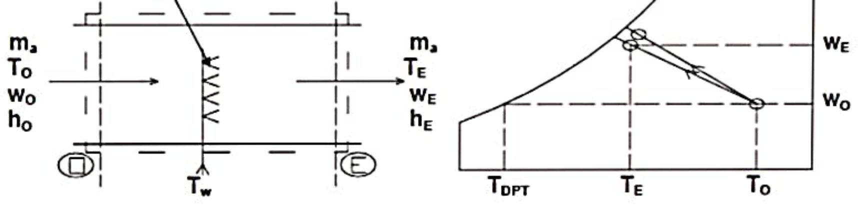


Fig.28.6: Cooling and humdification process

Aim: To calculate the cooling load of the confined space and compare the same with load estimation sheet.

The heating and cooling load calculation is the first step of the iterative HVAC design procedure; a full HVAC design involves more than the just the load estimate calculation. Right-sizing the HVAC system, selecting HVAC equipment and designing the air distribution system to meet the accurate predicted heating and cooling loads, begins with an accurate understanding of the heating and cooling loads on a space. The Air Conditioning Contractors of America (ACCA) Manual J Version 8 provides the detailed steps required to calculate the heating and cooling loads. The accurate heating and cooling loads are used to right-size the equipment with ACCA Manual S Residential Equipment Selection, then to design the air distribution system and ductwork with ACCA Manual T Air Distribution Basics for Residential and Small Commercial Buildings and ACCA Manual D Residential Duct System Procedure.

- **The Strategy Guideline: Accurate Heating and Cooling Load Calculations report provides information for the following groups:**

- Heating Ventilation and Air Conditioning (HVAC) Mechanical Contractors
- HVAC System Designers
- Builders
- House Remodelers.

- **calculations were manipulated for:**

- Outdoor/Indoor Design Conditions
- Building Components
- Ductwork Conditions
- Ventilation/Infiltration Conditions
- Worst Case Scenario (combining all the safety factors)

- **Building Components**

Building construction, proper details, and materials are critical components of the heating and cooling load calculations. The R-value of the building wall, roof, and foundation construction components can be accurately calculated using the insulation levels specified combined with the remainder of the components that make up the construction assembly (i.e. drywall, sheathing, exterior siding materials, structural framing system, roofing materials, etc.). The window performance, described by the U-value and SHGC, must be known and accurately represented by the data input. Shading provided by the overhang of eaves, insect screens, and internal blinds or shades will reduce the sensible heat gain. If

shading is ignored in the load calculation the cooling load will be inflated.

- **Heating and Cooling System Location and Duct Leakage:**

Best practice for HVAC design is to keep all ductwork within the conditioned space in order to eliminate the duct losses/gains to and from the outside conditions. Scenarios, such as the onestory slab-on-grade Orlando House, present challenges in keeping all ductwork inside conditioned spaces. In a slab-on-grade house, it is typical for an installer to put the HVAC system completely in the attic. Because it has a basement, the Chicago House does not present the same challenges to keeping the ductwork inside conditioned space. In a single-story house with a basement, the duct system is typically run in the basement, which is considered conditioned space provided the basement walls are insulated or there are supply registers in the basement. For ducts outside conditioned space, the heating and cooling loads are more sensitive to duct leakage and R-values of the duct insulation.

- **Comfort - Space Temperatures**

Short cycling limits the total amount of air circulating through each room, and can lead to rooms that do not receive adequate duration of airflow. Short cycling of an oversized system can lead to comfort complaints when the spaces located further from the thermostat do not change temperature as quickly as spaces near the thermostat. Even in an energy-efficient house with an enhanced thermal enclosure, this can lead some rooms being colder during the heating season and warmer in the cooling season. In attempt to make the spaces further from the thermostat more comfortable, the occupant may set the thermostat set point higher, requiring additional energy.

- **Comfort Humidity Control**

The risks associated with oversizing the cooling system, particularly in more humid climates, are also a concern. In the cooling season in humid climates, cold clammy conditions can occur due to reduced dehumidification caused by the short cycling of the equipment. The cooling system removes moisture from the air by passing the air across a condensing coil. The system must run long enough for the coil to reach a temperature where condensation will occur and an oversized system that short cycles may not run long enough to sufficiently condense moisture from the air. Excess humidity in the conditioned air delivered to a space may lead to mold growth within the house.

- **Space Heat Gain**

The manner in which it enters the space –

a. Solar radiation through transparent surfaces such as windows

b. Heat conduction through exterior walls and roofs

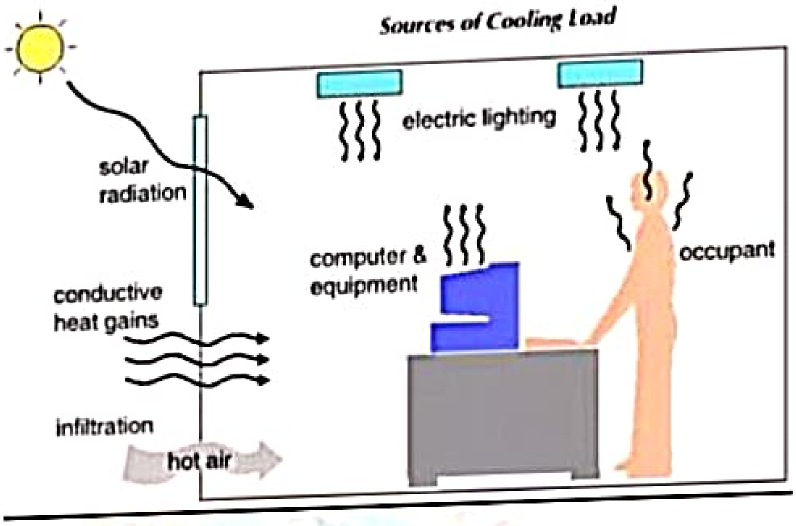
c. Heat conduction through interior partitions, ceilings and floors

d. Heat generated within the space by occupants, lights, appliances, equipment and processes

e. Loads as a result of ventilation and infiltration of outdoor air

f. Other miscellaneous heat gains

Sources of Cooling Load



Sensible heat - Heat which a substance absorbs, and while its temperature goes up, the substance does not change state. Sensible heat gain is directly added to the conditioned space by conduction, convection, and/or radiation. Note that the sensible heat gain entering the conditioned space does not equal the sensible cooling load during the same time interval because of the stored heat in the building envelope. Only the convective heat becomes cooling load instantaneously.

Sensible heat load is total of

a. Heat transmitted thru floors, ceilings, walls

b. Occupant's body heat

c. Appliance & Light heat

d. Solar Heat gain thru glass

e. Infiltration of outside air

f. Air introduced by Ventilation.

Latent Heat Loads - Latent heat gain occurs when moisture is added to the space either from internal sources (e.g. vapor emitted by occupants and equipment) or from outdoor air as a result of infiltration or ventilation to maintain proper indoor air quality. Latent heat load is total of

a. Moisture-laden outside air form Infiltration & Ventilation

b. Occupant Respiration & Activities

c. Moisture from Equipment & Appliances