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GOVERNMENT CO-ED POLYTECHNIC
MECHANICAL DEPARTMENT

Laboratory Manual

Refrigeration & Air Conditioning Lab

Diploma Vth Semester
Mechanical Engineering

GOVERNMENT CO-ED POLYTECHNIC
MECHANICAL DEPARTMENT

Dip Sem- 5 ME
Sub Code-
2037563(037)
Refrigeration & Air Conditioning Lab.

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S. No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	Mechanical Engineering	2037574 (037)	Refrigeration and Air Conditioning	70	20	30	-	-	120
2	Mechanical Engineering	2037563 (037)	Refrigeration and Air Conditioning (Lab)	-	-	-	30	50	80

LABARATORY CLASSES - INSTRUCTIONS TO STUDENTS

1. Students must attend the lab classes with ID cards and in the prescribed uniform.
2. Boys-shirts tucked in and wearing closed leather shoes. Girls' students with cut shoes, overcoat, and plait incite the coat. Girls' students should not wear loose garments.
3. Students must check if the components, instruments and machinery are in working condition before setting up the experiment.
4. Power supply to the experimental set up/ equipment/ machine must be switched on only after the faculty checks and gives approval for doing the experiment. Students must start to the experiment. Students must start doing the experiments only after getting permissions from the faculty.
5. Any damage to any of the equipment/instrument/machine caused due to carelessness, the cost will be fully recovered from the individual (or) group of students.
6. Students may contact the lab in charge immediately for any unexpected incidents and emergency.
7. The apparatus used for the experiments must be cleaned and returned to the technicians, safely without any damage.
8. Make sure, while leaving the lab after the stipulated time, that all the power connections are switched off.

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Signature of lab in charge

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EXPERIMENT No: 1

AIM:
Study on parts of refrigerator.

THEORY:

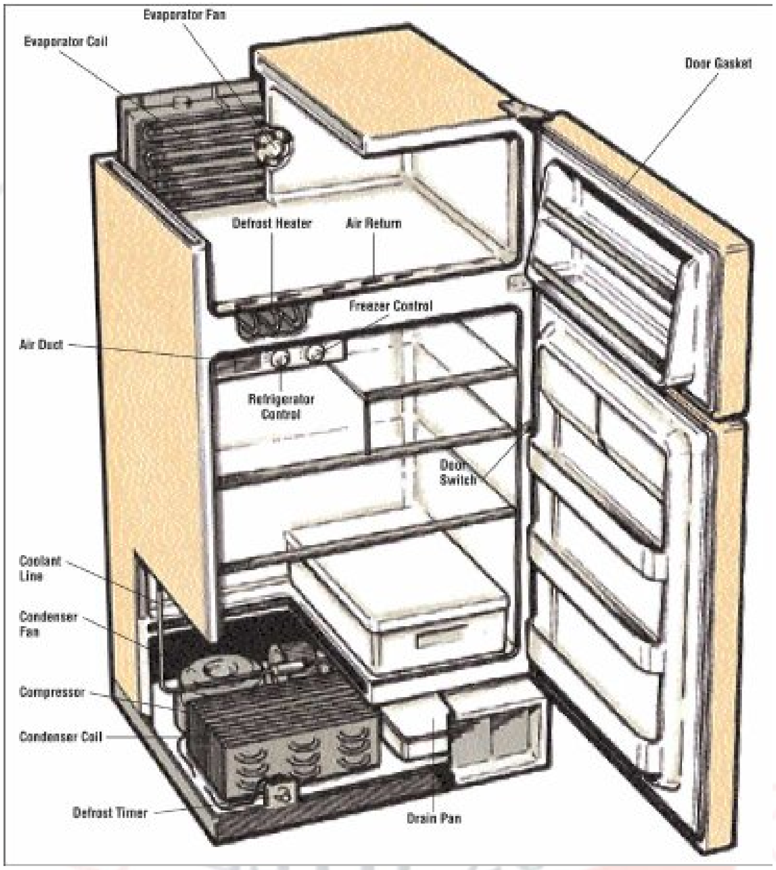


Figure 1: Vapor Compression Test Rig

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.

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.

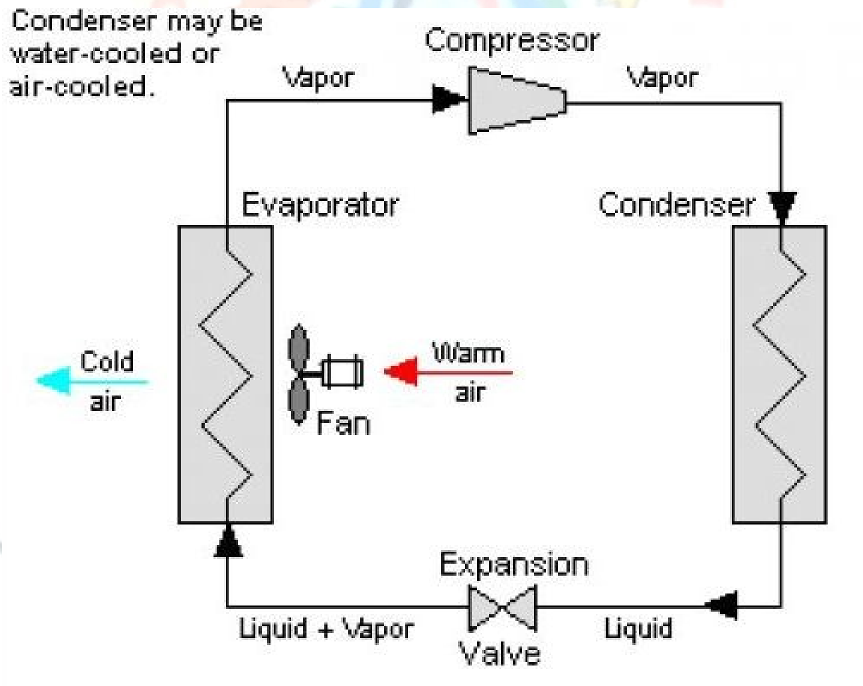


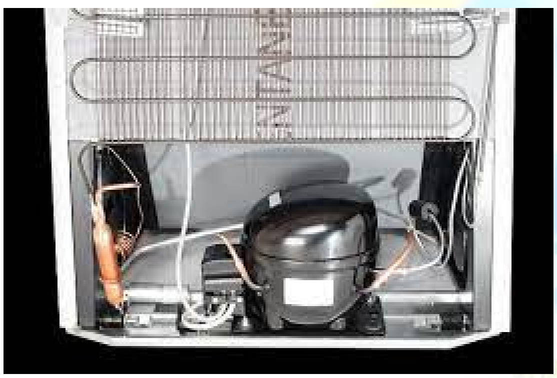
Figure 2: Components of vapour refrigeration system

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

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EXPERIMENT No:2

AIM: To study function and working of different parts of an Air Conditioning equipment.

APPARATUS:
A model of window room air conditioner.

THEORY:
A room air conditioner is a compact air conditioner unit which can be placed in a particular room for its air conditioning. The room may be an office, a residential room such as bed room, living room etc. The window type units are air cooled and are mounted in a window or wall of room to be air conditioned. They do not need any ductwork. It has a complete refrigeration plane, i. e. compressor, condenser, refrigerant, valves and evaporator coils

The units are also provided with thermostat control and filtering equipment.
A window room air conditioner is shown in Fig.
A window type air conditioner consists of following sub-assembles:

	Sub assembly	Parts
1.	System assembly	a. Evaporator b. Capillary c. Condenser d. Strainer e. Compressor
2.	Motor, fan and blower assembly	a. Fan b. Blower motor c. Motor mounting brackets
3.	Cabinet and grill assembly	a. Cabinet b. Grill
4.	Switch board panel	a. Selector switch b. Relay c. Thermostat d. Fan motor capacitor

WORKING:

The cool and low pressure vapour refrigerant is drawn from the evaporator to the compressor and it is compressed to high pressure and temperature. Generally, in this refrigerant is Freon gas i.e. R-12 or R-22 and a hermetic compressor is used. The high pressure and temperature gas runs through a set of coils so it can dissipate its heat and it condenses into liquid. The liquid is passed through the capillary and then flows into the evaporator. As refrigerant comes out of capillary, its temperature and pressure falls. This low temperature and pressure gas runs through a set of coils that allow the gas to absorb heat and cool down the air inside the building. The compressor draws this low pressure vapour and cycle is repeated. Most air conditioner also functions as dehumidifiers. They take excess water or moisture from the air and exit to atmosphere through the pipe.

Some factors should be kept in mind while selecting an air conditioner for a room:

1. Size of the room
2. Wall construction, whether light or heavy
3. Heat gain through ceiling and proportion of outside wall area which is covered with glass
4. Whether the room is to be used in the day time or at night only. The exposure to the sun of the walls of the room to be air conditioned and Room Ceiling height
5. Number of persons likely to use the room
6. Miscellaneous heat loads such as wattage of lamps, radio, television, computer, etc.

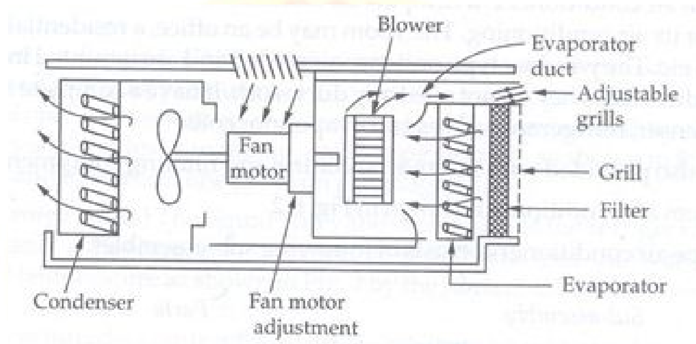

Fig. 1

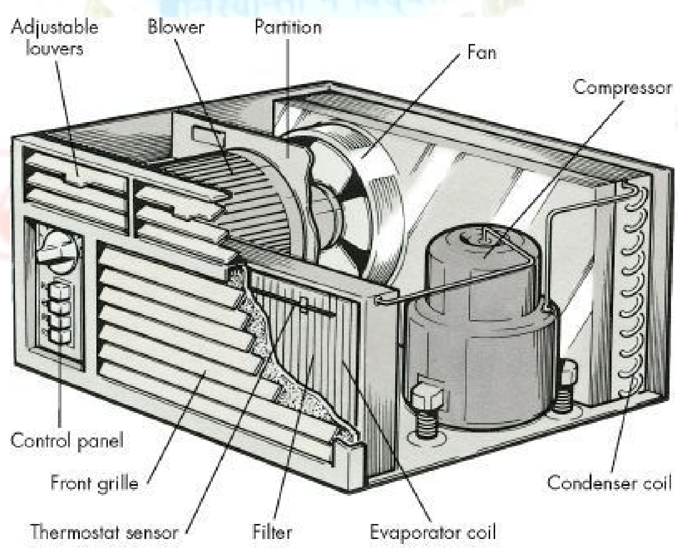

Fig. 2

CONCLUSION:

The model of Air conditioner was demonstrated and its working was studied.

EXPERIMENT No:3

AIM: Study and performance of domestic refrigerator. APPARATUS: Refrigerator test rig. (Vapour compression cycle)

THEORY: The refrigerator cycle in vapours forms finds application in countless industrial and domestic situations through out the world. For examples, the storage and transport of perishable food stuffs and drugs would be extremely difficult if not impossible without refrigeration's. Similarly the efficient operations of offices and factories in many part s of the world would be impossible without the use of refrigeration plants in air conditioning.

It is for this reason that engineers of many disciplines must have a good working knowledge of the refrigeration's cycle .a refrigerator is defined as a machine whose prime function is to remove heat from a low temperature region. Since the energy extracted cannot be destroyed, if follows that this energy required to operate the machine, must be rejected to the surrounding at a higher temperature, if the temperature of the rejections is high enough to be useful and this is the prime object of the machine, then the machine is called a HEAT PUMP.

The clausius statement of the second law of the thermodynamics states that heat will not pass from a cold to a hotter region without an "external agency" being employed. This external agency may be applied in the form of high-grade energy input of either "work" or a high-grade heat input. The high-grade heat input may take the form of either high temperature combustion products, electrical energy (in the form of heat) or solar energy.

The most common type of refrigerator or heat pump operates on the compression cycle and requires a work input. The vapour compression refrigeration test rig has been designed to enables students to safety study in the cycle in details. The test rig requires 220v ac,50c/s supply and fresh water supply connections.

REFRIGERANT USED - R12

REFRIGERATION RATE - 1400w maximum, but varies with the evaporating.

MAXIMUM CONDENSATING TEMP. – 50^o C.

EVAPORATING TEMP. - Variable by adjustment of load°C TO +10°-20 and cooling water temp.

COMPRESSOR - hermetically sealed 314l kirloskar

CONDENSER - shell and coil type

EVAPORATOR - compact once through concentric tube with refrigeration load supplied by separate concentric heating elements

EXPANSION VALVE - automatic expansion valve with two bypass capillary circuits.

THERMODYNAMIC ASPECTS OF REFRIGERATIONS:

The second law of thermodynamic includes the statements," it is impossible to transfer heat from a region at a low temperature to another at a higher temperature without the aid of an external agency".

Refrigerator and heat pumps are examples of machines, which transfer heat from a low to a high temperature region, and the "external agency" employed, may be either work or high-grade heat.

The first law of thermodynamics states in a cycle the net heat transfer is equal to the network transfer. Thus for a refrigerator, heat transfer at low temperature + heat transfer at high temperature = work done.

In the case of the refrigerator (or heat pump) using a work input, it follows that heat transfer at low temperature + work input = heat transfer at high temperature .if the external agency is high grade heat, the heat transfer at low temperature + heat transfer at high temperatures = 0

A machine whose prime function is to remove heat from a low temperature region is called the refrigerator.

A machine whose prime function is to deliver heat from a high temperature region is called the heat pump. From the first law of thermodynamics, it is apparent that a refrigerator must reject heat at a higher temperature and the heat pump must take in heat at a lower temperature. Thus, there is very little difference between the two plants, and both useful affects can be obtained from the same unit.

$$\text{COP} := \frac{\text{Refrigerating effect}}{\text{Work done}}$$

REFRIGERATION LOAD: This is determined by the input to the electric heating element in the evaporator and is controlled by the heat input control setting. The product of the voltmeter and ammeter reading gives the evaporator heat input rate.
CONDENSER PRESSURE: The cooling water flow rate and its inlet temperature controls condensor motor. Reduce the cooling water flow rate to increase the condenser pressure.

ELECTRIC INPUT: the voltmeter and ammeter indicates the input to the compressor motor. The electric power input is in the products of volts, amps, and the power factor applicable (0.8).

TEMPERATURE INDICATORS: the temperature may be measured at six points in the circuit by selecting station 1-6 and the appropriate temperature scale.

PROCEDURE:

1) Ensure that the operation of the plant is clearly understood.
2) Start the unit and adjust the evaporator heat input control and, to set the evaporating pressure adjust the condensor cooling water to give the required condensor pressure and hence saturation temperatures.
3) For performance curves start with a small duty, say 250w and increase this in increments of about 259w until the maximum duty is reached. The unit will respond quickly after the load change and stablise within 15 minutes, although it

may take a little longer at light loads. Stability is reached when changes in pressure temperature, flow, etc have ceased.

4) Reduce the refrigerator load. Switch off mains switch and turnoff the cooling water.

5) The unit should be started and allowed to stabiles with a refrigeration load of about 250w.

6) In the evaporator, the pressure and temperature are high and the heat has been a heat input from the electric heating element.

7) In the condenser, the pressure and temperature are high and the heat has been given up to the cooling water, which has been given up to the cooling water, which has become warmer.

8) The compressor increases both the pressure and temperature and that the compressor requires a work input to-do this.

9) Both the pressure and temperature fall across the expansion valve and that no work transfer involved.

PRECAUTIONS:

1) Do not touch the compressor or the pipelines, which may be hot or cold.
2) Final readings be recorded after steady conditions have reached say after running for at least 30 minutes at a particular setting of water flow rate and heater evaporator load.
3) Ensures that water is continuously flowing through the condenser under all conditions of compressor working.
4) The flow of water should not be permitted to fall below 1lpm.
5) High pressure and low pressure cut out set to shut off all electrical supplies to motor and evaporator heaters if condenser pressure exceeds 1400 KN-M2.
6) Reduce the refrigeration load (evaporator heat input control) switch off mains switch and turn off the cooling water.

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EXPERIMENT No: 3

AIM:
Study on heat exchanger

THEORY:
A heat exchanger is a device used to transfer heat between a solid object and a fluid, or between two or more fluids. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact.

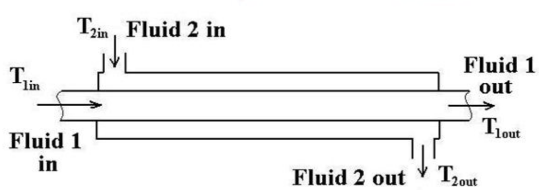
They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment.

The classic example of a heat exchanger is found in an internal combustion engine in which a circulating fluid known as engine coolant flows through radiator coils and air flows past the coils, which cools the coolant and heats the incoming air. Another example is the heat sink, which is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant.

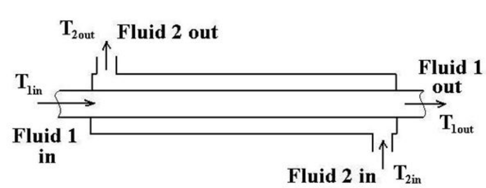
Types of Heat Exchanger:

1. Double pipe heat exchanger:

Double pipe heat exchangers are the simplest exchangers used in industries. On one hand, these heat exchangers are cheap for both design and maintenance, making them a good choice for small industries. On the other hand, their low efficiency coupled with the high space occupied in large scales, has led modern industries to use more efficient heat exchangers like shell and tube or plate. However, since double pipe heat exchangers are simple, they are used to teach heat exchanger design basics to students as the fundamental rules for all heat exchangers are the same.



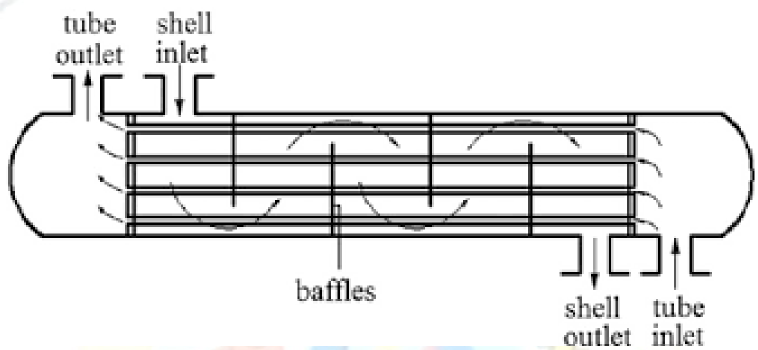
Double Pipe Heat Exchanger
Parallel Flow



Double Pipe Heat Exchanger
Counterflow

2. Shell and tube heat exchanger:

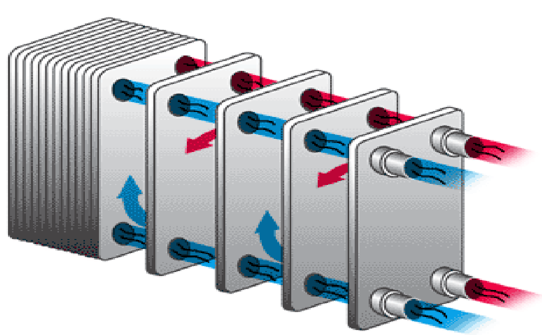
Shell and tube heat exchangers consist of series of tubes. One set of these tubes contains the fluid that must be either heated or cooled. The second fluid runs over the tubes that are being heated or cooled so that it can either provide the heat or absorb the heat required. A set of tubes is called the tube bundle and can be made up of several types of tubes: plain, longitudinally finned, etc. Shell and tube heat exchangers are typically used for high-pressure applications (with pressures greater than 30 bar and temperatures greater than 260 °C).This is because the shell and tube heat exchangers are robust due to their shape.



3. Plate heat exchanger:

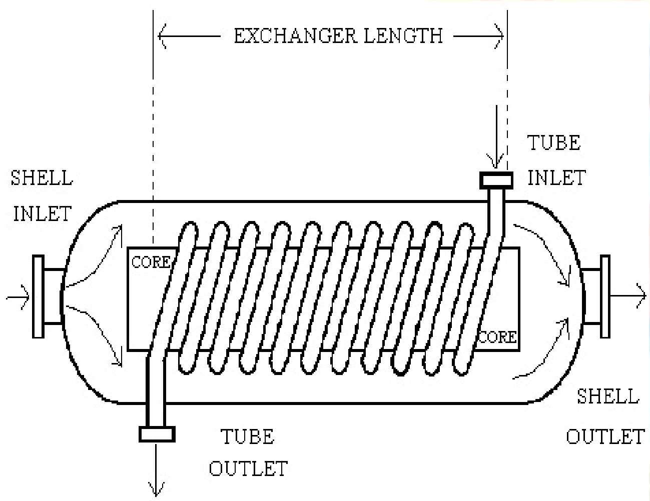
Another type of heat exchanger is the plate heat exchanger. These exchangers are composed of many thin, slightly separated plates that have very large surface areas and small fluid flow passages for heat transfer. Advances in gasket and brazing technology have made the plate-type heat exchanger increasingly practical.

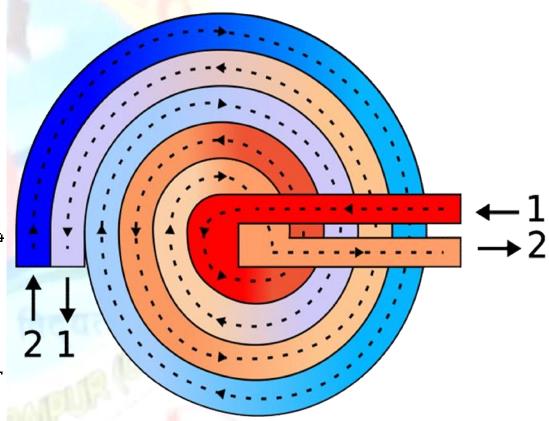
When compared to shell and tube exchangers, the stacked-plate arrangement typically has lower volume and cost. Another difference between the two is that plate exchangers typically serve low to medium pressure fluids, compared to medium and high pressures of shell and tube. A third and important difference is that plate exchangers employ more countercurrent flow rather than cross current flow, which allows lower approach temperature differences, high temperature changes, and increased efficiencies.



4. Helical-coil heat exchanger:

The main advantage of the HCHE, like that for the SHE, is its highly efficient use of space, especially when it’s limited and not enough straight pipe can be laid. Under conditions of low flow rates (or laminar flow), such that the typical shell-and-tube exchangers have low heat-transfer coefficients and becoming uneconomical. When there is low pressure in one of the fluids, usually from accumulated pressure drops in other process equipment.When one of the fluids has components in multiple phases (solids, liquids, and gases), which tends to create mechanical problems during operations, such as plugging of small-diameter tubes. Cleaning of helical coils for these multiple-phase fluids can prove to be more difficult than its shell and tube counterpart; however the helical coil unit would require cleaning less often.These have been used in the nuclear industry as a method for exchanging heat in a sodium system for large liquid metal fast breeder reactors since the early 1970s.





5. Spiral Heat Exchanger:

A modification to the perpendicular flow of the typical HCHE involves the replacement of shell with another coiled tube, allowing the two fluids to flow parallel to one another, and which requires the use of different design calculations. These are the Spiral Heat Exchangers (SHE), which may refer to a helical (coiled) tube configuration, more generally, the term refers to a pair of flat surfaces that are coiled to form the two channels in a counter-flow arrangement. Each of the two channels has one long curved path. The main advantage of the SHE is its highly efficient use of space. This attribute is often leveraged and partially reallocated to gain other improvements in performance, according to well known tradeoffs in heat exchanger design. (A notable tradeoff is capital cost vs operating cost.) A compact SHE may be used to have a smaller footprint and thus lower all-around capital costs, or an oversized SHE may be used to have less pressure drop, less pumping energy, higher thermal efficiency, and lower energy costs.

CONCLUSION:
Different types of heat exchangers were studied.

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EXPERIMENT No: 4

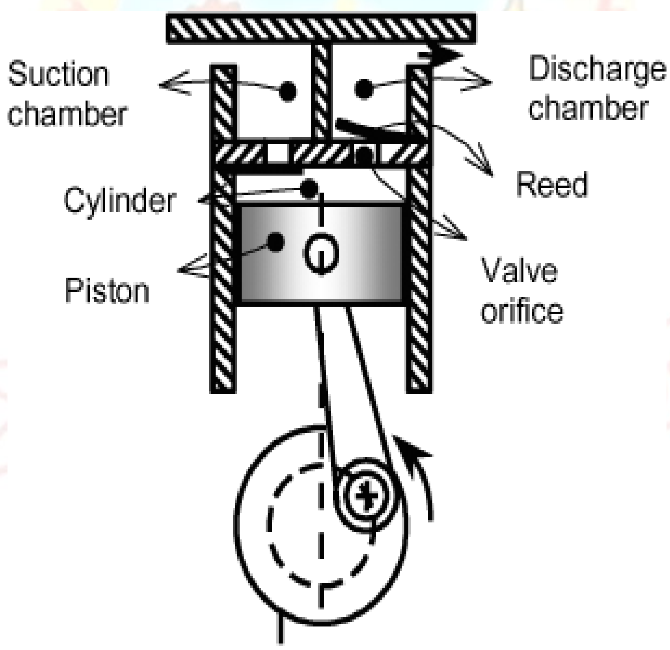
AIM:
Study on compression system.

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.

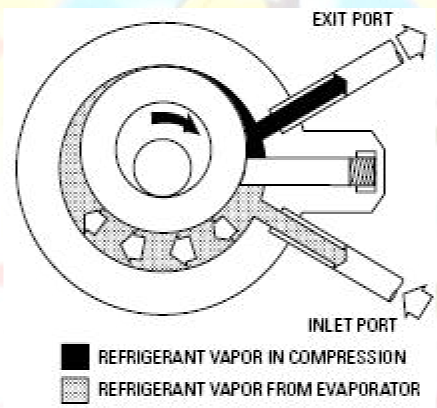
2. Rotary compressor:

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.

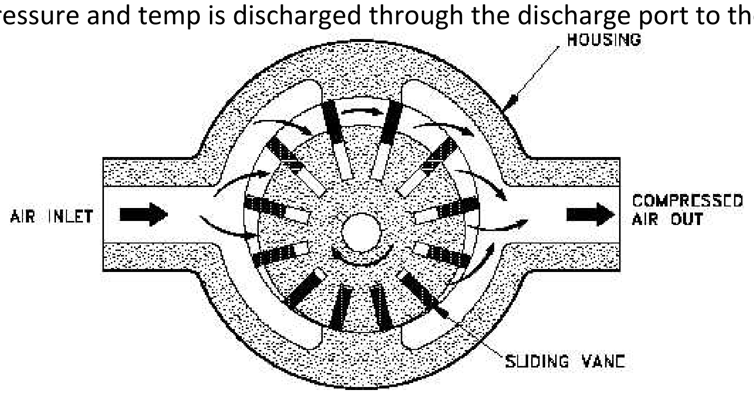
The two types of rotary compressors are: -

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.



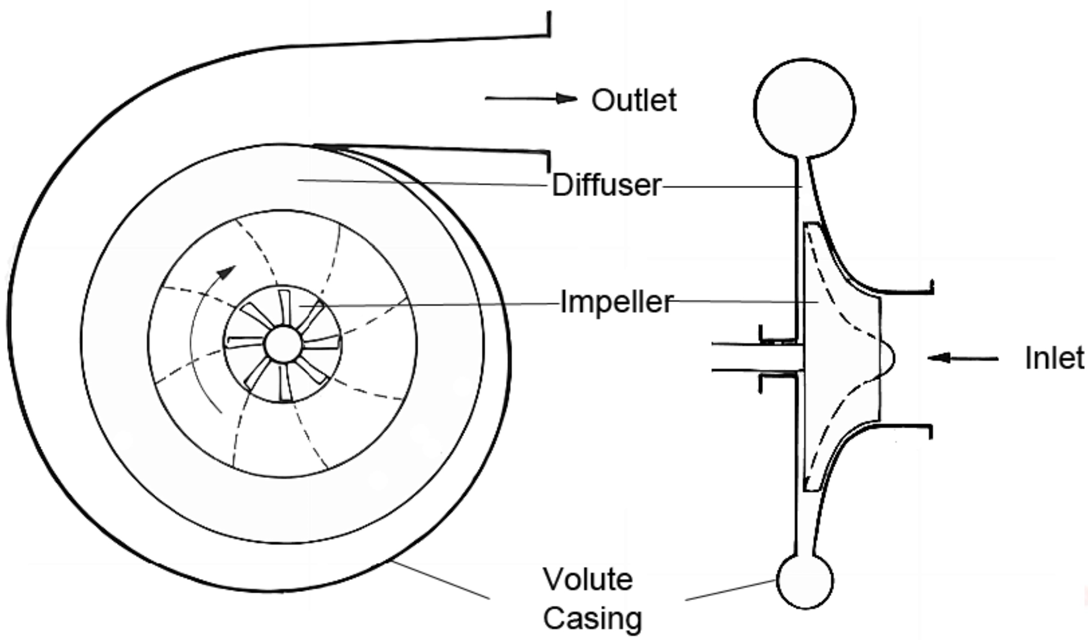
Rotating Blade type consists of a cylinder and a slotted rotor containing a number of blades. The centre of the rotor is eccentric with the centre of the cylinder. The blades are forced against the cylinder wall by the centrifugal action during the rotation of the motor. The low pressure and temperature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



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.

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EXPERIMENT No: 4

AIM: Study and performance of Window Air-Conditioner Theory:

Air condition is defined as simultaneous control over the air, regarding its temperature, humidity, motion and purity. Window type room air conditioner is used to condition the air of a particular space. Such as office room, bedroom of a house, drawing office, room etc. it cools the air and sometimes dehumidifies it. It operates automatically once it is put into operation.

Charge the refrigerant in Air-conditioner through the charging pipe of compressor with Suction Pressure 70 to 75psi and discharge pressure 250 to 270 psi. The compressor compresses the refrigerant with high pressure and high temperature to send it through discharge pipe to condenser, which the temperature of refrigerant to convert into liquid form.
High pressure liquid flow through filter and capillary to evaporator when liquid enters after capillary the refrigerant expands and change liquid to vapor by air of room, when room air through heat transfer to its evaporator becomes cool and flows in room by the grille. The vapor goes back to compressor and is again compressed. The refrigerant cycle continues the fan motor fitted in the centre of air conditioner with one side fitted with propeller type fan blade (condenser side) and one side blower of evaporator 9 room side). The air through fan condenses the refrigerant. The room air passes over evaporator and become cool and flow the cool air through grille louvers.

Specifications

a)	Fan Capacity	:	177lps
b)	Compressor	:	1.0 Ton (3.52 kW), Kirloskar make
c)	Refrigerant	:	R-22
d)	Heater1, 2, 3 & 4	:	each of 500 W
e)	Kettle Load	:	500 W
f)	Moisture Content	:	2257kj/kg of water evaporated in kettle
g)	Electric tube Load	:	18 W
h)	Power Factor cos ø	:	0.8
i)	Pressure Gauge	:	psin
j)	Compound Gauge	:	psin
k)	Temperature Sensor	:	Copper Constantan

Experimental Procedure

Step1: Fill water in the DBT/WBT Thermometer cassette.
Step2: Fill 500ml of water in the electric kettle.

Step3: Set the thermostat knob of the A/C at particular temperature. And run the A/C for nearly10 minutes.

Step4: Load the chamber by switching ON a heater(of predetermined load).

Step5: Add moisture from electric kettle by feeding regulated power to match the desired latent heat load.

Measurements

1. Note down the chamber load from the heater.
2. Note down the DBT & WBT from thermometer mounted near window gives room /chamber temperature.
3. Note down the input Amp &Volts of refrigeration units.
4. Note down the suction and discharge pressures (average during operation)
5. Note down the thermocouple temperatures in C at
   (a) Ambient Air.
   (b) Outgoing air from condenser.
   (c) Evaporator air at inlet and
   (d) Air leaving the evaporator at grille.

Observations

Name of Experiment : Window A/c test rig.

Refrigerant : R-22

Heater 1,2,3 & 4 : Each of 500W

Kettle load : 500W

Moisture Content : 2257 kJ/kg of water evaporated in kettle

Electric Tube Load : 18W

Power factor cos : 0.8

Conversion factor 1 kPa : psig x 6.89s

Run no	Latent Heat (W)	Heater Load (W)	Thermometer		Compressor		Suction pr. (psi)	Discharge pr.(psi)	Temp. ˚C			
			Wbt (˚C)	Dbt (˚C)	V Volt	I Amp			1	2	3	4

Calculations

1. Room sensible heat load (SHL) can be found out by the summation of Heater load and Tube light load

    Room Sensible Heat Load= Heater Load+Tube Light load in kJ/s or J/s or in watt.

2. Room latent heat load (LHL) can be found out from the moisture/steam generating capacity by the electrical kettle.
3. Room total heat load (THL) can be found out by the summation of room sensible heat load and room latent heat load.

    THL=SHL+LHL

4. Sensible heat factor (SHF) can be found out by the ratio of room sensible heat load and room total heat load.

    SHF= SHL/ THL

5. Apparatus dew point (ADP) can be obtained from the Psychometric chart supplied in the manual.
6. Dehumidified air is the amount of air being cooled and dried circulated by evaporator.

    Dehumidification rise= Temperature of Evaporator air into it– Temperature of Evaporator air at grill.

    Dehumidification air= SHL/ 1.23x Dehumidifier rise in lps

7. Coefficient of Performance of a Refrigerator (C.O.P) or EER

    = Refrigerator rate or Duty/ Power Input to the compressor

Precautions:

1. Run the apparatus for about 5 minutes without any load.
2. Fill the kettle with 500ml of water and estimate the moisture load.
3. operate the apparatus for 25-30 minutes only. Or add more water for generation of latent heat.
4. Do not touch the heater or the pipeline, which may be hot/cold.

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:

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

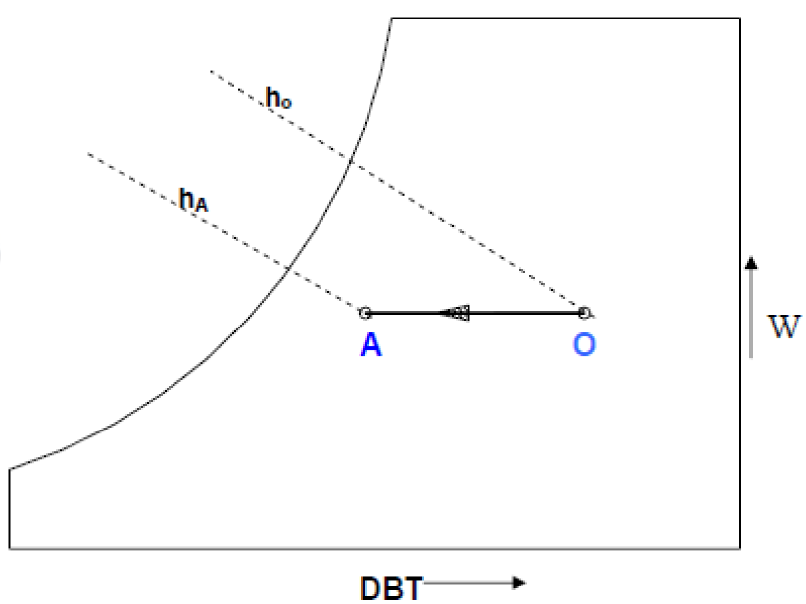


Fig.28.1: Sensible cooling process O-A on psychrometric chart

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:

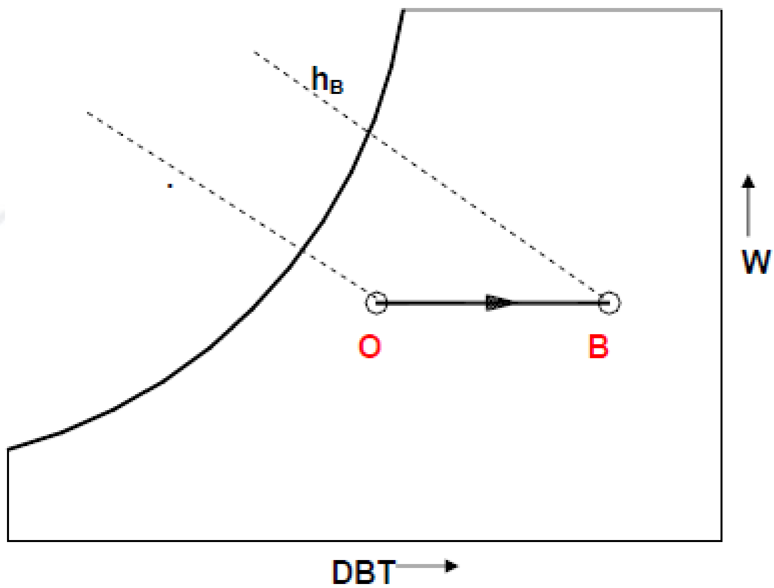


Fig.28.2: Sensible heating process on psychrometric chart

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 conditions by applying the conservation of mass and conservation of energy equations as given below:

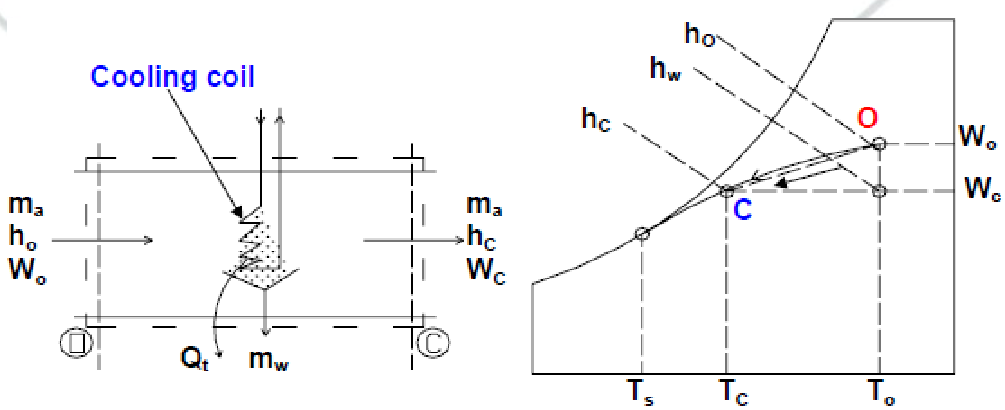


Fig.28.3: Cooling and dehumidification process (O-C)

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.

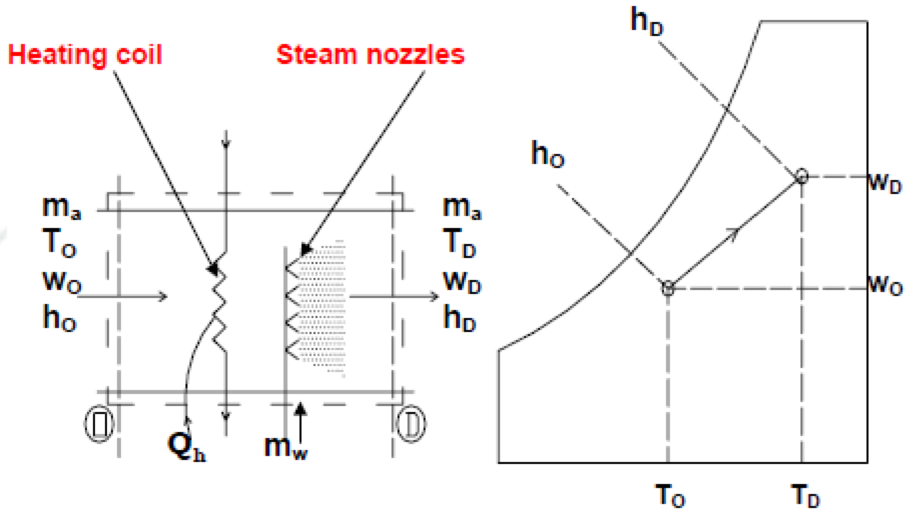


Fig.28.5: Heating and humidification process

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).

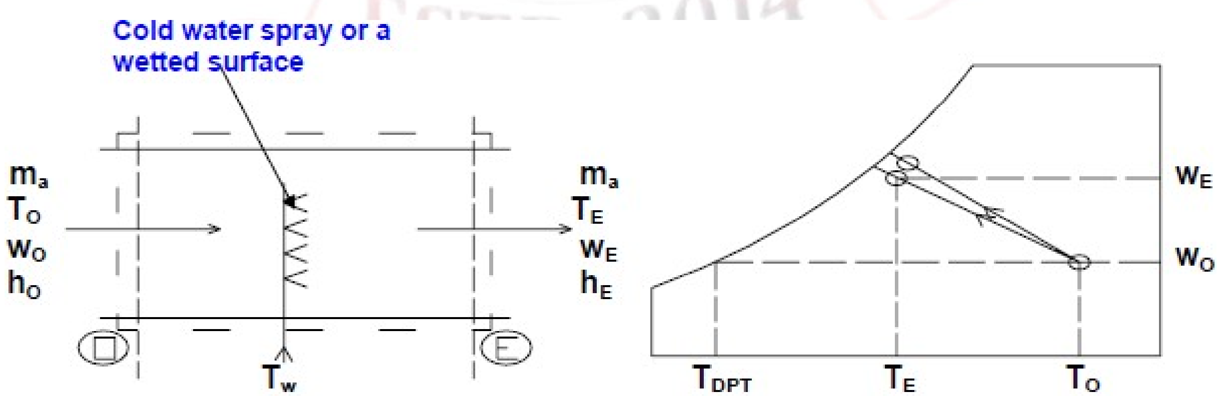


Fig.28.6: Cooling and humdification process

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

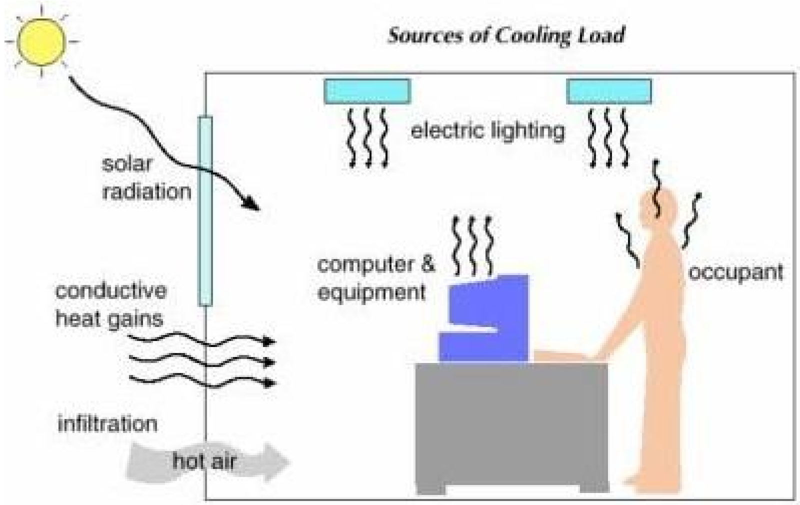
b. Heat conduction through exterior walls and roofs

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



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

gGg

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