Refrigeration & Air Conditioning Lab Manual
of
ICD Programme (Refrigeration & Air Conditioning-II) (ME-221B)
(4th Semester)

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GENERAL INSTRUCTION

1. All the students are instructed to wear protective uniform, Shoes and identity card before entering into the laboratory.
2. Before starting the exercise, students should have a clear idea about the principal of that exercise.
3. All the students are advised to come with completed record and corrected observation book of pervious experiment.
4. Do not operate any instrument/machine without getting staff member's prior permission.
5. All instruments are costly. Hence handle them carefully, to avoid fine for any breakage.
6. Utmost care must be taken to avert any possible injury while on Laboratory work. In case, anything occurs immediately report to the staff members.
7. One student from each batch should put his/her signature during receiving the instrument in instrument issue Register.

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List of Experiments

ME-221B ICD Programme

Refrigeration & Air Conditioning-II Lab (4th Semester)

AIM: To study different types of heat exchanger

OBJECTIVES:

1. To understand the different types of heat exchangers

2. To understand the working principle of each type of heat exchanger

3. To understand the applications of each type of heat exchanger

4. To understand the advantages and disadvantages of each type of heat exchanger

5. To understand the selection criteria for choosing a heat exchanger

THEORY:

A heat exchanger is a device used to transfer heat between two or more fluids. The fluids may be in contact with each other or may be separated by a solid wall. There are many different types of heat exchangers each with its own unique working principle and applications

The five most common types of heat exchangers are the coil heat exchanger, the plate heat exchanger, and the shell and tube heat exchanger, bare type heat exchanger, fin and tube type heat exchanger.

COIL TYPE HEAT EXCHANGERS

The coil heat exchanger is the simplest type of heat exchanger. It consists of a coiled tube through which the two fluids pass.

Figure-1.1 Coil Type Heat Exchanger

The main applications of coil type heat exchangers are in the refrigeration and air conditioning industries. Coil type heat exchangers are also used in the food and beverage industry, the chemical industry, and the power industry

PLATE TYPE HEAT EXCHANGERS

The plate heat exchanger is a more sophisticated type of heat exchanger. It consists of a series of plates through which the two fluids pass. The advantage of the plate heat exchanger is that it has a high heat transfer coefficient and is resistant to fouling. The disadvantage is that it is more expensive to construct than the coil heat exchange power

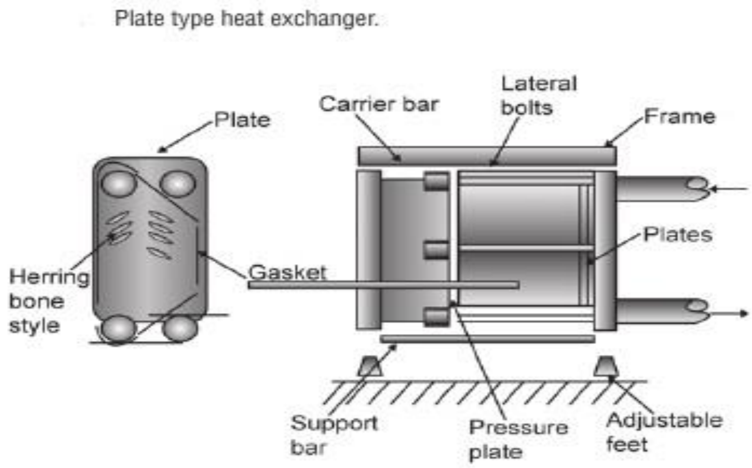

Figure-1.2 Plate Type Heat Exchanger

SHELL AND TUBE TYPE

The shell and tube heat exchanger is the most common type of heat exchanger. It consists of a series of tubes through which the two fluids pass. The advantage of the shell and tube heat exchanger is that it has a high heat transfer coefficient and is resistant to fouling. The disadvantage is that it is bulky and expensive to construct.

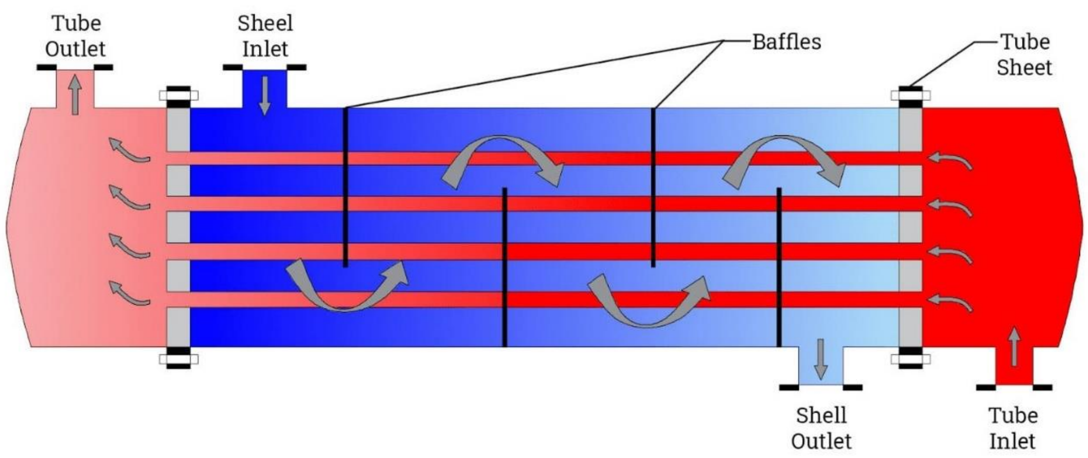

Figure-1.3 Shell and Tube Type Heat Exchanger

BARE TYPE HEAT EXCHANGER

The bare type heat exchanger is a simple type of heat exchanger that does not use a casing. The advantage of the bare type heat exchanger is that it is cheap to construct. The disadvantage is that it is prone to fouling.

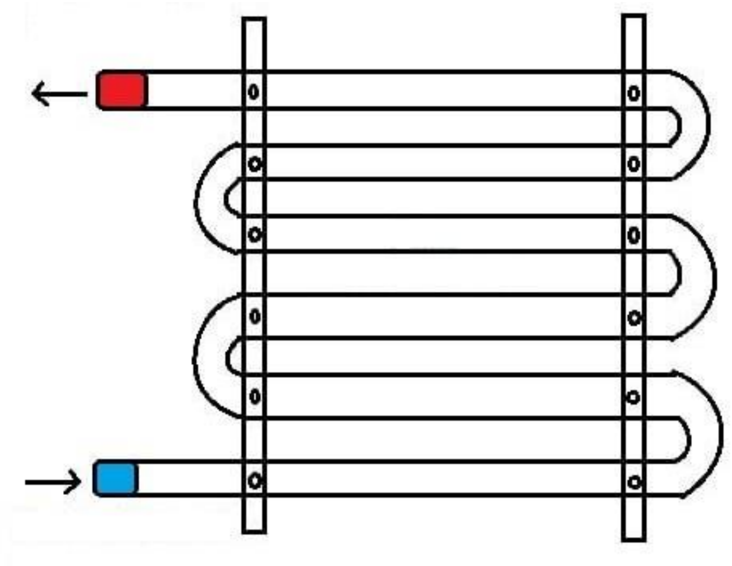

Figure-1.4 Bare Type Heat Exchanger

FIN AND TUBE TYPE

The fin and tube type heat exchanger is a type of heat exchanger that uses fins to increase the surface area. The advantage of the fin and tube type heat exchanger is that it has a high heat transfer coefficient. The disadvantage is that it is expensive to construct

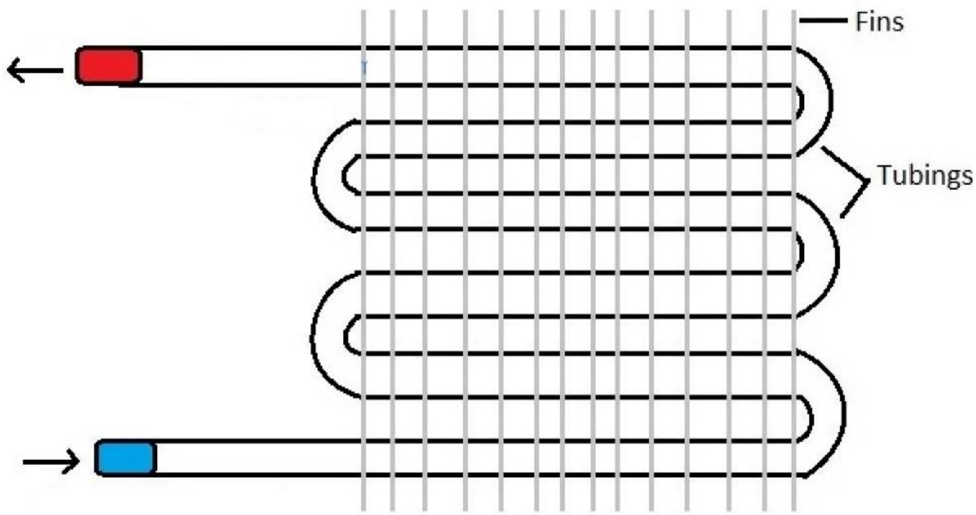

Figure-1.5 Fin and Tube Type Heat Exchanger

TUBE IN TUBE TYPE

Tube-in-tube heat exchanger (also known as **double tube heat exchanger**) consists of a heat exchanger with two concentric tubes. The product flows through the inner tube while the service does it through the space between the two tubes.

The tube in tube exchange is used for efficient heat transfer between two fluids. Tube in tube heat exchanger finds its application in industries where heat treatment is subjected to filids of high viscosity, density or high fiber or solid particles.

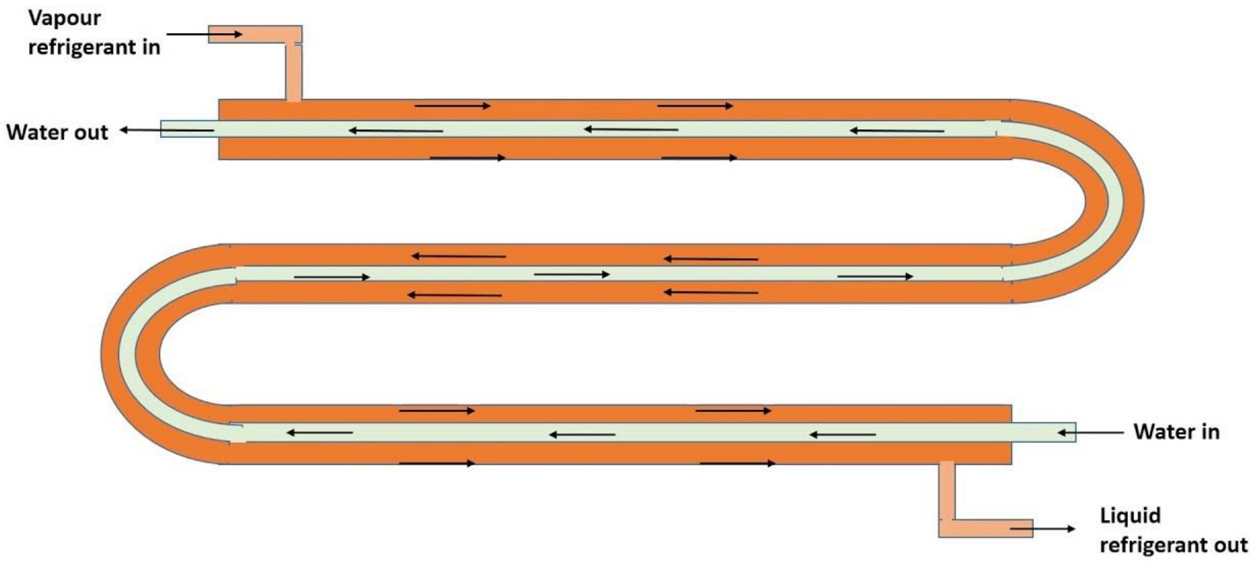

Figure-1.6 Tube in Tube Type Heat Exchanger

AIM: **To demonstrate the working of water cooler.**

OBJECTIVE:-

•To understand the basic components of a water cooler

•To demonstrate the refrigeration cycle used in a water cooler

INTRODUCTION:-

A water cooler is a device used to cool and dispense drinking water. It is commonly found in offices, schools, and other public places.

As the name indicates water cooler is refrigeration equipment which is used to cool the water in the temperature range of 10 ^{0}C to 20 ^{0}C for drinking purposes.

A water cooler consists of the following main parts such as compressor, condenser, fan with motor, water storage tank, expansion device, evaporator and filter. A thermostatic switch is provided to control the temperature of water.

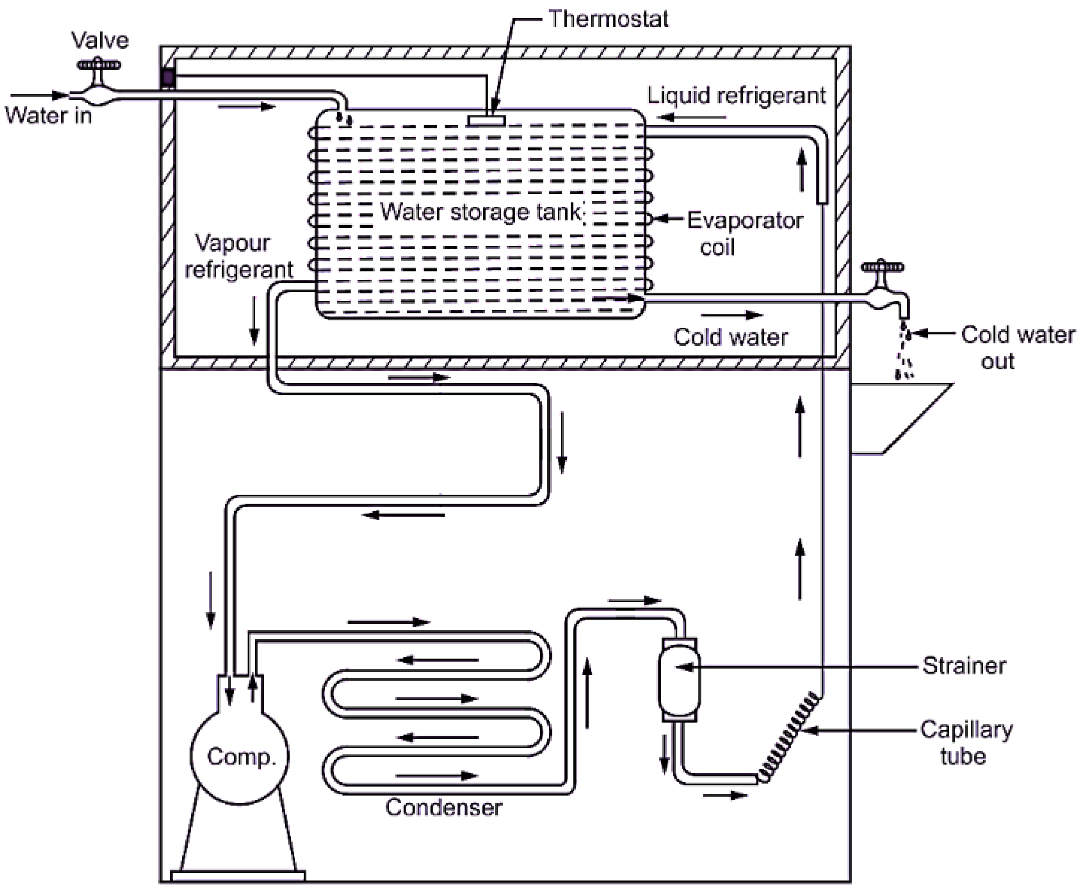

Figure-2.1 Storage Type Water Cooler

APPARATUS:-

A basic mechanical vapor compression refrigeration system is designed to cool the potable water. The compressor raises the pressure of refrigerant and then pumps it into the condenser. The main function of the condenser is to remove the Heat absorbed by the refrigerant in evaporator. It is made in coil shape, large plate area with fins and removes the heat by forced air circulation. The expansion device controls the amount of refrigerant that should be admitted into the Evaporator.

THERMOSTATIC SWITCH / CONTROL:-

A thermostatic switch or control can be used to demonstrate the working of a water cooler by controlling the temperature of the refrigerant used in the cooler's refrigeration system. The thermostatic switch is typically mounted on the refrigerant line and acts as a temperature sensor. It opens or closes the circuit to the compressor based on the temperature of the refrigerant. When the temperature rises above a set point, the switch closes the circuit and the compressor starts to run. When the temperature falls below the set point, the switch opens the circuit and the compressor stops running.

EVAPORATOR:-

An evaporator is a component in a refrigeration or air conditioning system that removes heat from a refrigerant, causing it to condense into a liquid form. In a water cooler, the evaporator is responsible for cooling the water that is dispensed from the cooler.

Typically, the evaporator works by passing warm water over a series of coils that contain refrigerant in a gaseous form. As the refrigerant absorbs heat from the water, it vaporizes and expands, causing it to move through the system and into the compressor. The compressor then pressurizes the refrigerant, causing it to heat up, and it is then passed through the condenser coils, where it releases its heat and condenses back into a liquid.

The refrigerant then returns to the evaporator, where the cycle starts over again. This continuous process of refrigerant expanding and contracting helps to keep the water in the cooler at a cool temperature, allowing it to be dispensed for drinking or other uses

SPECIFICATION:-

Capacity : 60 liter per hour

Compressor : CAJ 2612 M
Water storage tank : 60 liter
Type : Storage type

PROCEDURE:-

- Identify the different components of the water cooler, including the evaporator, compressor, condenser, and refrigerant lines.

- Locate the inlet and outlet pipes for the water in the cooler.
- Fill a container with room temperature water and place it near the inlet pipe.
- Measure the temperature of the water in the container using the thermometer. Record this temperature as the starting temperature.
- Turn on the water cooler and allow the water to flow through the inlet and outlet pipes for 2-3 minutes
- After 2-3 minutes, measure the temperature of the water in the container again using the thermometer. Record this temperature as the ending temperature.
- Calculate the change in temperature by subtracting the starting temperature from the ending temperature.
- Repeat steps 5-7 two more times, for a total of three trials.

CALCULATION:-

Initial temperature of water = $T_1\ ^0C$

Final temperature of water = $T_2\ ^0C$

Change in temperature (ΔT). = $T_1 – T_2$

Heat rejected by water = m.S.T

= $m.C_p.\Delta T$ KJ

($S = C_p = 4.2$ kJ/kg ^0C)

Energy consumed or

Work done = $(W_2\text{-}W_1) \times 3600$ kJ

(WD) = change in reading of energy meter × 3600 kJ (Kwh = 3600 kJ)

COP = RE / WD

NOTE: Conversions as per:

m = calculate from equipment in liters then change it in liters

1 liter = 0.001 mcu

P = density of water 1gm/cm^3

Convert in m^3 = 1000kg/m^3

=liter (1000 × 0.0001) = 1 kg

= 60 liter = 60 kg

$S = C_p = 4.187$ kJ/kg K

RE = Refrigeration effect = mc_p (T_2-T_1)

WD = (W_2-W_1)

Reading given on energy meter in kWh (Kilo watt hour)

1 kWh = 3600 kJ

WD = (W_2-W_1) × 3600 kJ

COP = RE / WD

COP = Coefficient of Performance

PRECAUTIONS:-

Be careful when handling the thermometer and the water in the container to avoid burns or spills.

Always follow the manufacturer's instructions when operating the water cooler.

AIM: - COP Calculation of Windows Air Conditioner Test Rig

INTRODUCTION:

The coefficient of performance (COP) is a measure of the efficiency of an air conditioner. It is defined as the ratio of the cooling output to the energy input. In this lab, you will learn how to calculate the COP of a window air conditioner using a test rig.

1. Compression. 2. Condenser

3. Expansion. 4. Vaporization

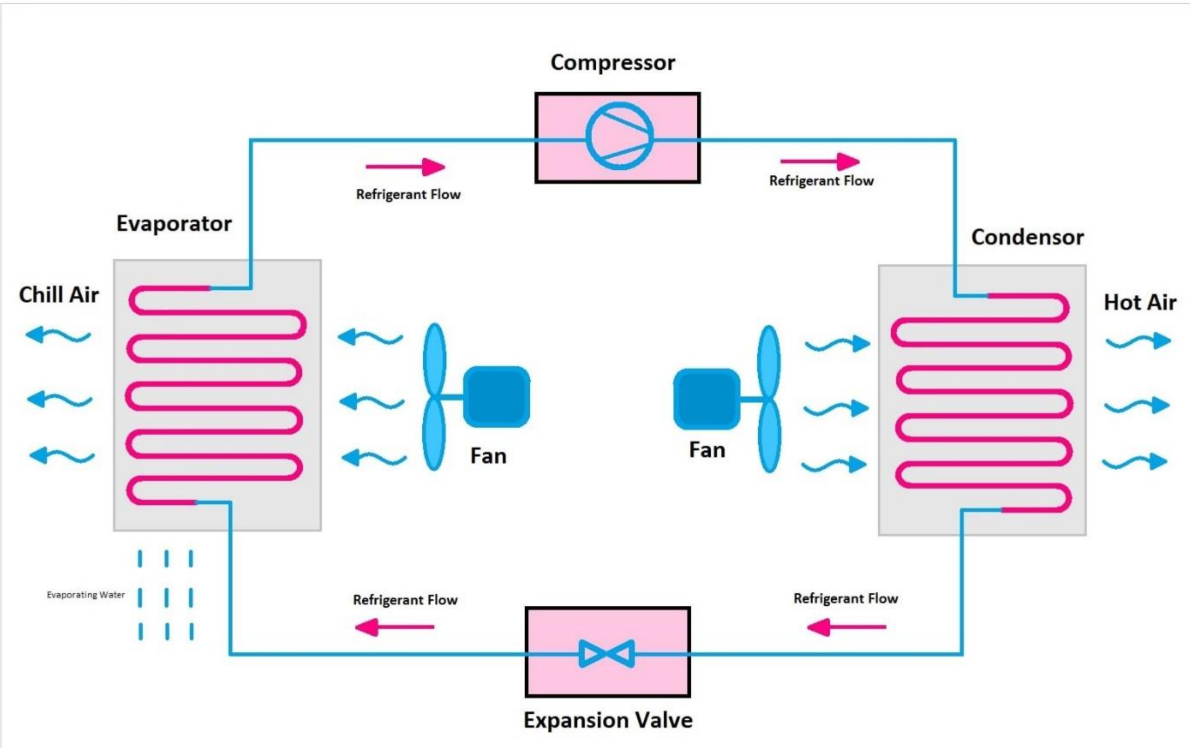

Figure-3.1 Air Conditioning System

COMPRESSION PROCESS

In the compression process the energy used to compress the vapour turns into heat and increases its temperature and enthalpy, so that at the end of compression the vapour state is in the superheated part of the diagram and outside the saturation curve.

CONDENSATION PROCESS

Condenser removes heat from the hot refrigerant vapor gas vapor until it condenses into a saturated liquid state, a.k.a. condensation. After condensing, the refrigerant is a high-pressure, low-temperature liquid, at which point it's routed to the loop's expansion device

EXPANSION PROCESS

The expansion valve removes pressure from the liquid refrigerant to allow expansion or change of state from a liquid to a vapor in the evaporator. The high-pressure liquid refrigerant entering the expansion valve is quite warm. This may be verified by feeling the liquid line at its connection to the expansion valve

VAPORIZATION PROCESS

As the refrigerant circulates through the system, it is alternately compressed and expanded, changing its state from a liquid to a vapor. As the refrigerant changes state, heat is absorbed and expelled by the system, lowering the temperature of the conditioned space

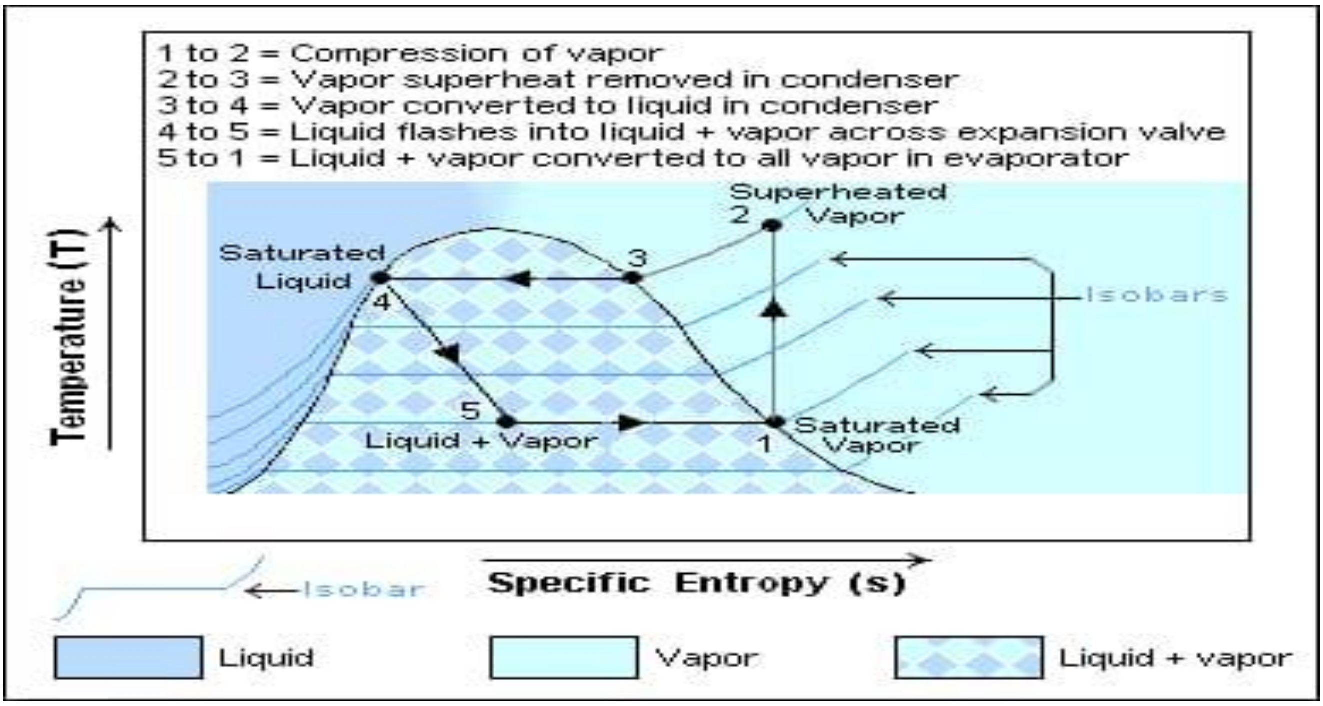

Figure-3.2 Temperature vs Specific Entropy Curve

EQUIPMENT REQUIRED:

Figure-3.3 Window air conditioner test rig

- Thermocouples
- Data logger
- Stopwatch
- Multimeter
- Power meter
- Calculator

PROCEDURE:

• Set up the window air conditioner test rig according to the manufacturer's instructions.

• Connect the thermocouples to the evaporator inlet, evaporator outlet, condenser inlet, and condenser outlet.

• Connect the data logger to the thermocouples and set it up to record temperature readings every 30 seconds.

• Turn on the air conditioner and allow it to run for at least 10 minutes to stabilize the temperatures.

• Record the ambient temperature in the room using a thermometer.

• Measure the voltage and current using the multimeter and power meter, respectively.

• Use the following formula to calculate the cooling capacity:

• Cooling capacity = mass flow rate x specific heat of air x (evaporator outlet temperature - evaporator inlet temperature)

Observation Table

Sr. no.	**P_1**	**P_2**	**T_1**	**T_2**	**T_3**	**T_4**	**M_r**
1.							
2.							
3.							

Where:-

P_1 = Suction Pressure

P_2 = Discharge Pressure

T_1 = Temperature before entering to compressor

T_2 = Temperature after exit from compressor

T_3 = Temperature after condenser

T_4 = Temperature after expansion valve

M_r = Rotameter reading (KG/Min)

Note: The mass flow rate can be calculated by measuring the weight of water collected in the condensate tray over a period of time.

Use the following formula to calculate the energy input:

Energy input = voltage x current x time

Use the following formula to calculate the COP:

COP = Cooling capacity / Energy input

Repeat steps given above for at least 3 different operating conditions, such as different temperature settings and fan speeds.

Calculate the average COP for the different operating conditions.

CALCULATION

COFFICIENT OF PERFORMANCE: The Coefficient of Performance is defined as the ratio of heat extracted in the Evaporator to the work done on the Refrigerant.

COP = Q/W

Where, V×I = Work input to the Compressor

Using values (P_1, P_2, T_1, T_2, T_3 and T_4) Locate Points 1, 2, 3 and 4 on the P-H Chart for R-22 and obtain the Enthalpy Values H_1, H_2, H_3 & H_4

C.O.P$_{(Theoretical)}$ = $(H_1-H_4)/(H_2-H_1)$

C.O.P$_{(Actual)}$ = Q/ (Work input to the Compressor)

Where, Work input to the Compressor = V×I

Work input to Compressor can also be measure by the Energy Meter.

Electrical input power, I_p= $(10/T_c)\times(3600/EMC)$

Where.

Energy Meter constant (EMC) = 1200 (rev/kwh)

T_c= Time revolution for Indications to Complete 10 Indications.

e.g. An energy meter having a meter constant of 1200 revolution per kWh is found to make 5 revolution in 75 seconds. The load power is?
Answer. We know that
EMC = No. of revolution/Energy consumed
EMC = No. of Revolution/(Power × time) [Power = Energy/time]
1200 = 5/[Power × (75/3600)] Since, time given in seconds, to convert it into hour divide by 3600
Power = 0.2 kW

Taking motor efficiency as 75% we have input shaft power (S_p)

$S_p = I_p \times 0.75$

DATA ANALYSIS

- Plot a graph of COP vs. operating condition.
- Analyze the results and discuss the factors that affect the COP.

- Compare the COP of the window air conditioner to the manufacturer's specifications.

CONCLUSION:

In this lab, you learned how to calculate the COP of a window air conditioner using a test rig. You also learned how to analyze the results and identify the factors that affect the COP. The COP is an important measure of the efficiency of an air conditioner and can be used to compare different models. By understanding how to calculate the COP, you can make more informed decisions when purchasing an air conditioner.

AIM:- The calculation of heat load for room air conditioner through the Psychrometric chart.

[A] ROOM HEAT LOAD ESTIMATION

Room Air Conditioner Heat Load Estimator

	Heat Source	(A)Floor Area m2	(A) Multiplying factor W/m2				Sensible Heat	Latent Heat
			Exposed to Sun			Fully Shaded	Cooling Load (A)X(B) Watt	Cooling Load (A)X(B)X1.3 Watt
			No awnings No Curtains No Blinds	No awnings or Curtains or Blinds	Awnings Curtains blinds			
Area of Windows	South	6.59	120	95	65	60	395.4	
	South East	------	380	260	130	60		
	East	------	430	300	145	60		
	North East	------	370	260	130	60		
	North	6.59	270	190	100	60	395.4	
	North West	------	370	260	130	60		
	West	6.59-1.95	430	300	145	60	278.4	
	South West	------	380	260	130	60		
Area of Walls	Outside wall area less glass		Exposed to the Sun	Brick, brick veneer, weather board, fibro		35		
						40		
		2.7X3=8.1	Not exposed	Brick, brick veneer, weather board, fibro		15	121.5	
	Internal wall area	9.29	8				74.32	
	Ceiling area	9.29	Un-insulated 50		Insulated 8		74.32	
	Suspended Floor area	9.29	Un-carpeted 12		Carpeted 6		111.48	
	Door area	1.95	Closed when not in use		100		195	
People		5	Sitting or sleeping		120W/person	SH 63	315	5X54.2X1.3 =352.3
						LH 54.2		
			Active		250W/person			
Lights Appliances			Power/lights		20W/m2		250	
Sensible Cooling Load (Watt)							2210.82	
Required thermal cooling capacity = Sensible cooling load x 1.3							2874.06	

*Dimension/Data in column 2 is for the load testing chamber of RAC Lab.

Figure-4.1 Room Air Conditioner Heat Load Estimator

AIM:- The calculation of heat load for room air conditioner through the Psychrometric chart.

INTRODUCTION:

Air conditioning is a system used to create and maintain certain temperature, relative humidity and air purity conditions in an inside space by removing the existing heat and moisture from the room.

An air conditioner is made up of many components, but the major parts doing the heavy lifting of moving the air indoors and outdoors are the evaporator, condenser, expansion valve, and compressor.

PSYCHROMETRIC CHART:

A psychrometric chart presents physical and thermal properties of moist air in a graphical form. It can be very helpful in troubleshooting and finding solutions to greenhouse or livestock building environmental problems.

A psychrometric chart is used to design winter and summer air conditioning by analysing different air conditioning processes like humidification. Dehumidification, heating and cooling processes. This article discusses the thermodynamic properties of moist air and the representation of these properties in psychrometric charts.

[B] AIR CONDITIONING TONNAGE CALCULATION

1. UNIT CONVERSION :-

1 Watt 3.6 kJ/hr

1 tonne 14000 kJ/hr

2. COOLING CONDITIONS :-

Outside Condition: Temp. 38°C, RH 50%

(Marked as Point 1 on Psychrometric Chart)

Required inside Condition: Temp. 25°C, RH 50%

(Marked as Point 2 on Psychrometric Chart)

Air mixing point for supply air to cooling coil

(Marked as Point 3 on Psychrometric Chart)

Temperature of cooling coil

(Marked as Point 4 on Psychrometric Chart)

Apparatus dew point

(Marked as Point 6 on Psychrometric Chart)

Sensible Heat **2874.06 Watt = 10346.62 kJ/hr**

Latent Heat **352.3 Watt = 1268.28 kJ/hr**

Bypass factor **0.2** (Bypass Factor is part of the total air through the coil which fails to come into contact with the surface of the cooling coil)

[C] PSYCHROMETRIC CHART

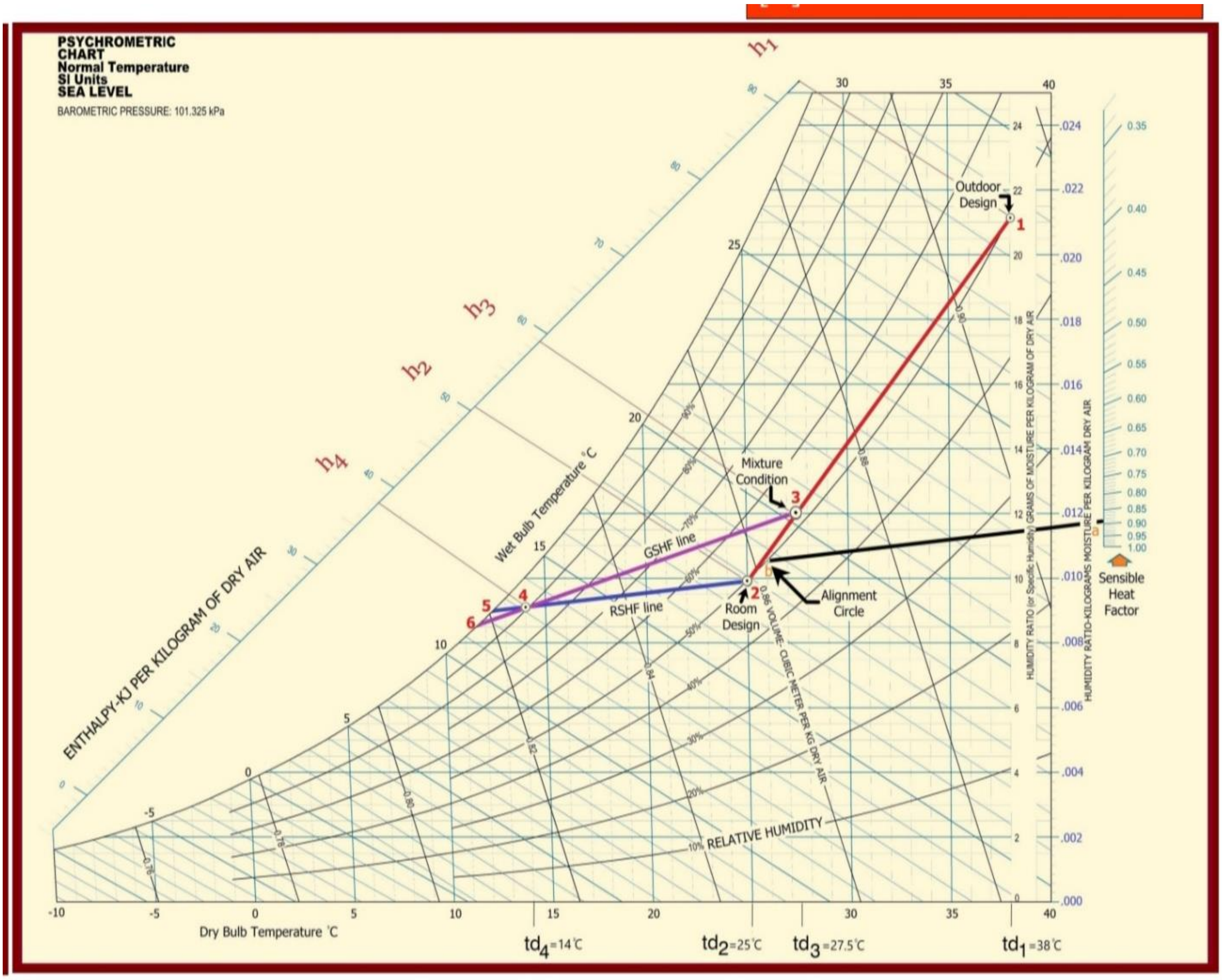

Figure-4.2 Psychrometric chart

From Phychrometric Chart:

h_1	92.3 kJ/hr	td_1	38°C
h_2	50.4 kJ/hr	td_2	25°C
h_3	59 kJ/hr	td_3	27. 5°C
h_4	38 kJ/hr	td_4	14°C (by trial and error method)

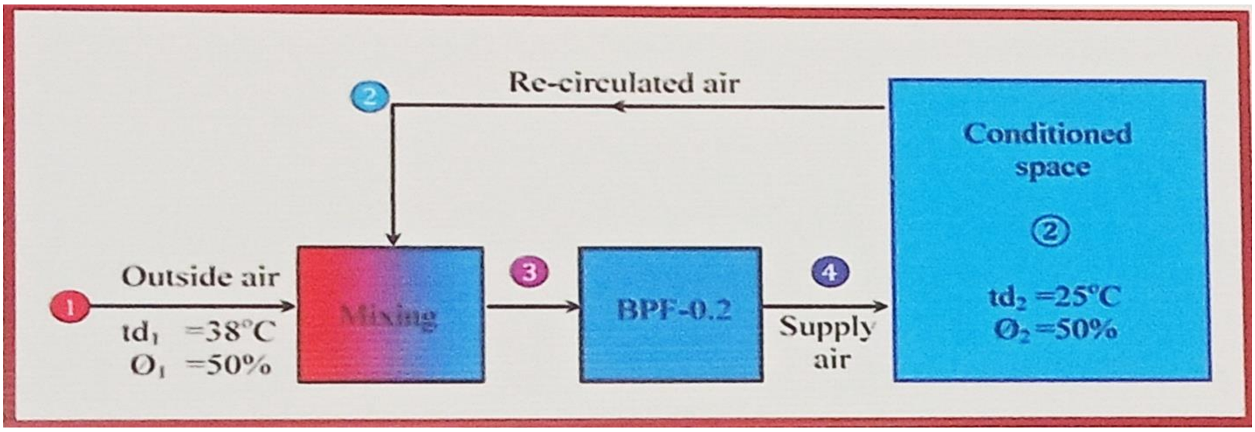

Figure-4.3 Conventional Recirculating Air Conditioning System

Outside design Conditions	**38°C DBT, 50% RH**
Inside design conditions	**25°C DBT, 50% RH**
Room sensible heat gain (RSH)	**10346.62 kJ/hr**
Latent Heat gain (RLH)	**1268.28 kJ/hr**
Bypass factor	**0.2**

3. CALCULATION:-

We know,

$$RSHF = \frac{RSH}{RSH+RLH} = \frac{10346.62}{10346.62-1268.28} = \mathbf{0.89}$$

RSHF: Room Sensible Heat Factor

Now mark this calculated value of RSHF=0.89 on the sensible heat factor scale as point a and join with point b which is the alignment circle (i.e. 26°C DBT and 50% RH) from point2, draw a line 2-5 parallel to this line ab. The line 2-5 is called RSHF line. Since 20% of fresh air or outside air is mixed with 80% of supply air, therefore the condition of air entering the cooling coil after mixing process is marked On the line 1-2 by point 3, such that

Length 2-3 = Length 1-2 x 0.2 (Accordingly locate Point 3 on Psychrometric Chart)

Through point 3, draw a line 3-6 (known as GSHF line) intersecting the RSHF line at Point 4 and the saturation curve at point 6.

Now,

Apparatus dew point:

Let By pass factor is 0.2

$$B.F = \frac{td4-td6}{td3-td6} \rightarrow 0.2 = \frac{14-td6}{27.5-td6}$$

td_1 = 14°c (trial and error method)

Apparatus dew point (td_6) = 10.6°C

AIR MASS FLOW RATE :

Now :

$$m_a = \frac{RSH+RLH}{h2-h4} \rightarrow m_a = \frac{10346.62+1268.28}{h2-h4}$$ = 936.69 **kJ/hr**

Refrigeration load on cooling coil = m_a ($h_3 - h_4$)

= 936.69(59-38)

= 19,670.49 kJ/hr

= $\frac{19,67049}{14,000}$ = 1.4 tonne

AIM: STUDY OF CENTRALIZED AIR CONDITIONING

• **INTRODUCTION**:

Central Air Refrigeration Systems are widely used in homes, commercial buildings, and industries to provide cooling and heating. These systems use a refrigerant to absorb and transfer heat from one location to another.

Components of a Central Air Conditioning System

To get a better sense of how your air is cooled, it helps to know a little bit about the parts that make up the air conditioning system. A typical central air conditioning system is a two-part or split system that includes:

- The outdoor unit contains the condenser coil, compressor, electrical components and a fan.
- The evaporator coil, which is usually installed on top of the gas furnace inside the home.
- A series of pipes, or refrigeration lines, connecting the inside and outside equipment.
- Refrigerant, the substance in the refrigeration lines that circulates through the indoor and outdoor unit.
- Ducts that serve as air tunnels to the various spaces inside your home.
- A thermostat or control system to set your desired temperature.

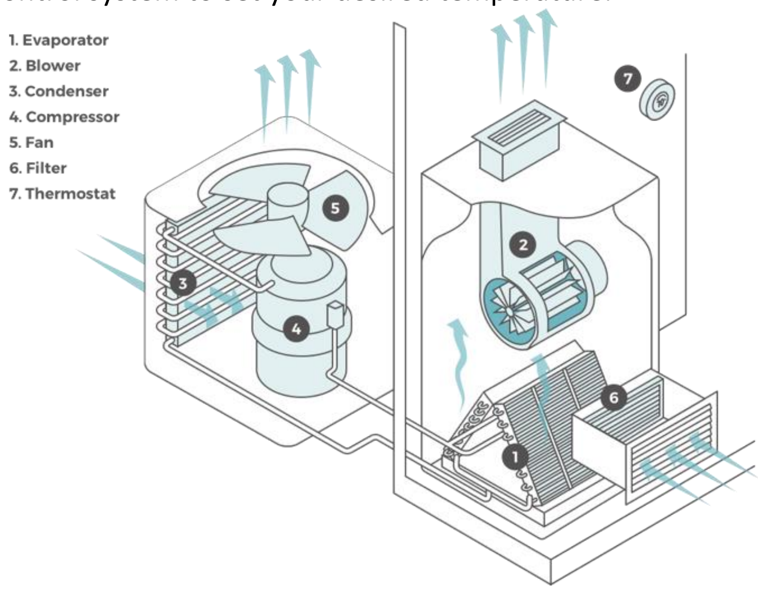

Figure-5.1 Components of a Central Air Conditioning System

How Central Air Conditioning Works

Now that we have a better understanding of the components that make up central air conditioning systems let's explore how they function together to cool your interiors.

Heat Exchange Process

As mentioned, the refrigeration cycle starts with the evaporator coil inside the indoor unit. Warm air from your home is drawn into the air handler, which then passes over the cold evaporator coil. The refrigerant inside the coil absorbs the heat, causing it to evaporate and travel to the compressor. The compressor increases the refrigerant's pressure and temperature before sending it to the condenser coil in the outdoor unit.

At the condenser coil, the heat is released into the outdoor air as the refrigerant condenses back into a liquid state. The cooled refrigerant then returns to the evaporator coil, and the cycle repeats itself. Throughout this process, the air handler continuously blows the cooled air into your living spaces while drawing in warm air to be cooled by the evaporator coil.

Air Distribution and Circulation

Apart from taking care of the heat exchange process, central air conditioning systems also ensure proper air circulation in your living spaces. The air handler (or furnace) pushes the cooled air into the ductwork, distributing it evenly throughout your home or workplace. Return ducts are essential to circulate the warm air back to the air handler, ensuring a continuous flow of conditioned air for enhanced comfort and better indoor air quality.

Thermostat and Control

A thermostat is essential in controlling and maintaining your central air conditioning system. It acts as a communication bridge between you and your air conditioning unit, allowing you to set the desired temperature and keep your living spaces comfortable. Modern thermostats often come with advanced features, such as programmable settings and smart capabilities that enable you to control your air conditioners remotely, increasing comfort levels and energy efficiency.

Advantages of Central Air Conditioning Systems

Benefits

- Indoor comfort during warm weather – Central air conditioning helps keep your home cool and reduces humidity levels.

- Cleaner air – As your central air conditioning system draws air out of various rooms in the house through return air ducts, the air is pulled through an air filter, which removes airborne particles such as dust and lint. Sophisticated filters may remove microscopic pollutants, as well. The filtered air is then routed to air supply duct-work that carries it back to rooms.

- Quieter operation – Because the compressor-bearing unit is located outside the home, the indoor noise level from its operation is much lower than that of a free-standing air conditioning

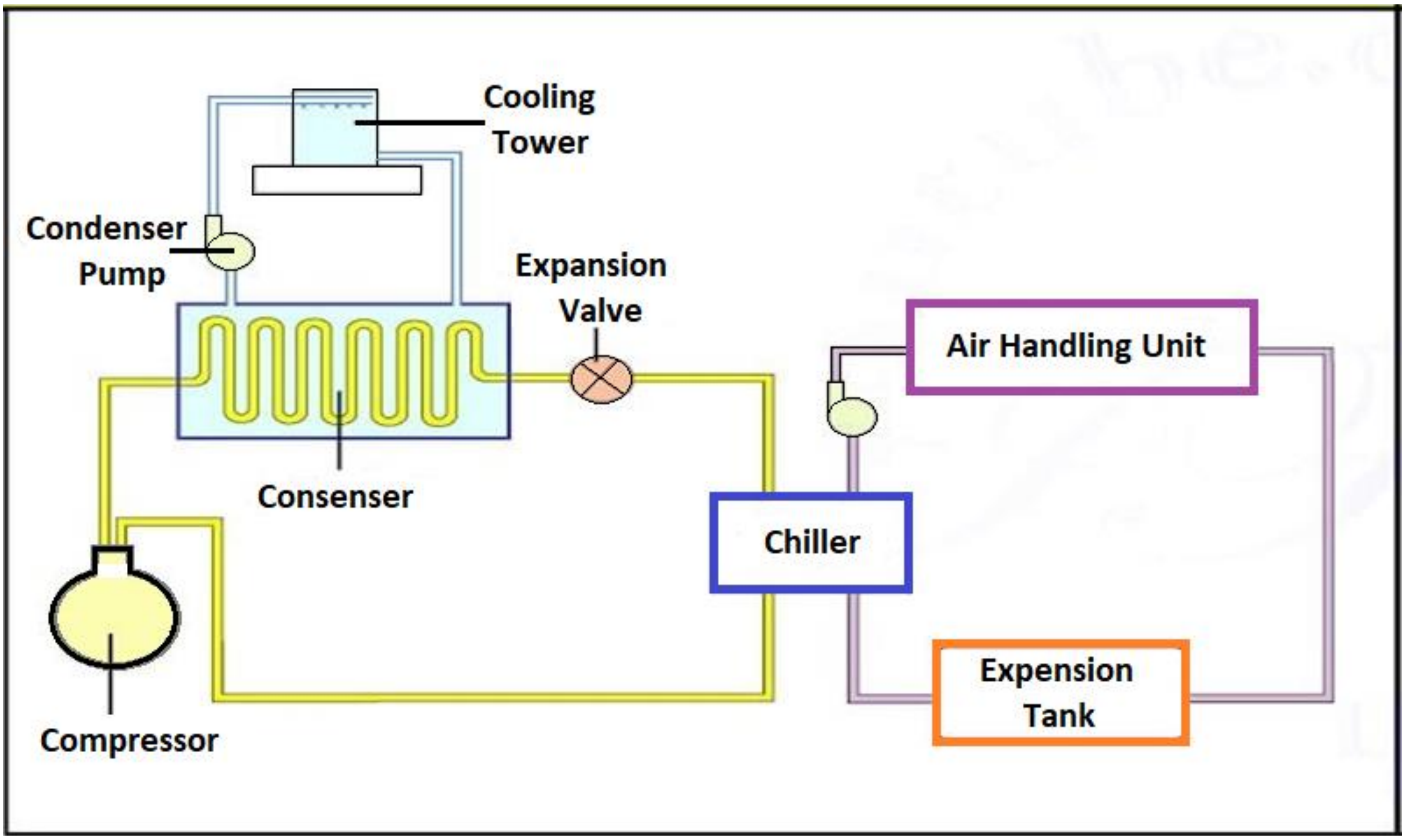

Figure-5.2 Central Air Conditioning System

AIM: Study of a Car Air-Conditioner.

THEORY:

The main purpose of the car air conditioner is to make the cabin ambiance comfortable for the occupants. A car AC requires same component we need for a common air conditioning system but materials are different. A compressor which is used in automobile AC is very compact in size and is operated by belt pully system. This pully is attached with compressor through a electromagnetic clutch which rotates the compressor when cooling is required and this clutch disconnects the rotation when temperature is achieved by giving freewheeling to compressor but compressor pully remains in rotation.

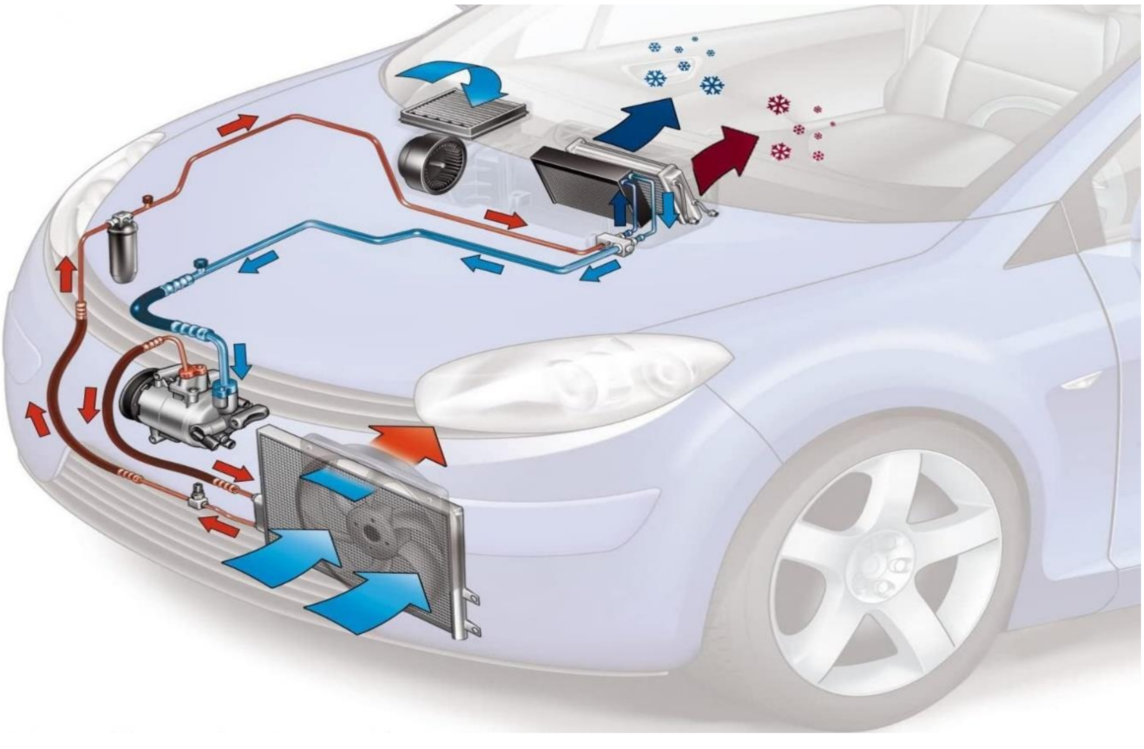

Figure-6.1 Car Air Conditioning System

The four major functions:

To be effective, the automotive air conditioner must control four conditions within the vehicle interior.

•It must cool the air.

•It must circulate the air.

•It must purifier the air.

• It must dehumidify the air.

These functions are essential if passenger comfort is to be maintained when the ambient temperature and humidity are high.

By performing these functions, the air conditioner maintains the body comfort of the passengers.

Main parts of a Car Air-Conditioner

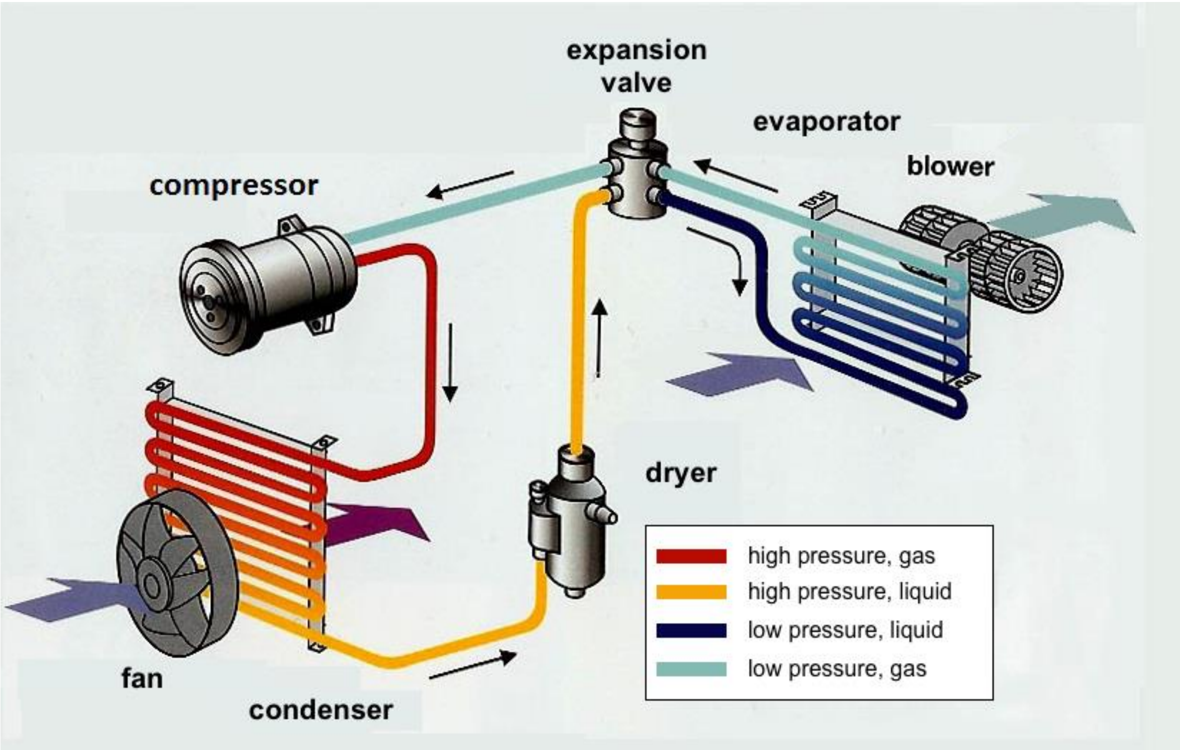

Figure-6.2 Main parts of a CAR Air Conditioner

Compressor:

There are various makes and types of compressors used in automotive air conditioning systems operating on R134a. The internal design could be Piston, Scroll, Wobble plate, Variable stroke or vane. Regardless, all operate as the pump in the A/C system to keep the R134a and lubricating oil circulating and to increase the refrigerant pressure and thus temperature.

Types of compressor used in car ac.

Wobble plate, Scroll type, Variable stroke, Rotary vane etc.

Condenser:

The condenser function is to act as heat exchanger and allow heat to flow from the hot refrigerant to the cooler outside air.

R134a entering the condenser will be a high pressure high temperature vapour. As the R134a vapour travels throw the tubes of the condenser heat is given off to the cooler ambient air; the refrigerant vapour condenses and changes to a liquid state.

Thermal expansion valve:

Refrigerant flow to the evaporator must be controlled to obtain maximum cooling, while ensuring that complete evaporation of the liquid refrigerant takes place. This is an accomplished by the thermal expansion Valve (TXV).

Evaporators:-

Refrigerant enters the evaporator coil as a cold low-pressure liquid. As this liquid passes through the evaporator coil, heat moves from the evaporator coil, heat moves from the warm air blowing across the evaporator fins into cooler refrigerant. This air that has now been cooled is then ducted into the cabin via the blower motor.

When there is enough heat to cause a change of state, a large amount of the heat moves from the air to the refrigerant. This causes the refrigerant to change from a low-pressure cold liquid into a cold vapour. (Latent heat of evaporation).

As the warmer air blows across the evaporator fins, moisture contained in that air (humidity) will condense on the cooler evaporator fins. Condensed moisture then runs off through the drain tubes located at the underside of the evaporator case.

Filter drier receiver:-

The filter drier acts as a particle filter, refrigerant storage container and most importantly moisture absorber.

Accumulator:-

The function of the accumulator is to store refrigerant, filter particles, absorb moisture and separate vaporous refrigerant

From liquid refrigerant. The normal process of the Orifice Tube System works when refrigerant leaves the evaporator coil as a mixture of vapour and liquid. This liquid enters the accumulator and falls to the bottom. The vapour rises to the top and continues onto compressor. The liquid refrigerant in the bottom of the accumulator gradually vaporizes off. This vapour rises, and then pulls into the compressor.

AC Refrigerants

In the past, automotive air conditioning systems used R-12 as the refrigerant. R-12 (aka Freon) is a very effective CFC-based (chlorofluorocarbon) refrigerant that is not flammable and not poisonous to humans. During the late 1980s, scientists discovered that widespread use of R-12 was damaging the earth’s ozone layer.

Manufacturers transitioned to R-134a in the mid-1990s. R-134a is an HFC-based (hydrofluorocarbon) refrigerant that does not have the ozone-destroying properties of Freon. The newest refrigerant is R-1234yf, which produces fewer greenhouse gases. Europe requires the use of R-1234yf, and it will likely become the new standard in the United States.

The Refrigeration Cycle

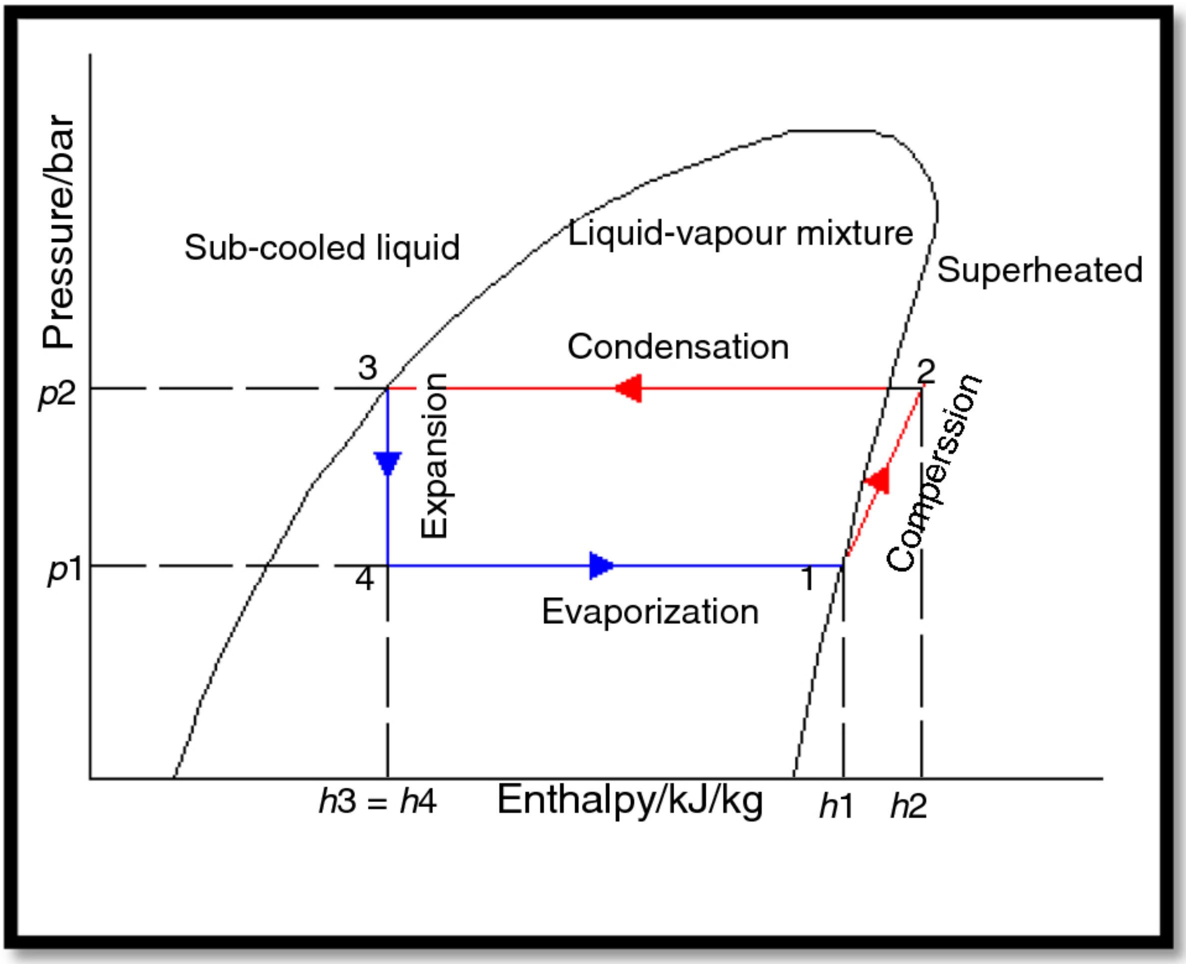

Figure-6.3 Pressure vs Enthalpy Chart

1. Compression: The refrigerant enters the compressor as a low-pressure gas. The compressor compresses it, raising both its pressure and temperature.

2. Condensation: The high-pressure, high-temperature gas then moves to the condenser coil. Here, it releases heat to the outside air and condenses into a high-pressure liquid.

3. Expansion: The high-pressure liquid refrigerant passes through the expansion valve. The pressure drops rapidly, and the refrigerant expands and cools, turning into a low-pressure, cold gas.

4. Evaporation: The cold refrigerant gas flows through the evaporator coil. It absorbs heat from the indoor air, which cools down the air. The refrigerant gas then returns to the compressor to start the cycle again.

Precautions:-

1. Always wear eye protection when servicing air conditioning systems or handling refrigerant.
2. Avoid breathing refrigerant and lubricant vapour or mist. Exposure may irritate eyes, nose and throat. If Accidental discharge occurs, ventilate the work area.
3. Do not allow refrigerants to come in contact with open flames and high-temperature surfaces. Decomposition is hazardous, and can occur if refrigerant is exposed to high temperatures (open flames, hot Metal surfaces, etc.)

4. HFC-134a is not flammable at normal ambient temperatures and atmospheric pressure. However, tests have shown it to be combustible at certain pressures and ambient temperatures when mixed with air under pressure in a sealed environment. Service equipment or vehicle A/C systems should not be pressure tested or leak tested with compressed air.
5. To prevent refrigerant cross-contamination, use separate service equipment for each refrigerant. Lubricant and refrigerant left in hoses and equipment can be a source of cross-contamination.
6. NEVER perform service on recovery/recycling/recharge equipment (other than routine maintenance) without first consulting authorized service personnel. The removal of internal fittings and filters can cause the escape of refrigerant under pressure.
7. Recovery/recycling/recharge equipment often contains parts that may produce arcs or sparks. Do not use this equipment near flammable liquids or vapours.

AIM: To demonstrate the working of cooling tower.

INTRODUCTION:

Water warmed by passing through heat exchangers, condensers and the like are cooled by contact with atmospheric air for reuse. The latent heat of water is so large that only a small amount of evaporation produces large cooling effects. Since the rate of mass transfer is usually small, the temp. level is generally fairly low. Air and water are low cost substances and where large volumes must be handled in industry as in many water cooling operations, equipment of low initial cost and operating cost is essential.

Types of Cooling Tower

On the basis of air circulation, the cooling towers are of the following types:

1. Natural draft cooling towers
2. Mechanical draft cooling towers

<u>Natural Draft or Atmospheric Cooling Tower</u>

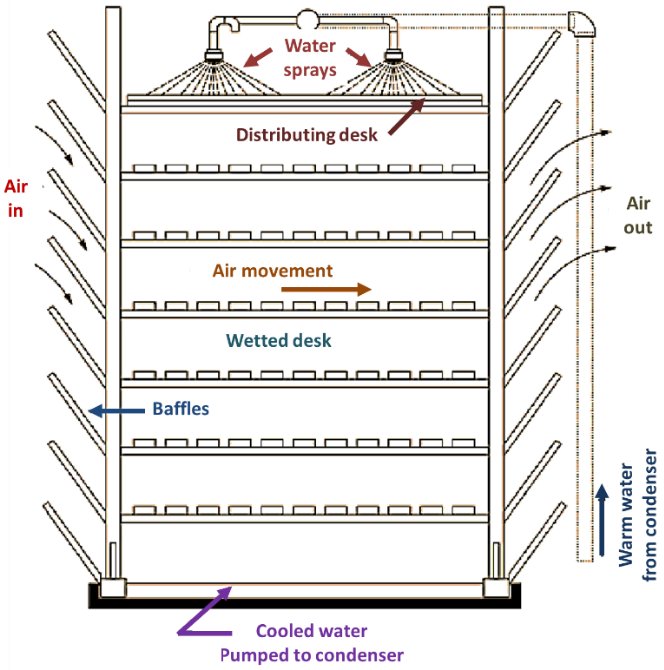

Figure-7.1 Natural Draft Towers

In this tower, the circulation of air through the tower is by natural convection. The hot water is pumped to the top of the tower and is sprayed down through nozzles. The water gives its heat to the air, cools down and is collected at the bottom of the tower, from which is sent to the condenser for reuse. Such a tower has been shown in Fig. 1. These are high and are installed in an open place. These are provided with distributing decks, which have groves to have to have an even distribution of water over the whole tower. The water flows down through these decks as a 'spray' and cools down, when comes in contact of air. Natural draft cooling is a cheap method, but if temperature of atmospheric air is high, it takes much time for the cooling.

Mechanical Draft Cooling Towers

In mechanical draft towers, the movement of air (draft) is mechanical, i.e., created by fans – water falls from top to the bottom of a vertical shell and collected in a basin at the bottom. The draft of air is made to circulate from bottom to top of the shell either by 'forced' or 'include' draft fans. As the air passes against the flow of water it can pick up more heat as compared to natural draft towers, so less air is required to cool the same amount of water. They are of two types:

1. Forced draft cooling towers
2. Induced draft cooling tower

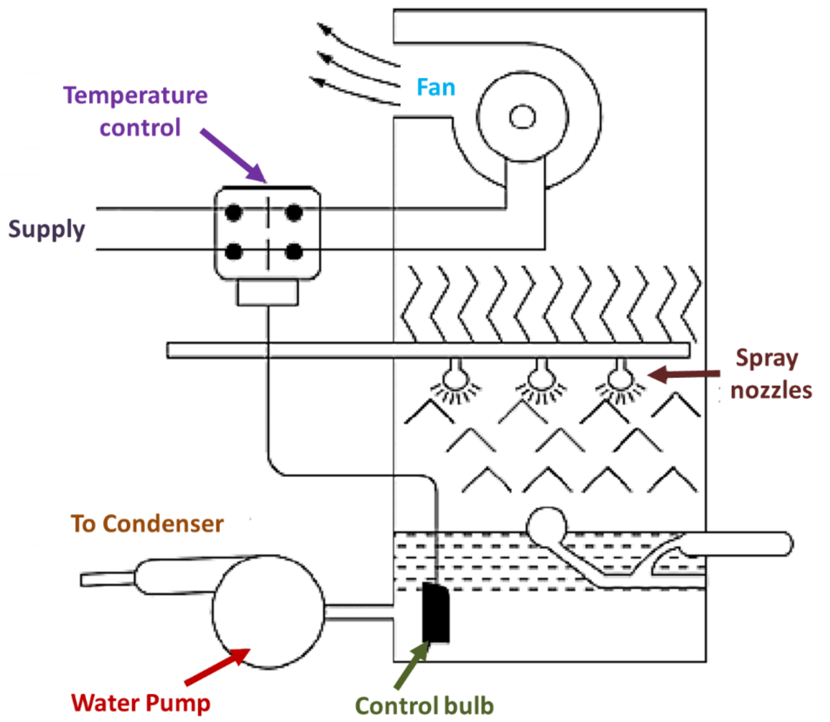

Figure-7.2 Forced draft cooling tower

The fan in these towers is installed at the top. The maintenance cost of the equipment is high. The tower is closed from all sides (see Figure 2). The air moves from top to bottom. The spray eliminators are used to 'filter' out of the air. The water comes through nozzles and cools water, which is accumulated at the bottom.

Advantages of Mechanical Draft Cooling Towers

1. This is more efficient than induced draft tower.
2. The vibration and noise are minimum as mechanical equipment's are set on a solid foundations.
3. As it handles dry air, problems of fan blade erosion are less.

Disadvantages of Mechanical Draft Cooling Towers

1. There is possibility of recirculation of hot, humid exhaust coming out from the top of the tower through the low pressure air intake region.
2. During cold weather, ice is formed on nearby equipment.

3. The fan size is limited to 4 meters.
4. The power requirement of forced draft fan is approximately double that of induced draft system for the same capacity.

Induced draft cooling tower

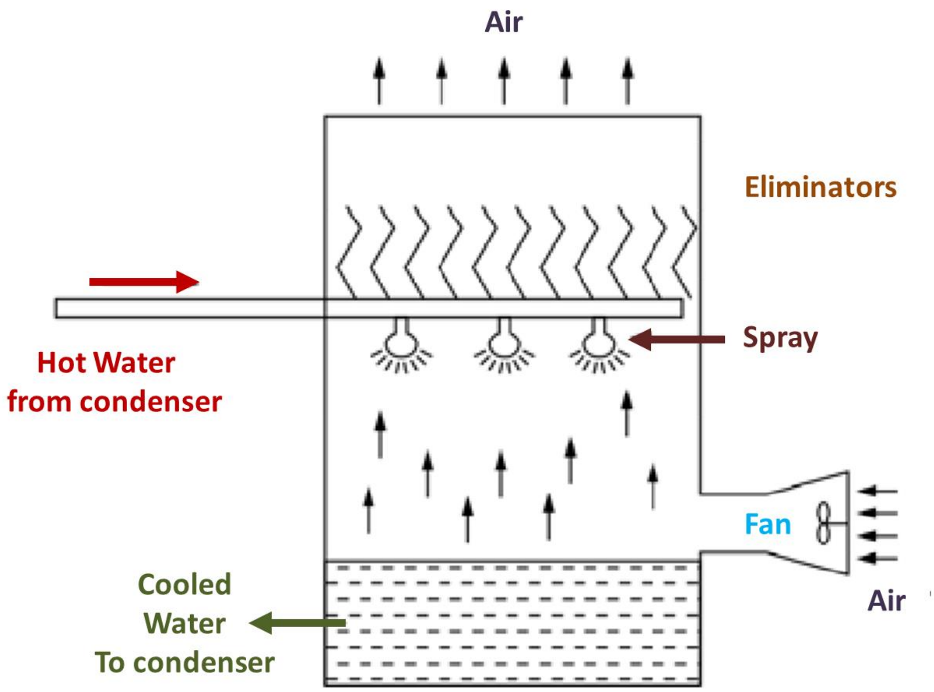

Figure-7.3 Induced draft cooling tower

This is similar to the forced tower, with a difference that fan may be installed near ground (see Figure 3) and the air flows from bottom to the top. The water eliminators are also installed to prevent loss of water with the outgoing air, i.e., to "filter out" the air. The induced draft fan is more desirable than a forced draft fan as

1. It provides an even air distribution
2. It eliminates the chance of recirculating discharged hot air, which is possible with a forced fan.

Advantages of Induced draft cooling tower

1. The main advantage is that coldest water comes in contact the driest air and warmest water comes in contact with the most humid air.
2. The size up to 20 m in diameter can be used.
3. The initial cost is lower due to the reduction in pump capacity required and smaller length of water pipes.

Disadvantages Induced draft cooling tower

1. This requires higher power motor to drive the fan compared with forced draft fan handling same air water flow.
2. The air velocities through the packings are unevenly distributed.

SPECIFICATONS:

TYPE	:	Mechanical Draft
FAN	:	220 volts, single phase, 2800 R.P.M.

TEMP. GAUGE : Provided at sump tank and collecting tank.

FLOW MEASUREMENT : Rota meter is provided to measure the flow rate of water.

HEATERS : Two heaters are provided with separate controls with a capacity of 2 kw each.

WATER SUPPLY SYSTEM : Nozzles.

APPARATUS :

The apparatus consists of cooling tower, sump tank, feed block and control panel nozzles are provided for uniform distribution of water over trays. Rota meter measures the flow rate of water entering the cooling tower. The temp. of feed water to cooling tower can be controlled by thermostatic switch provided on the control panel. Separate switches are provided for water heaters. Temp. gauges measures the inlet and outlet temperatures. An orifice meter is provided to measure the air flow rate.

PROCEDURE & CACULATIONS:

Fill the sump tank with fresh water. After some time, the water will

Reach the desired temp. Switch on the pump & fan. Adjust the

Water flow rate to cooling tower with the help of bypass valve.

Switch on the mains supply. Adjust the thermostat to the desired heating level and switch on the heating elements. Note the temp. reading of ingoing outgoing water. We can take different readings with different rates and temperatures.

Q = Vol. Flow rate of air.

$$Q = C_d \times \frac{\pi}{4} \times d^2 \times \sqrt{2gh} \times \sqrt{\frac{\rho_w}{\rho_a}} m^3/\text{sec.}$$

Where

C_d = Co-efficient of discharge = 0.64

g = Acc. due to gravity = 9.81 m/s^2

h = Difference of water level in manometer in meters. W.E

ρ_w = Density of water = 1000 kg./ m^3

ρ_a = Density of air = 1.03 kg./ m^3

d = Diameter of orifice = m = 12.8 cm

Inlet temp. = T_1

Outlet temp. = T_2

Water cooled = $(T_1 - T_2)\ ^0C$

$$\eta_{Cooling} = \frac{T_{condenser} - T_{outlet\ water}}{T_{condenser} - T_{WB}}$$

PRECAUTIONS :

1. Be sure that the heaters are always dipped in water.
2. Open the valve of return pipe before switching on the pump.
3. Never heat the water above 80 ^{0}C.

AIM: Study of various types of Fan and Blower used in air conditioning

Both fans and blowers are commonly used equipment for cooling and providing air circulation throughout buildings, internal spaces, outdoor environments, and more. They're also vital components in HVAC systems. While 'fans' and 'blowers' are often considered synonymous, they each have different functionalities, advantages, and applications. According to ASME, a fan is a device with a pressure ratio of up to 1.11. A blower has a pressure ratio between 1.11 And 1.2.

APPLICATIONS

Fans and blowers are used for very different applications. The two common applications of fans are:

- Cooling areas by moving the air
- Ventilating spaces, such as living areas

The common applications of blowers are:

- Drying goods and surfaces by forcefully directing air toward it
- Cleaning surfaces and areas, like a leaf blower
- Increasing the size of a fire

DIFFERENCE BETWEEN FAN AND BLOWER

Fan	**Blower**
Has blades for functioning or rotation	Has impellers for rotation
Is an electrical device	Is a mechanical device
It consumes less electricity	This relatively consumes more power
It offers medium airflow depending on the capacity	It offers better airflow than fans
Some types include radial fans, industrial axial fans, and propeller fans	The two main categories are centrifugal and positive displacement blowers

Types of Air Conditioner Blowers and Fans

Propeller Fan

You will probably encounter this type of fan in your daily life. It has a disk-type wheel mounted on a plate with a direct drive or belt-driven motor connected to it. When it is operating, it is noisy and is only used in applications where noise is not a factor. Look out for its usage as an exhaust and condenser fan.

It is used in applications where low-pressure differentials but large volumes of air movement are required. It is also known as an axial fan, as the air flows parallel to the axis of rotation of the fan.

CENTRIFUGAL FAN

This type of fan is also known as a radial fan, as the air flows perpendicularly to the axis of rotation of the fan. Here are the major types of centrifugal fans:

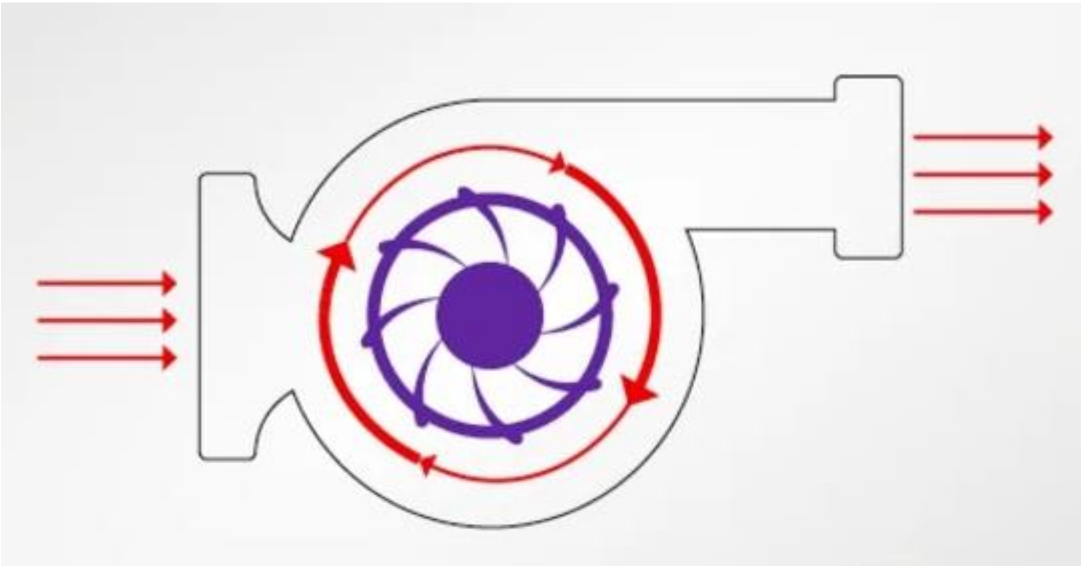

Figure-8.1 Centrifugal Fan

Forward Curved

One category of the wheel design is the forward curved centrifugal fan, which is also known as a squirrel cage blower. It has a forward curved blade with a cut-off design that prevents the air from going around the fan housing.

It is quieter than the propeller type and provides high differential pressure between the inlet and outlet. This type of fan is suitable to be used to move air in the ducts around the building.

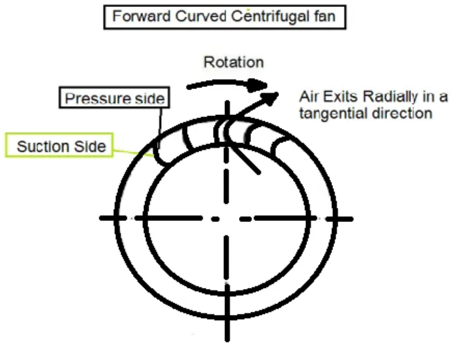

Figure-8.2 Forward Curved Centrifugal Fan

Backward Inclined

Backward inclined with a flat and single-thickness metal blade is another design that is used for smaller unit applications.

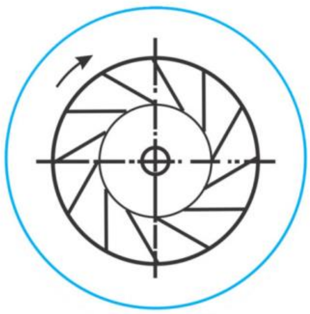

Figure-8.3 Backward Inclined Centrifugal Fan

Backward Curved

Backward curved with curve and single thickness metal fan blade is used in medium and high static pressure applications.

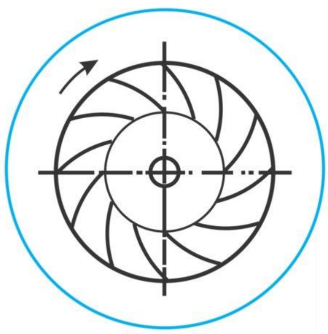

Figure-8.4 Backward Curved Centrifugal Fan

Airfoil

Airfoil with a curve and double-thickness metal blade design is sometimes used. Its aerodynamic design makes it a popular design in applications where efficiency and quietness are required.

Figure-8.5 Airfoil Design Fan

Vane-axial Fan

This design has a disk-type wheel, which is housed in a cylinder tube. Air guide vanes are built into the tube to guide the flow of the cold air properly.

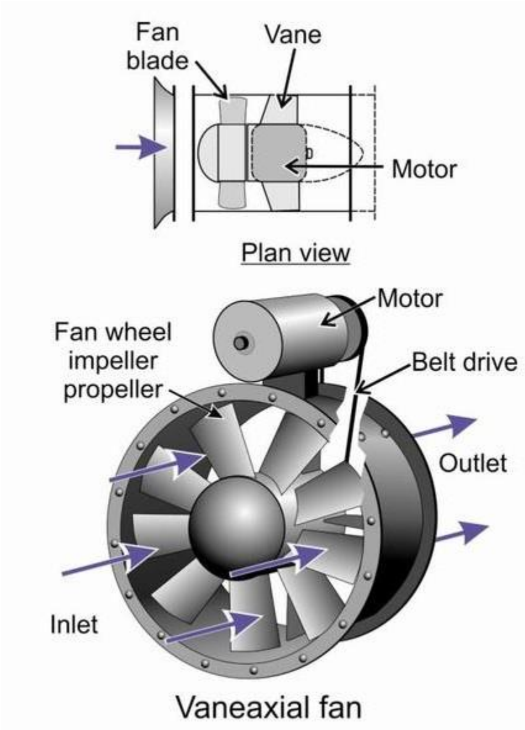

Figure-8.6 Vane-Axial Fan

Tube-axial Fan

This design has a propeller inside the cylinder with a belt-driven or direct-drive motor connected to it.

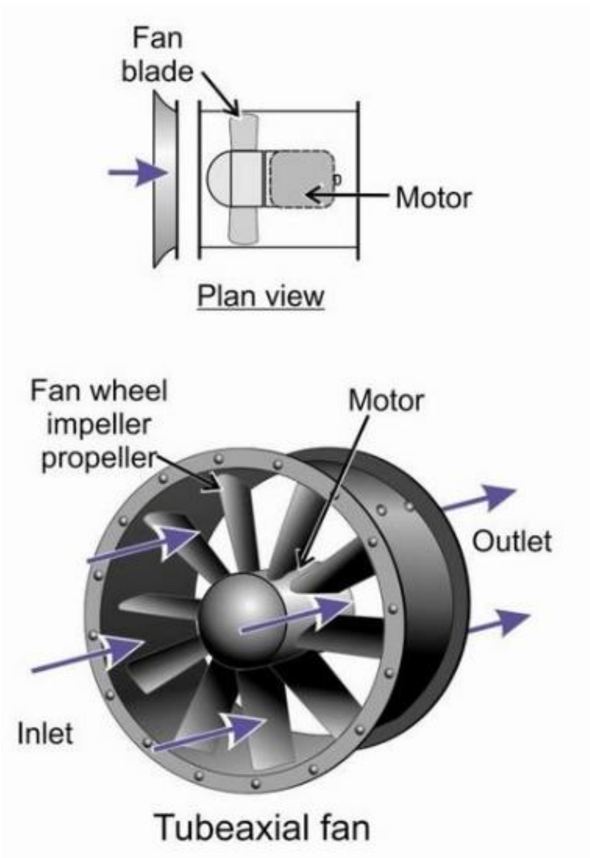

Figure-8.7 Tube-Axial Fan

AIM: Demonstrate of trouble shooting in using Air Conditioner Fault Simulator

BASIC COMPONENTS AND THEIR FUNCTIONS

Compressor: compresses the low pressure vapour coming from the evaporator so that its pressure is raised. Raising of the pressure is required to condense the vapour.

Condenser: will condense the high pressure vapour coming from compressor. This is where vapour is converted into liquid. Air is the medium used to transfer heat.

Thermostatic Expansion Valve: installed just before the evaporator, it reduces the pressure of the liquid refrigerant so that it evaporates in the evaporator. (it was held as liquid due to high pressure)

Capillary tube: Also acts as an expansion device, just like expansion valve. Only, it cannot adjust to varying loads. 2 capillary tubes of different lengths are provided in this unit.

Evaporator: Here the refrigerant, after reduction of pressure through the expansion valve, evaporates. While doing so, it absorbs the latent heat of evaporation from the surroundings, that is, air.

In this unit, 2 evaporator coils are provided to enable the users to use any one of them to see the different load conditions.

Accumulator: Since the compressor is designed only to handle vapours and it can get damaged if liquid comes in its suction line, accumulator is installed between evaporator and compressor. If some liquid does not get evaporated in the evaporator and comes towards compressor, the accumulator stops it and allows it to the compressor only after it becomes vapour.

It also checks the oil return as it does not allow sudden oil movement in large quantity.

Liquid Receiver: Receives liquid refrigerant from the condenser and supplies liquid to expansion devices. An air purge valve is provided on the receiver to purge air from the system if required.

Drier: is used in liquid line, before expansion valve. It acts as strainer and also removes any moisture from refrigerant before the refrigerant reaches the small orifice of expansion valve or capillary tube. Thus it prevents choking of expansion valve, and acts as the cleaning agent of the system.

Liquid Indicator: Watch the liquid flow.

LPHP: is a very important control for the safety of the system. It cuts of the electric supply to motor if there is a malfunction like high discharge pressure or very low discharge pressure.

Dimmerstat: To vary the voltages so that various experiments can be undertaken.

Temperature Controller: As a thermostat it puts off the system when desired temperature level is reached.

Temperature Indicators: For continuous reading of temperatures at various locations.

Fault switches: Normally all the switches remain OFF. When a particular fault is desired that switch is put down.

FAULT SWITCHES

1. F-1 Condenser fan off (Speed control through regulator)
2. F-2 Bigger evaporator fan off (Speed control through regulator)
3. F-3 Smaller evaporator fan off.
4. F-4 LP by passed (Yellow signal will still work when pressure is low)
5. F-5 HP by passed (Red signal will still work when pressure is high)
6. F-6 Temperature controller by passed.
7. F-7 Neutral supply to motor cut off.
8. F-8 Dummy
9. F-9 Dummy

Figure-9.1 Air Conditioner Fault Simulator

FAULT GENERATION AND STUDY

Sr. No.	Fault	How to create	Effect of the fault
1.	Condenser fan not Switch off working	Switch off condenser fan from switch -1.	1. Condenser temperature will increase (check temperature at T-3 and T- 4. Thus the pressure will also increase check pressure at P-3 & P-4. 2. Watch the pressure increase for some time. 3. As soon as pressure will reach beyond set limit on H.P. side of HP LP cutout, the HP LP cutout will work. (Indicating lamp & beep will come) and motor will stop working Indicating operation of H.P. cut outs.
2.		Switch on condenser fan	1. Condenser temperature will start decreasing (check temperature at T-3 and T- 4). Thus the pressure will also decrease check pressure at P-3 & P-4. 2. Watch the pressure decrease for some time. 3. As soon as pressure will reach within set limit on H.P. side of HP LP cutout, the HP LP cutout will again switch on the system.
3	Evaporator fan not working	Switch of evaporator fan switch No. 2	1. Ice formation at coil will take place. Indicating fan is not working 2. Cold air cannot be felt in front of evaporator. 3. When the temperature of the evaporator goes below the set temperature the temperature controller (T-1) will operate and switch off the motor.
4.	HP LP cutout faulty (HP faulty)	Operate switch No. 5	1. This fault indicates when HP LP cutout is faulty i.e. the HP LP does not operate. The light indication and the sound indication will come (indicating the fault) however the system will be working (can be observed from the working of compressor). 2. Alternatively switch off the condenser fan, the pressure will increase at P3 & P4 but the system will not stop working indicating faulty HP LP cutout.
5.	Tubes chocked/ clogged	Close partially the valve V-1 (valve V-2 fully closed) of evaporator	1. Pressure on L.P. side will decrease. Can be seen at the Pressure gauge P1 & P2 2. As soon as the pressure goes lower than the set pressure the L.P. cutout will work. The Indicator lamp will glow, annunciation sound will come and the motor will stop working, indicating working of HP LP cutout.
6.	HP LP cutout faulty (LP faulty)	Operate switch No. 5	1. This fault indicates when HP LP cutout is faulty i.e. the HP LP will not act being faulty and will not stop the system. The light indication and the

			sound indication will come (indicating the fault) however the system will be working (can be observed from the working of compressor). This situation can also be observed by partially closing Valve V-1, which will decrease the pressure on LP side. When the LP side pressure goes below the set pressure (Please check pressure gauge P1 & P2) the MP LP cutout should work but in this case due to this fault HP LP cutout will not work but we can see the fault at the indicator lamp and with sound.
7.	System pressure unbalanced	Partially close valve V1	The discharge pressure will increase and the suction will decrease making the system pressure unbalanced which will operate HP LP cutout.
8.	Effect of capillary	a)Open valve V3 Check the pressure at P1 & P3 and (valve V4 & V5 to be calculate the pressure differential, kept closed) b) Open valve V4 (valve V3 & V5 to be kept closed)	Check the pressure at P1 & P3 and calculate the pressure differential. Check the pressure at P1 & P3 and calculate the pressure differential. The pressure differential will be more when bigger capillary is used. The size of the capillary varies as per system parameters and design
9.	Improper electricity supply to the motor	1-cut off neutral to Motor by switch No.7 2-Bring the input voltage between 0-20volts by dimmer 3-working of starting capacity & running capacitor	Motor will not work indicating improper supply. Motor will not work indicating improper supply. The motor will not work if any of the starters are faulty

PRECAUTIONS

- Do not run the unit if voltage is too high or too low.
- Stop the unit in case of abnormally high amp.
- Stop the unit if discharge pressure gets excessively high.
- Stop the unit there is abnormal noise from any moving part.
- Stop the unit if there is excessive ice formation on the evaporator coil.