MALLA REDDY ENGINEERING COLLEGE (AUTONOMOUS)

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DEPARTMENT OF MECHANICAL ENGINEERING

M. Tech – II SEM

ADVANCED REFRIGERATION AND AIR-CONDITIONING LAB MANUAL

2018-19 Onwards (MR-18)	MALLA REDDY ENGINEERING COLLEGE (Autonomous)	M.Tech. (Thermal Engg) II Semester		
Code: 83109	ADVANCED REFRIGERATION & AIR CONDITIONING LAB	L	T	P
Credits: 1.5		-	-	3

Course Objectives: The objective of this course is to apply different principles and analyse phenomena of refrigeration and air conditioning

List of Experiments:

1. Determination of the refrigerating effect and work input, actual and theoretical COP of the refrigeration system
2. Determination of the compressor efficiency at varying functioning condition of given refrigeration system.
3. Determination of co-efficient of performance of the given unit when working as heat pump.
4. Determination of co-efficient of performance of the unit when working as refrigerator.
5. Determination of tower efficiency and humidification effect through the exchange of heat between air and water in a cooling tower.
6. Preparation of heat balance sheet for the given cooling tower.
7. Experiment on the air conditioning test rig for the determination of quality of air.
8. Determination of COP of the thermoelectric refrigeration system
9. Performance analysis at Temperature variations for thermoelectric refrigeration.
10. Determination of quality of air for given air conditioning system
11. Effect of properties of refrigerant on the functioning of refrigeration system
12. Load calculation for air conditioning

Course Outcomes:

At the end of the course, students should be able to:

1. Determine and analyse the COP of refrigeration systems
2. Determine and analyse the efficiency of refrigeration compressors
3. Determine the COP of the heat pump
4. Conduct experiments on the cooling tower
5. Determine the quality of air at various conditions.

CO- PO Mapping
(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

COs	Program Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	3	2	3
CO2	2	2	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	2	2	3	3	2	2

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DETERMINATION OF THE REFRIGERATING EFFECT AND WORK INPUT, ACTUAL AND THEROTICAL COP OF THE REFRIGERATION SYSTEM

AIM:

- To determine the refrigeration effect and work input, actual and theoretical COP of the refrigeration system

INTRODUCTION:

Refrigeration is a process by which the temperature of a given space is reduced below that of the atmosphere or surroundings. Refrigeration can be realized by several methods, for example, Ice refrigeration, dry ice Refrigeration, evaporative refrigeration, air Refrigeration, vapour compression Refrigeration etc. the modern Refrigeration used the vapour compression method. In this method, a closed system the (refrigerant) experiences a thermodynamic cycle; by virtue of doing network on the system in such a cycle, it is possible to extract heat from a low temperature source (the Refrigeration space) and to reject heat to a higher temperature sink (the atmosphere or cooling water)

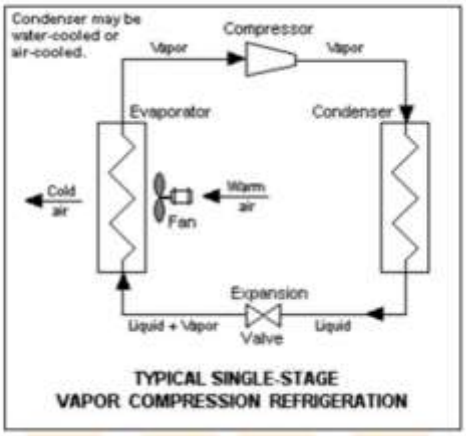
Fig. (1) shows the schematic of the vapour compression machine. The thermodynamic cycle in temperature- entropy (T-S) diagrams are shown in fig.(2). The cycle consists of the following processes

(1) – (2) : isentropic compression (in ideal cycle) of vapour refrigerant from lower pressure to higher pressure, temperature increases. (but in actual practice, the process is not isentropic because of losses and inefficiency)
(2) – (3) : condensation of high pressure of saturated/super heated vapour to liquid at high pressure.
(3) – (4) : constant enthalpy process in throttling valve or capillary tube expansion of high pressure liquid vapour mixture – temperature decreases.
(4) – (1) : vaporization of refrigerant in evaporator at constant lower pressure.
Cooling of atmosphere or surroundings takes place due to absorption of latent heat in vaporization.
In the ideal cycle the refrigerant enters the throttling valve/capillary as a liquid at (3) and leaves (4) at constant enthalpy as liquid – vapour mixture. The refrigerant enters the evaporator and extracts heat from the refrigerated space at constant temperature (T1) and lower pressure in the vaporization process (4-1). The refrigerant may leave the evaporator as a two phase mixture or as a saturated vapour or as a slightly superheated vapour as shown in fig.(2). Ideally, the refrigerant is compressed to the condenser pressure in the isentropic process (1-2). Heat is rejected from the condenser to the atmosphere or cooling water in the process (2-3).
The “co-efficient of performance” (COP) is defined as the ratio of the refrigeration obtained to the net work done on the system in the cycle:
The actual co-efficient of performance must take into account the effect of irreversibility in the individual processes as well as heat losses to or heat gain from the surroundings through the walls of interconnecting piping.
The capacity of the refrigerator is the rate at which heat can be extracted from the cold body, or in other words, is the rate at which refrigeration is produced. It is expressed in “tons of refrigeration”. A ton of refrigeration is defined as 80,000 K.Cal in 24 hour period. This is the rate of refrigeration obtained when a ton of ordinary ice is melted in 24 hour period, assuming that the latent heat of fusion is 80 K.Cal/kg. in actual practice, one ton of refrigeration is taken as equivalent to 50 K.Cal/min or 3000 K.Cal/hr. the horse power input –per ton of refrigeration in terms of refrigeration in terms of co-efficient of performance of the refrigerator is given by.

HP/Ton = 4.715/COP

DESCRIPTION:

The vapour compression refrigeration system consists of a compressor, an air cooled condenser, and expansion device (a solenoid valve and a capillary tube are provided of which one can be used at a time),a Rota meter to measure the flow rate of liquid refrigerant (R134a), a filter driver and an evaporator (water chiller). The system is provided with thermo couples and a digital temperature display to measure temperatures at various locations. Two pressure gauges are fitted on at the suction and other at the discharge side of the compressor. A fan is provided to supply air over the condenser coil. An energy meter is provided to measure the power consumed by the compressor.



PROCEDURE:

1. Take the initial temperature of water in water chiller (evaporator).
2. Switch – ON the mains and the console.
3. Keep either the throttle valve or the capillary tube open. Both devices have the same expansion (or throttling) effect.
4. Switch –ON the motor which drives the compression and the fan (which cools the condenser)
5. The refrigerant passes through the vapour compression cycle as mentioned earlier resulting in cooling in evaporator chamber or freezer
6. Run the system for some period so that the temperature of water falls down say by 4 to 5^0C.
7. Note down the temperatures, pressure gauge readings, Rota meter reading, Current, and Voltage readings for a drop of every 5^0C in evaporator temperature.

T1 = Temperature at compressor inlet (°C)
T2 = Temperature at compressor outlet (°C)
T3 = Temperature at condenser outlet (°C)
T4 = Temperature at evaporator inlet (°C)
T5 = Temperature inside freezer
P1 = Pressure upstream of the compressor, Kg/Cm^2
P2 = Pressure downstream of the compressor, Kg/Cm^2
V = Voltage of the compressor, Volts
I = Current to the compressor, Amps
The temperature T5 in the freezer denotes the refrigeration process

8. Using the measured temperatures, pressures and power input to the compressor, the co-efficient of performance and the capacity of the refrigerator can be determined using the formulae given.
9. Once experimentation is completed switch off the Compressor

OBSERVATIONS:

Sl. No	TEMPERATURE, °C						Energy reading. m		P1 in Bar	P2 in Bar	COP	
	T1	T2	T3	T3	T4	T5	Voltage (V)	Current (A)			Theoretical	Actual

CALCULATIONS:

1. Refrigerating effect = $H_1 - H_4$
2. Work input = $H_2 - H_1$
3. Coefficient of Performance :

$$COP = \frac{(H_1 - H_4)}{(H_2 - H_1)}$$

Where,

H1 = Enthalpy of the refrigerant at exit of the evaporator.
H2 = Enthalpy of the refrigerant at exit of the compressor.
H3 = Enthalpy of the refrigerant at exit of the condenser.
H4 = Enthalpy of the refrigerant at exit of the throttle valve/capillary tube.

The values of enthalpies of the refrigerant at different states are obtained from pressure-enthalpy chart provided.

Note;

H1 is obtained for Temperature T1 and Pressure P1
H2 is obtained for Temperature T2 and Pressure P2
H3 is obtained for Pressure P2
H4 = H3

Check the DATA SHEET for the values of enthalpy.

4. Actual COP = $\frac{\text{Net refrigerating effect (Rn), KJ}}{\text{Energy (or) power supplied to the compressor (w)}}$

Net refrigerating effect (Rn) = $mc_p\Delta T$ KW
Where m = mass of water taken =11kg
c_p = specific heat of water = 4.187 Kj/Kg^0 K
ΔT =temperature drop of water ^{0}K (T_{Final} - $T_{Initial}$)
Work input (or) power supplied to the compressor, w= V X I

PRECAUTIONS:

- While doing Capillary, switch off the Solenoid Valve and when doing with Throttle Valve Switch on the Solenoid Valve and close the valves at the Capillary. This is most important task before starting the experiment.

- Minimum of 10min has to be maintained b/w switching off and on of the compressor, otherwise the compressor diaphragm may be damaged.

RESULT :

- The refrigerating effect =_______________.
- The work input = _________________.
- Theoretical COP = __________________.
- Actual COP = ____________________.

DETERMINATION OF THE COMPRESSOR EFFICIENCY AT VARYING FUNCTIONING CONDITION OF GIVEN REFRIGERATION SYSTEM

AIM:

- To determine the compressor efficiency at varying functioning condition of given refrigeration system.

INTRODUCTION:

Compressor: The function of compressor is to draw the refrigerant from evaporator and compresses it to a high temperature and pressure before it is supplied to the condenser.

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 ammonia (NH3) (R-717), R-12, R-22 and CH3Cl (R-40). The reciprocating compressors are available in sizes as small as 1/2 KW which are used in small domestic refrigeration and up to about 150 KW for large capacity. The two types of reciprocating compressor in general are :-

- Single acting vertical compressor.
- Double acting horizontal compressor.

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.

Volumetric efficiency η_v is the term defined in the case of positive displacement compressors to account for the difference in the displacement or swept volume V_P in-built in the compressor and volume V_S of the suction vapour sucked and pumped. It is expressed by the ratio

$$\eta_v = V_S / V_P$$

It can also be expressed as

$$\eta_v = 1 + C - C(P_1/P_2)^{1/\Upsilon}$$

DESCRIPTION:

The vapour compression refrigeration system consists of a compressor, an air cooled condenser, and expansion device (a solenoid valve and a capillary tube are provided of which one can be used at a time),a Rota meter to measure the flow rate of liquid refrigerant (R134a), a filter driver and an evaporator (water chiller). The system is provided with thermo couples and a digital temperature display to measure temperatures at various locations. Two pressure gauges are fitted on at the suction and other at the discharge side of the compressor. A fan is provided to supply air over the condenser coil. An energy meter is provided to measure the power consumed by the compressor.

PROCEDURE:

1. Take the initial temperature of water in water chiller (evaporator).

2. Switch – ON the mains and the console
3. Keep either the throttle valve or the capillary tube open Both devices have the same expansion (or throttling) effect.
4. Switch –ON the motor which drives the compression and the fan (which cools the condenser)
5. The refrigerant passes through the vapour compression cycle as mentioned earlier resulting in cooling in evaporator chamber or freezer
6. Run the system for some period so that the temperature of water falls down say by 4 to 5^0C.
7. Now note down the temperatures, pressure gauge readings, Rota meter reading, current and voltage reading.
8. Repeat steps 6 and 7 and take the corresponding readings.
9. Wait for about 30 minutes and note the temperatures T1 to T5 and pressures P1 and P2

T1 = Temperature at compressor inlet (°C)
T2 = Temperature at compressor outlet (°C)
T3 = Temperature at condenser outlet (°C)
T4 = Temperature at evaporator inlet (°C)
T5 = Temperature inside freezer
P1 = Pressure upstream of the compressor, Kg/Cm²
P2 = Pressure downstream of the compressor, Kg/Cm²
V = Voltage of the compressor, Volts
I = Current to the compressor, Amps

The temperature T5 in the freezer denotes the refrigeration process

10. Using the measured temperatures, pressures and power input to the compressor, the co-efficient of performance and the capacity of the refrigerator can be determined using the formulae given.
11. Once experimentation is completed switch off the Compressor

OBSERVATIONS:

Sl. No	TEMPERATURE, °C						Energy readings		P1 in Bar (Discharge)	P2 in Bar (Suction)	η_v (Volumetric Efficiency)
	T1	T2	T3	T3	T4	T5	Voltage (V)	Current (I)			
1											
2											
3											

CALCULATIONS:

$\eta_v = 1+C- C(P_1/P_2)^{1/\Upsilon}$

Where,

η_v = Volumetric efficiency.
P1 = Discharge Pressure
P2 = Suction Pressure

C = 0.04

Graph: Volumtric efficiency Vs Suction Pressure

PRECAUTIONS:

While doing Capillary switch off the Solenoid Valve and when doing with Throttle Valve Switch on the Solenoid Valve and close the valves at the Capillary. This is most important task before starting the experiment.

Minimum of 10min has to be maintained b/w switching off and on of the compressor, otherwise the compressor diaphragm may be damaged.

RESULT :

- Volumetric efficiency =______________.

DETERMINATION OF CO-EFFICIENT OF PERFORMANCE OF THE GIVEN UNIT WHEN WORKING AS HEAT PUMP

AIM:

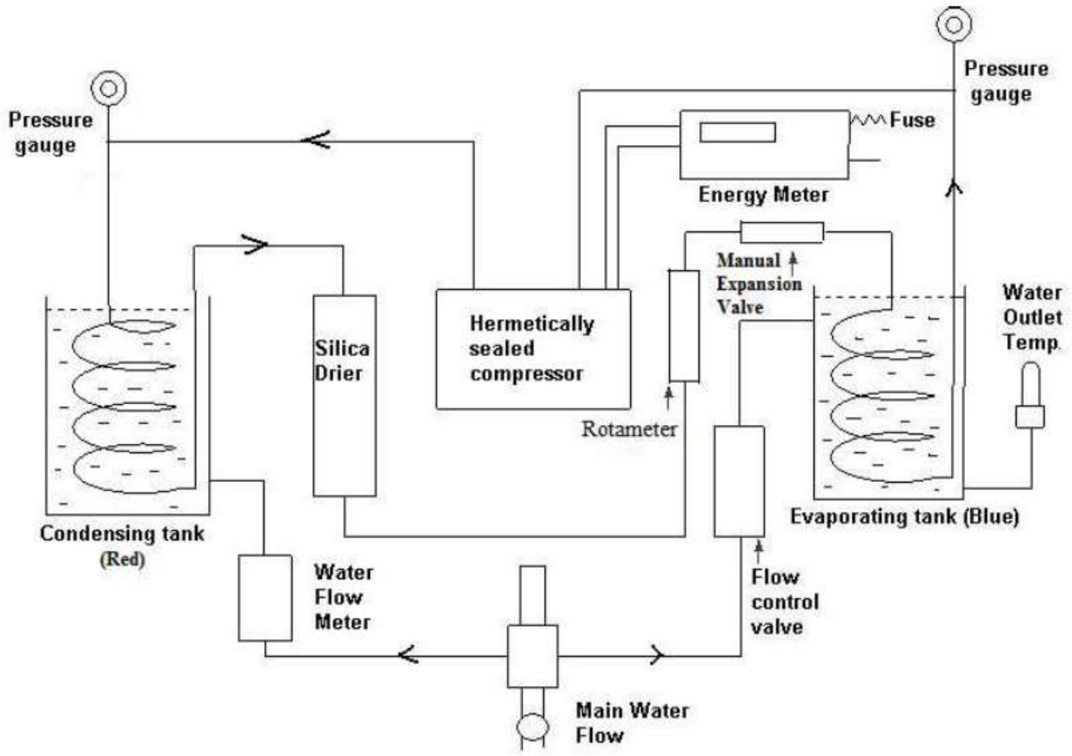
- To determine the COP of the heat pump

INTRODUCTION:

A heat pump is an electrical device that extracts heat from one place and another. The heat pump is not a new technology; it has been used in canada and around the world for decades. Refrigerators and air conditioner are both common examples of this technology. Heat pump transfer heat by circulating a substance called a refrigerant through a cycle of evaporation and condensation (see figure1). A compressor pumps the refrigerant between two heat exchanger coils. In one coil, the refrigerant is evaporated at low pressure and absorbs heat from its surroundings. the refrigerant is then compressed en route to the other coil, where it condenses at high pressure. At this point, it releases the heat it absorbed earlier in the cycle. Refrigerators and air conditioners are both examples of heat pumps operating only in the cooling mode. A refrigerator is essentially an insulated box with a heat pump system connected to it. The evaporator coil is located inside the box, usually in the freezer compartment. Heat is absorbed from the location and transferred outside, usually behind underneath the unit where the condenser coil is located. Similarly, an air conditioner transfers heat from inside a house to the outdoors. The heat pump cycle is fully reversible, and heat pump can provide year-round climate control for your home heating in winter and cooling and dehumidifying in summer. Since the ground and air outside always contain some heat, a heat pump can supply heat to a house even on cold winter.

DESCRIPTION:

The vapour compression refrigeration system consists of a compressor, an air cooled condenser, and expansion device (a solenoid valve and a capillary tube are provided of which one can be used at a time),a Rota meter to measure the flow rate of liquid refrigerant (R134a), a filter driver and an evaporator (water chiller). The system is provided with thermo couples and a digital temperature display to measure temperatures at various locations. Two pressure gauges are fitted on at the suction and other at the discharge side of the compressor. A fan is provided to supply air over the condenser coil. An energy meter is provided to measure the power consumed by the compressor.



PROCEDURE:

1. Fill measured quantity of water in condenser and evaporator banks and note down the initial temperature of tanks.
2. Switch – ON the mains and the console
3. Switch on the compressor
4. The refrigerant passes the vapour compression cycle as mentioned earlier resulting in cooling in evaporator chamber or freezer
5. Wait for above 5 minutes and note the temperature T1 to T6 and pressure P1 to P2.

T1 = Temperature at compressor inlet (°C)
T2 = Temperature at compressor outlet (°C)
T3 = Temperature at condenser inlet or compressor outlet (°C)
T4 = Temperature of water at condenser inlet (°C)
T5 = Temperature at condenser outlet (°C)
T6 = Temperature inside freezer (°C)
P1 = Pressure upstream of the compressor, Kg/Cm²
P2 = Pressure downstream of the compressor, Kg/Cm²
V = Voltage of the compressor, Volts
I = Current to the compressor, Amps

The temperature T5 in the freezer denotes the refrigeration

6. Note the voltmeter and ammeter reading.
7. Using the measured temperatures, pressures and power input to the compressor, the coefficient of performance can be determined using the procedure given below.
8. Once experimentation is completed switch off the Compressor

OBSERVATIONS:

Sl. No		TEMPERATURE, °C	Energy	Pressure, Kg/ cm^2

	Lpm	T1	T2	T3	T4	T4	T5	T6		Current (A)	Voltage (V)		
1													
2													
3													
4													
5													

CALCULATIONS:

1. Power Input to the Compressor ,w = V x I

V = Voltage input to the compressor in volts
I = current input to the compressor in amps

2. Heat released in the condenser Qc: = $m_w c_{pw} \Delta T_w$

m_w = mass flow rate of water in kg/sec
c_{pw} = specific heat of water = 4180 j/kg k
ΔT_w = Temperature difference = T3–T2

3. Coefficient of performance of heat pump : COP = Qc/W

PRECAUTIONS :

1. Check all the electrical connections
2. Do not run the equipment if the voltage is below 180V
3. Do not switch on the compreesor frequently
4. Do not attempt to alter the equipment as this may cause damage to the whole system

RESULT :

The Coefficient of performance of the given Heat pump is obtained at different rates.

DETERMINATION OF CO-EFFICIENT OF PERFORMANCE OF THE GIVEN UNIT WHEN WORKING AS REFRIGERATOR

AIM:

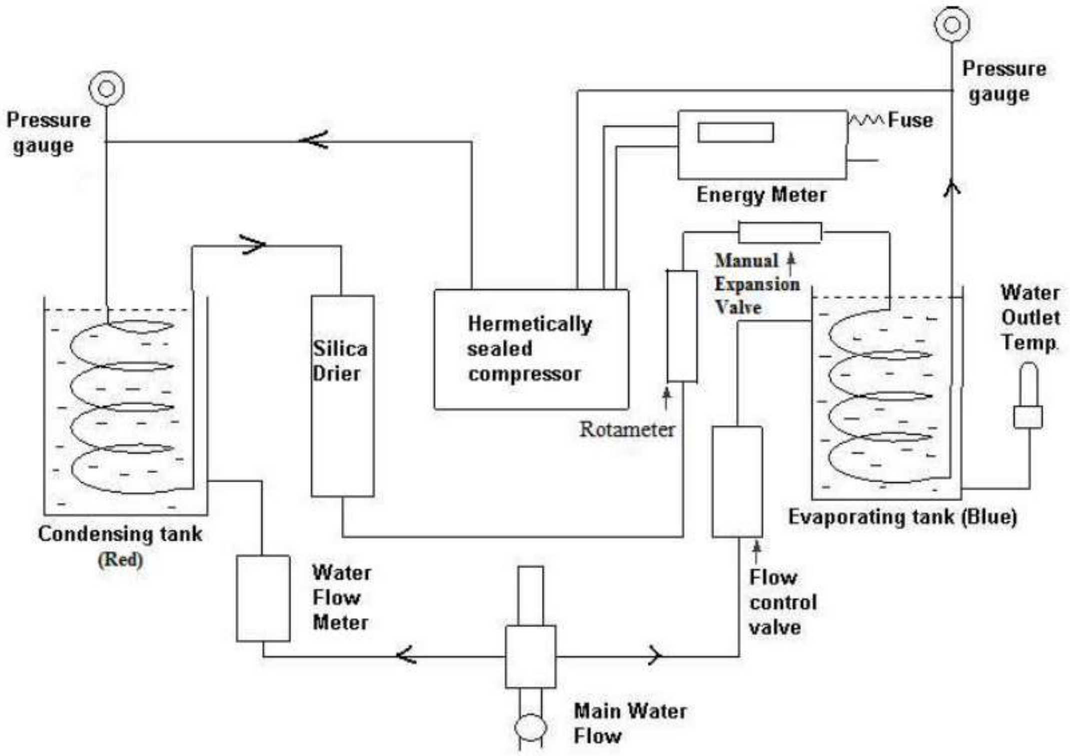
- To determine the COP of the unit when working as refrigerator

INTRODUCTION:

A heat pump is an electrical device that extracts heat from one place and another. The heat pump is not a new technology; it has been used in canada and around the world for decades. Refrigerators and air conditioner are both common examples of this technology. Heat pump transfer heat by circulating a substance called a refrigerant through a cycle of evaporation and condensation (see figure1). A compressor pumps the refrigerant between two heat exchanger coils. In one coil, the refrigerant is evaporated at low pressure and absorbs heat from its surroundings. the refrigerant is then compressed en route to the other coil, where it condenses at high pressure. At this point, it releases the heat it absorbed earlier in the cycle. Refrigerators and air conditioners are both examples of heat pumps operating only in the cooling mode. A refrigerator is essentially an insulated box with a heat pump system connected to it. The evaporator coil is located inside the box, usually in the freezer compartment. Heat is absorbed from the location and transferred outside, usually behind underneath the unit where the condenser coil is located. Similarly, an air conditioner transfers heat from inside a house to the outdoors. The heat pump cycle is fully reversible, and heat pump can provide year-round climate control for your home heating in winter and cooling and dehumidifying in summer. Since the ground and air outside always contain some heat, a heat pump can supply heat to a house even on cold winter.

DESCRIPTION:

The vapour compression refrigeration system consists of a compressor, an air cooled condenser, and expansion device (a solenoid valve and a capillary tube are provided of which one can be used at a time),a Rota meter to measure the flow rate of liquid refrigerant (R134a), a filter driver and an evaporator (water chiller). The system is provided with thermo couples and a digital temperature display to measure temperatures at various locations. Two pressure gauges are fitted on at the suction and other at the discharge side of the compressor. A fan is provided to supply air over the condenser coil. An energy meter is provided to measure the power consumed by the compressor.



PROCEDURE:

1. Fill measured quantity of water in condenser and evaporator banks and note down the initial temperature of tanks
2. Switch – ON the mains and the console
3. Switch on the compressor
4. The refrigerant passes the vapour compression cycle as mentioned earlier resulting in cooling in evaporator chamber or freezer
5. Set the water flow rate provided to extract the heat from the system
6. Wait for above 5 minutes and note the temperature T1 to T6 and pressure P1 to P2.

T1 = Temperature at compressor inlet (°C)
T2 = Temperature at compressor outlet (°C)
T3 = Temperature at condenser inlet or compressor outlet (°C)
T4 = Temperature of water at condenser inlet (°C)
T5 = Temperature at condenser outlet (°C)
T6 = Temperature inside freezer (°C)
P1 = Pressure upstream of the compressor, Kg/Cm²
P2 = Pressure downstream of the compressor, Kg/Cm²
V = Voltage of the compressor, Volts
I = Current to the compressor, Amps

7. Using the measured temperatures, pressures and power input to the compressor, the coefficient of performance can be determined using the procedure given below.
8. Once experimentation is completed switch off the Compressor

OBSERVATIONS:

Sl. No		TEMPERATURE, °C	Energy	Pressure, Kg/ cm^2

	Lpm	T1	T2	T3	T4	T4	T5	T6	Current (A)	Voltage (V)		
1												
2												
3												
4												
5												

CALCULATIONS:

1. Power Input to the Compressor ,W = V x I

V = Voltage input to the compressor in volts
I = current input to the compressor in amps

2. Heat absorbed in the Evaporator Qe: = $m_w c_{pw} \Delta T_w$

$m_{w\,=}$ mass flow rate of water in kg/sec
c_{pw} = specific heat of water = 4180 j/kg k
$\Delta T_{w\,=}$ Temperature difference = T4–T1

3. Coefficient of performance of heat pump : COP = Qe/W

PRECAUTIONS :

1. Check all the electrical connections
2. Do not run the equipment if the voltage is below 180V
3. Do not switch on the compressor frequently
4. Do not attempt to alter the equipment as this may cause damage to the whole system

RESULT :

The Coefficient of performance of the given Refrigerator is obtained at different rates.

DETERMINATION OF TOWER EFFICIENCY AND HUMIDIFICATION EFFECT THROUGH THE EXCHANGE OF HEAT BETWEEN AIR AND WATER IN A COOLING TOWER

AIM:

To study & find out the efficiency of cooling tower and humidification effect.

INTRODUCTION:

The cooling tower is conjunction with the water-cooled condenser. Water is passing through the condenser water tubes only gets warmed up but does not get contaminated. It can, therefore, be used again, after cooling. The cooling tower cools the warm water for re – circulating it in the condenser. It is thus water conservation equipment. The heat removed by the refrigeration system from the space or product to be cooled is ultimately thrown to the atmosphere through the cooling tower in a water-cooled condenser system. Thus the cooling tower should function efficiently for the refrigeration system to perform well.
The warm water from the condenser is pumped to the top of the cooling tower. From there it is allowed to fall down a substational height to the cooling tower tank or through at the bottom. The falling water droplets are cooled by the air circulating through the tower. The cooling is brought about by sensible heat transfer and by the evaporation of a portion of the water. To facilitate heat transfer, the water from the cooling tower in fine droplets or film. This is accomplished in:-

1.) The atmospheric cooling tower by the use of spray nozzles which spray water from the top of the cooling tower.

2.) The forced draft or induced draft cooling tower, by increasing the surface area of water. Water is allowed to trickle over the special type of fiber material closely packed in the cooling tower. Water spreads over the fiber martial thus creating the large surface area for heat transfer between water and air.

The water vapour produced by the evaporation of water is carried away by the air circulating through the tower. Thus the air coming out from the cooling tower will be humid and warm.
Capacity of cooling towers:
The capacity of cooling tower depends upon the amount of evaporation of water that takes place. The amount of evaporation of water in turn, depends upon the following factors:

1. The amount of water surface exposed to the air.
2. The length of the exposure time
3. The velocity of air passing over the water droplets formed in cooling tower.
4. The wet bulb temperature of the atmospheric air.

Note: - When the wet bulb temp. of air decreases the air can absorb more water vapour and therefore evaporate more water. Thus the capacity of the cooling tower increases.

Types of cooling towers:

1. Natural draft cooling tower
2. Mechanical draft cooling tower

DESCRIPTION:

The unicool cooling tower consists of about 1.2 meter length of tower made form transparent acrylic sheet for the clear visualization fitted over the conical housing.
The main m.s. tank of capacity of about 80 ltr. Is provided through which centrifugal pump

sucks water and delivers to the geyser through flow meter. In geyser the temp. of water gets increases and it sprays on the top of cooling tower through spray nozzles over the decking material (fiber). Then water is allowed to trickle over the decking material closely packed in the cooling tower. Water spreads over the fiber martial thus creating the large surface area for heat transfer between water and air. A centrifugal type blower with control valve is used to blow air inside the cooling tower. The falling water droplets are cooled by the air circulating through the tower. The cooling is brought about by sensible heat transfer and by the evaporation of a portion of the water.
The water vapour produced by the evaporation of water is carried away by the air circulating through the tower.

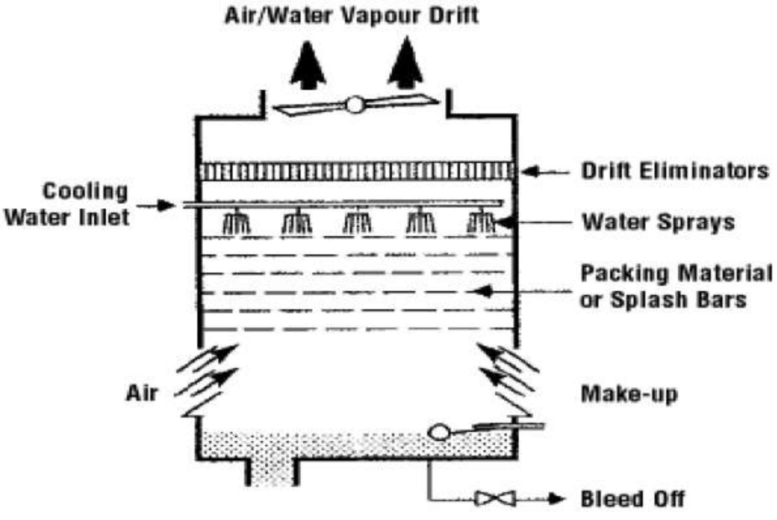


Figure: Forced draft cooling tower

PROCEDURE:

1. Note down the initial conditions (DBT and WBT) of air at inlet and outlet of the duct and also take the initial energy meter reading of the compressor.
2. By taking all necessary precautions, switch on the main keeping the capillary valves open.
3. Run the unit for some time say 15 mins, and take the temperatures, pressure readings, Rota meter readings, energy meter reading and the velocity of air at outlet of the duct.
4. Run the unit for another 15 mins and take the readings.
5. Repeat the procedure with solenoid valve as expansion device and switch of the unit.

OBSERVATIONS:

S.no.	Temp. Of water inlet to cooling tower (T1)	Temp. Of water outlet to cooling tower (T2)	Wet bulb temp. Of atmospheric air (T3)

CALCULATIONS:

$$\text{Efficiency of cooling tower} = \frac{\text{Actual cooling obtained Efficiency of cooling tower}}{\text{Theoretical cooling to be obtained}}$$

$$\text{Efficiency of cooling tower} = \frac{T1-T2}{T1-T3}$$

PRECAUTIONS:

Don’t switch on the heater without water supply

RESULT :

The efficiency of cooling tower is………

PREPARATION OF HEAT BALANCE SHEET FOR THE GIVEN COOLING TOWER

AIM:

To prepare heat balance sheet for the given cooling tower

INTRODUCTION:

The cooling tower is conjunction with the water-cooled condenser. Water is passing through the condenser water tubes only gets warmed up but does not get contaminated. It can, therefore, be used again, after cooling. The cooling tower cools the warm water for re – circulating it in the condenser. It is thus water conservation equipment. The heat removed by the refrigeration system from the space or product to be cooled is ultimately thrown to the atmosphere through the cooling tower in a water-cooled condenser system. Thus the cooling tower should function efficiently for the refrigeration system to perform well.
The warm water from the condenser is pumped to the top of the cooling tower. From there it is allowed to fall down a substational height to the cooling tower tank or through at the bottom. The falling water droplets are cooled by the air circulating through the tower. The cooling is brought about by sensible heat transfer and by the evaporation of a portion of the water. To facilitate heat transfer, the water from the cooling tower in fine droplets or film. This is accomplished in:-

1.) The atmospheric cooling tower by the use of spray nozzles which spray water from the top of the cooling tower.

2.) The forced draft or induced draft cooling tower, by increasing the surface area of water. Water is allowed to trickle over the special type of fiber material closely packed in the cooling tower. Water spreads over the fiber martial thus creating the large surface area for heat transfer between water and air.

The water vapour produced by the evaporation of water is carried away by the air circulating through the tower. Thus the air coming out from the cooling tower will be humid and warm.
Capacity of cooling towers:
The capacity of cooling tower depends upon the amount of evaporation of water that takes place. The amount of evaporation of water in turn, depends upon the following factors:

1. The amount of water surface exposed to the air.
2. The length of the exposure time
3. The velocity of air passing over the water droplets formed in cooling tower.
4. The wet bulb temperature of the atmospheric air.

Note: - When the wet bulb temp. of air decreases the air can absorb more water vapour and therefore evaporate more water. Thus the capacity of the cooling tower increases.

Types of cooling towers:

1. Natural draft cooling tower
2. Mechanical draft cooling tower

DESCRIPTION:

The unicool cooling tower consists of about 1.2 meter length of tower made form transparent acrylic sheet for the clear visualization fitted over the conical housing.
The main m.s. tank of capacity of about 80 ltr. Is provided through which centrifugal pump sucks water and delivers to the geyser through flow meter. In geyser the temp. of water gets

increases and it sprays on the top of cooling tower through spray nozzles over the decking material (fiber). Then water is allowed to trickle over the decking material closely packed in the cooling tower. Water spreads over the fiber martial thus creating the large surface area for heat transfer between water and air. A centrifugal type blower with control valve is used to blow air inside the cooling tower. The falling water droplets are cooled by the air circulating through the tower. The cooling is brought about by sensible heat transfer and by the evaporation of a portion of the water.

The water vapour produced by the evaporation of water is carried away by the air circulating through the tower.

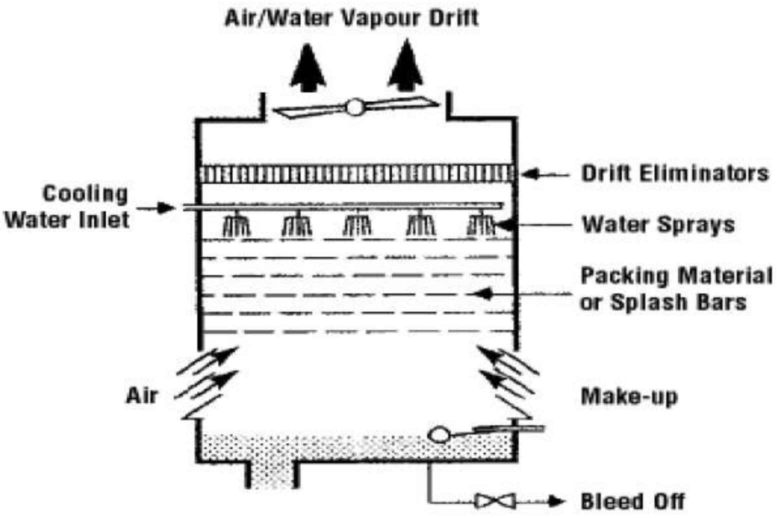


Figure: Forced draft cooling tower

PROCEDURE:

1. Note down the initial conditions (DBT and WBT) of air at inlet and outlet of the duct and also take the initial energy meter reading of the compressor.
2. By taking all necessary precautions, switch on the main keeping the capillary valves open.
3. Run the unit for some time say 15 mins, and take the temperatures, pressure readings, Rota meter readings, energy meter reading and the velocity of air at outlet of the duct.
4. Run the unit for another 15 mins and take the readings.
5. Repeat the procedure with solenoid valve as expansion device and switch of the unit.

OBSERVATIONS:

Energy balance chart using psychometric chart

station	Water bulb temperature	Dry bulb temperature	Wet bulb temperature	humidity	Enthalpy KJ/kg
Bottom					
5					
4					
3					
2					
1					
Top					

PRECAUTIONS:

Don’t switch on the heater without water supply

RESULT :

The Heat balance sheet from psychrometric chart is prepared

DETERMINATION OF QUALITY OF AIR FOR GIVEN AIR CONDITIONING SYSTEM

AIM:

- To determine the quality of air for given air conditioning system

INTRODUCTION:

The science of air conditioning deals with maintaining a desirable internal air conditions irrespective of external atmospheric conditions. The factors involved in any air conditioning installation are:

- Temperature
- Humidity
- Air movement and circulation
- Air filtering, cleaning and purification

The simultaneous control of these factors within the required limits is essential for human comfort or for any industrial application of the air conditioning system.

In any air conditioning system, temperature and humidity are controlled by thermodynamic processes. Depending on the session, the air conditioning processes. Involve cooling, heating, humidification and dehumidification of air. Other aspects such as air movements, circulations, purification, etc. are obtained by installing suitable fans, blowers, ducting and filters.

This equipment is designed to demonstrate different air conditioning processes such as cooling, heating, humidification, etc. required for different season of the year

IMPORTANT DEFINITIONS :

Dry Air

Mechanical mixture of oxygen, nitrogen, carbon dioxide, etc.

Moist Air

Mixture of dry air and water vapour.

Saturated Air

Is such a mixture of dry air and water vapour when the air has diffused the maximum amount of water vapour into it.

Degree of Saturation

Is the ratio of actual mass of water vapour in a unit mass of dry air to the mass of water vapour in the same mass of Dry air when it is saturated at the same temperature and Pressure.

Humidity

Is the mass of water vapour present in 1 Kg of dry air expressed in gm per Kg of dry air

Absolute humidity

Is the mass of water vapour present in 1 m^3 of dry air, gm per cubic meter of dry air

Relative Humidity

Is the ratio of actual mass of water vapour in volume of moist air to the mass of water vapour in the same volume of saturated air at the same temperature and pressure.

Dry bulb temperature

Is the temperature of air recorded by a thermometer when it is not affected by the moisture present in the air.

Wet Bulb Temperature

Is the temperature of the air recorded by a thermometer when its bulb is surrounded by a wet cloth exposed to the Air

Psychrometer

Is an instrument containing dry bulb thermometer and wet bulb thermometer. The difference in the readings of these two thermometers gives the relative humidity of the air surrounding the Psychrometer.

DESCRIPTION:

The equipment consists of a cooling coil which is a part of the vapour compression refrigeration system working on Freon – 22. In the upstream and downstream of the cooling coil, heaters are provided to heat air either at the upstream or the downstream of the cooling coil. A steam generator is provided to increase humidity of air. The system is provided to increase humidity of air. The system is provided with fans, air duct and valve system to circulate air over the cooling coil and heater and to operate the system in both closed and open cycle. the system is instrumented with thermometers, digital humidity indicators, pressure indictors and wind velocity indicators to determine the state of air – moisture mixture during the operation of the air conditioning system. Following are the important components:

- Cooling coil of the vapour compression Air Conditioning system consisting of Suitable Duct where air passes for conditioning, Compressor, condenser, throttle / capillary tube, pressure and temperature Indicators with selector switch and power meter. The system works on Freon-22
- Air Heaters – one at the inlet and other at the outlet are provided
- Steam generator which consists of immersion type heating coil
- Suction fan (2 Nos)
- Valve system to change the system to perform in both closed and open
- Wet Bulb & Dry Bulb Temperatures (2 Nos) placed before and after evaporator / cooling coil.
- Instrumentation to measure the temperature at different points, power input and Pressure readings,
- Thermostat to limit temperatures in the cooling coil to not exceed the inlet condition of compressor.

PROCEDURE:

1. Note down the initial conditions (DBT and WBT) of air at inlet and outlet of the duct and also take the initial energy meter reading of the compressor.
2. By taking all necessary precautions, switch on the main keeping the capillary valves open.
3. Run the unit for some time say 15 mins, and take the temperatures, pressure readings, Rota meter readings, energy meter reading and the velocity of air at outlet of the duct.
4. Run the unit for another 15 mins and take the readings.
5. Repeat the procedure with closing the inlet air and recirculating the outlet air and switch of the unit.

OBSERVATIONS:

Initial conditions

	DBT	WBT
Inlet		
Outlet		

Energy meter reading = Kwh

S.No	Suction pressure		Discharge pressure		Temperatures, °C				
	Psi	bar	Psi	bar	T_1	T_2	T_3	T_4	T_5

Rota meter reading	Inlet		Outlet		Air velocity m/s	EMR	COP	
	DBT	WBT	DBT	WBT			actual	theoretical

CALCULATIONS:

1. Dehumidification = (w_i - w_o) gm/kg of dry air

Where w_i& w_o are specific humidities from psychrometric chart.

PRECAUTIONS:

- Only one expansion device should operate at a time.
- Care should be taken while noting down the energy meter reading.

RESULT :

- Water vapour removed is ______________.

DETERMINATION OF COP OF THE THERMOELECTRIC REFRIGERATION

AIM:

To determine the COP of thermo electric refrigeration system.

INTRODUCTION:

In 1822 seebeck observed that, " if a closed circuit were made of two dissimilar metals, an electrical current flows in the circuit when the two junctions were maintained at different temperatures " . His investigations covered a wide range of elements and compounds. This resulted in publication of a series in which the investigated materials were arranged in the order of magnitude of their effect. However, he failed to realize the significance of his discovery. In 1834. Peltier observed the inverse effect, if an electrical current flows across the junction between two dissimilar material, heat was either absorbed or evolved. Peltier did not realize the significance of his discovery either, and moreover, failed to recognize the connection between his discovery and that of Seebeck. It is alleged that Lenz ended all conjecture surrounding these discoveries by freezing a small quantity of water placed in the vicinity of the junction between a bismuth and antimony rod through which a direct current was passed. These were two of the materials in which Seebeck had observed the most pronounced effect. A third effect was pointed out by Thomson (Lord Kelvin) in 1851. It related heat absorbed or evolved in a single conductor to the temperature gradient along it and the current flowing through it. This effect takes place in addition to the Joule (FR) heating. However, in thermoelectric cooling materials, Kelvin's is a second order effect when compared with Peltier's and Seebeck's, and will not be further considered. For many years. Practical application of these thermoelectric effects was almost exclusively restricted to thermocouples for temperature measurement, because metals exhibit a comparatively small Seebeck effect. However, the Seebeck effect in semiconductors can be considerably greater. The advent of the transistor and other semiconductor devices have stimulated research pertaining to properties of semiconductors in general, from this, materials have been developed in which thermoelectric effects are of sufficient magnitude so that fabrication of useful devices has become a reality.

Seebeck Effect : For a small temperature difference between the two junction of materials A and B, the open circuit voltage developed is proportional to the temperature difference and is given by: $\Delta E = \alpha\ AB\Delta T$ Where, Δ E = open circuit voltage developed α AB = relative Seebeck coefficient (the difference between absolute Seebeck Coefficients for materials A and B). Δ T = temperature difference between junctions of materials A and B. In practice, the absolute Seebeck coefficient, α , of a material is determined with respect to a material such as lead, in which the Seebeck coefficient is negligible. In metals, α does not exceed 0.00005 volt/deg C in semiconductors available for thermoelectric applications in 1966, α is typically 0.0002 to 0.00025 volt/deg C.

Peltier Effect : The same circuit can be considered to be made up of materials A and B, into which a battery is introduced to provide a direct current, (I). At the junction between the two dissimilar materials, the heat evolved or absorbed in unit time is proportional to the current flowing and is given by : Q I = π AB where Q = heat evolved or absorbed in unit time, watts. π AB = relative Peltier coefficient for materials A and B. I = direct current flowing, amperes. Lord Kelvin, by performing a thermodynamic analysis of such a Thermoelectric circuit, showed a relationship exists between α and π $\pi = \alpha T$ Where T = the absolute temperature, Kelvin. Hence, heat absorbed or evolved per unit at the junction between two dissimilar materials is given by: Q = α AB IT Although thermodynamics do not accept Kelvin's derivation of his well-known relations because he considered the effects reversible, a more rigorous treatment, by application of irreversible thermodynamic, leads to the same results.

DESCRIPTION:

A couple circuit consisting of two dissimilar thermoelectric materials is referred to as a couple. The two thermoelectric materials are represented by n and p. The n-type has a negative Seebeck coefficient and an excess of electrons. The p-type has a positive Seebeck coefficient and a deficiency of electrons actually flow in the opposite direction. While there are a total of four connections between the thermoelectric junctions; the upper or cold one, at which heat is a absorbed; and the lower or hot one, at which heat is evolved. If the direction of current were reversed, the upper junction would evolve heat, the lower would absorb it. The temperature gradient between hot and cold junctions is not linear because of production of Joule heat within each leg. The conducted heat arriving at the cold junction is given by: (5.0) 2 CΔT + I R Where C = thermal conductance of couple legs, watts per degree Celsius.

PROCEDURE:

Coefficient of performance : Power to the module is set and heater power adjusted to maintain ambient temperature on the cold side of the module . Repeat over the whole range . The curve shows that the coefficient is highest when module has to do the minimum work .

	Heater power		Module power			
	voltage	current	voltage	current		

Wh : Heater power Wm : Module power

CALCULATIONS:

COP = Wh/Wm

Wh : Heater power Wm : Module power

Graph : Module power v/s COP ,

RESULT :

COP of Thermoelectric Module is………

DETERMINATION OF PERFORMANCE ANALYSIS AT TEMPERATURE VARIATIONS FOR THERMOELECTRIC REFRIGERATION

AIM:

To determine the performance analysis at temperature variations for thermo electric refrigeration system.

INTRODUCTION:

Seebeck Effect : For a small temperature difference between the two junction of materials A and B, the open circuit voltage developed is proportional to the temperature difference and is given by:

$\Delta E = \alpha_{AB} \Delta T$

Where, ΔE = open circuit voltage developed

α_{AB} = relative Seebeck coefficient (the difference between absolute Seebeck Coefficients for materials A and B).

ΔT = temperature difference between junctions of materials A and B.

In practice, the absolute Seebeck coefficient, α , of a material is determined with respect to a material such as lead, in which the Seebeck coefficient is negligible. In metals, α does not exceed 0.00005 volt/deg C in semiconductors available for thermoelectric applications in 1966, α is typically 0.0002 to 0.00025 volt/deg C.

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$Q I = \pi_{AB}$

where Q = heat evolved or absorbed in unit time, watts.

π_{AB} = relative Peltier coefficient for materials A and B.

I = direct current flowing, amperes.

Lord Kelvin, by performing a thermodynamic analysis of such a Thermoelectric circuit, showed a relationship exists between α and π

$\pi = \alpha T$

Where T = the absolute temperature, Kelvin.

Hence, heat absorbed or evolved per unit at the junction between two dissimilar materials is given by:

$Q = \alpha_{AB} IT$

Although thermodynamics do not accept Kelvin's derivation of his well-known relations because he considered the effects reversible, a more rigorous treatment, by application of irreversible thermodynamic, leads to the same results.

DESCRIPTION:

A couple circuit consisting of two dissimilar thermoelectric materials is referred to as a couple. The two thermoelectric materials are represented by n and p. The n-type has a negative Seebeck coefficient and an excess of electrons. The p-type has a positive Seebeck coefficient and a deficiency of electrons actually flow in the opposite direction. While there are a total of four connections between the thermoelectric junctions; the upper or cold one, at which heat is a absorbed; and the lower or hot one, at which heat is evolved. If the direction of current were reversed, the upper junction would evolve heat, the lower would absorb it. The temperature gradient between hot and cold junctions is not linear

because of production of Joule heat within each leg. The conducted heat arriving at the cold junction is given by:
$C\Delta T + (0.5)I^2 R$ Where C = thermal conductance of couple legs, watts per degree Celsius.

PROCEDURE:

Evaluation of the peltier effect : DC Power is applied to the module at a variety of settings . When settled both temperatures are noted . Observe that at higher power inputs I^2R and heat conduction factors tend to overwhelm the cooling effect .

	Module power			
	voltage	current		

Graph : Module Power v/s cold & hot side Temperature and temp. difference

Evaluation of Seebeck effect : By use of heater power create a temperature differential across the module . When settled note the open circuit voltage across the module voltmeter . Voltage and temperature can be seen to have a linear relationship .

	Heater power			
	voltage	current		

Graph : Seebeck open ckt voltage v/s Temperature gradient ΔT

RESULT :

DETERMINATION OF QUALITY OF AIR FOR GIVEN AIR CONDITIONING SYSTEM

AIM:

- To determine the quality of air for given air conditioning system

INTRODUCTION:

The science of air conditioning deals with maintaining a desirable internal air conditions irrespective of external atmospheric conditions. The factors involved in any air conditioning installation are:

- Temperature
- Humidity
- Air movement and circulation
- Air filtering, cleaning and purification

The simultaneous control of these factors within the required limits is essential for human comfort or for any industrial application of the air conditioning system.

In any air conditioning system, temperature and humidity are controlled by thermodynamic processes. Depending on the session, the air conditioning processes. Involve cooling, heating, humidification and dehumidification of air. Other aspects such as air movements, circulations, purification, etc. are obtained by installing suitable fans, blowers, ducting and filters.

This equipment is designed to demonstrate different air conditioning processes such as cooling, heating, humidification, etc. required for different season of the year

IMPORTANT DEFINITIONS :

Dry Air
Mechanical mixture of oxygen, nitrogen, carbon dioxide, etc.

Moist Air
Mixture of dry air and water vapour.

Saturated Air
Is such a mixture of dry air and water vapour when the air has diffused the maximum amount of water vapour into it.

Degree of Saturation
Is the ratio of actual mass of water vapour in a unit mass of dry air to the mass of water vapour in the same mass of Dry air when it is saturated at the same temperature and Pressure.

Humidity
Is the mass of water vapour present in 1 Kg of dry air expressed in gm per Kg of dry air

Absolute humidity
Is the mass of water vapour present in 1 m^3 of dry air, gm per cubic meter of dry air

Relative Humidity
Is the ratio of actual mass of water vapour in volume of moist air to the mass of water vapour in the same volume of saturated air at the same temperature and pressure.

Dry bulb temperature
Is the temperature of air recorded by a thermometer when it is not affected by the moisture present in the air.

Wet Bulb Temperature
Is the temperature of the air recorded by a thermometer when its bulb is surrounded by a wet cloth exposed to the Air

Psychrometer

Is an instrument containing dry bulb thermometer and wet bulb thermometer. The difference in the readings of these two thermometers gives the relative humidity of the air surrounding the Psychrometer.

DESCRIPTION:

The equipment consists of a cooling coil which is a part of the vapour compression refrigeration system working on Freon – 22. In the upstream and downstream of the cooling coil, heaters are provided to heat air either at the upstream or the downstream of the cooling coil. A steam generator is provided to increase humidity of air. The system is provided to increase humidity of air. The system is provided with fans, air duct and valve system to circulate air over the cooling coil and heater and to operate the system in both closed and open cycle. the system is instrumented with thermometers, digital humidity indicators, pressure indictors and wind velocity indicators to determine the state of air – moisture mixture during the operation of the air conditioning system. Following are the important components:

- Cooling coil of the vapour compression Air Conditioning system consisting of Suitable Duct where air passes for conditioning, Compressor, condenser, throttle / capillary tube, pressure and temperature Indicators with selector switch and power meter. The system works on Freon-22
- Air Heaters – one at the inlet and other at the outlet are provided
- Steam generator which consists of immersion type heating coil
- Suction fan (2 Nos)
- Valve system to change the system to perform in both closed and open
- Wet Bulb & Dry Bulb Temperatures (2 Nos) placed before and after evaporator / cooling coil.
- Instrumentation to measure the temperature at different points, power input and Pressure readings,
- Thermostat to limit temperatures in the cooling coil to not exceed the inlet condition of compressor.

PROCEDURE:

(A) HEATING OF AIR
- Put ON the mains switch and start air flow through the duct.
- Put ON the heaters, as required.
- Wait till steady state conditions is reached note down the readings.
- Repeat the procedure at different air flow rates and changing the heat input.

(B) HUMIDIFICATION OF AIR
- Fill up sufficient water in steam generator, and start the steam heater.
- After some time, steam will be generated. Now start air flow through the duct, and slightly open the steam control valve so that steam will be injected in the
- stream of air.
- Note down the readings.

OBSERVATIONS:

Initial conditions

	DBT	WBT
Inlet		
Outlet		

Energy meter reading = Kwh

S.No	Suction pressure		Discharge pressure		Temperatures, °C				
	Psi	bar	Psi	bar	T_1	T_2	T_3	T_4	T_5

Rota meter reading	Inlet		Outlet		Air velocity m/s	EMR	COP	
	DBT	WBT	DBT	WBT			actual	Theoretical

CALCULATIONS:

1. Humidification = $(w_i - w_o)$ gm/kg of dry air

Where w_i& w_o are specific humidities from psychrometric chart.

PRECAUTIONS:

- Only one expansion device should operate at a time.
- Care should be taken while noting down the energy meter reading.

RESULT :

- Water vapour added is _______________.

EFFECT OF PROPERTIES OF REFRIGERANT ON THE FUNCTIONING OF REFRIGERATION SYSTEM

AIM:

- To determine effect of properties of refrigerant on the functioning of refrigeration system

INTRODUCTION:

The thermodynamic efficiency of a refrigeration system depends mainly onits operating temperatures. However, important practical issues such as thesystem design, size, initial and operating costs, safety, reliability, andserviceability etc. depend very much on the type of refrigerant selected for agiven application. Due to several environmental issues such as ozone layerdepletion and global warming and their relation to the various refrigerants used,the selection of suitable refrigerant has become one of the most important issuesin recent times. Replacement of an existing refrigerant by a completely newrefrigerant, for whatever reason, is an expensive proposition as it may call forseveral changes in the design and manufacturing of refrigeration systems. Henceit is very important to understand the issues related to the selection and use ofrefrigerants.

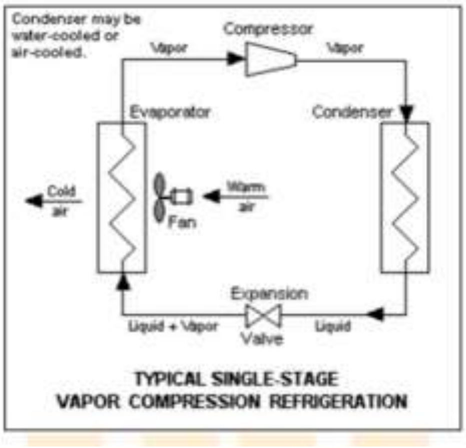
Selection of refrigerant for a particular application is based on the followingrequirements:
i. Thermodynamic and thermo-physical properties
ii. Environmental and safety properties, and
iii. Economics

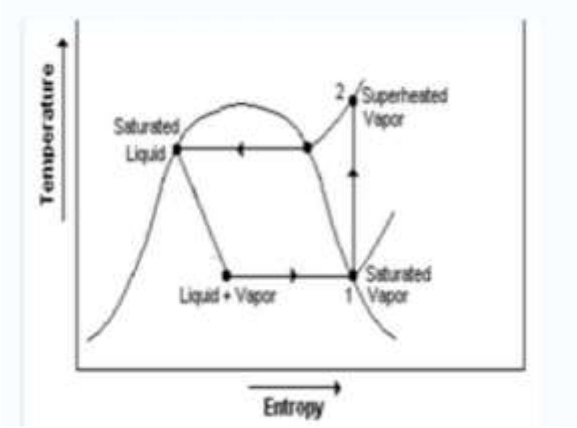
Thermodynamic and thermo-physical properties:

The requirements are:
a) Suction pressure: At a given evaporator temperature, the saturation pressureshould be above atmospheric for prevention of air or moisture ingress into thesystem and ease of leak detection. Higher suction pressure is better as it leads tosmaller compressor displacement
b) Discharge pressure: At a given condenser temperature, the dischargepressure should be as small as possible to allow light-weight construction ofcompressor, condenser etc.
c) Pressure ratio: Should be as small as possible for high volumetric efficiencyand low power consumption
d) Latent heat of vaporization: Should be as large as possible so that the requiredmass flow rate per unit cooling capacity will be small.
e)Freezing Point: The freezing point of the refrigerant should be lower than the lowest operating temperature of the cycle to prevent blockage of refrigerant pipelines.

DESCRIPTION:

The vapour compression refrigeration system consists of a compressor, an air cooled condenser, and expansion device (a solenoid valve and a capillary tube are provided of which one can be used at a time),a Rota meter to measure the flow rate of liquid refrigerant (R134a), a filter driver and an evaporator (water chiller). The system is provided with thermo couples and a digital temperature display to measure temperatures at various locations. Two pressure gauges are fitted on at the suction and other at the discharge side of the compressor. A fan is provided to supply air over the condenser coil. An energy meter is provided to measure the power consumed by the compressor.





PROCEDURE:

1. Take the initial temperature of water in water chiller (evaporator).
2. Switch – ON the mains and the console.
3. Keep either the throttle valve or the capillary tube open. Both devices have the same expansion (or throttling) effect.
4. Switch –ON the motor which drives the compression and the fan (which cools the condenser)
5. The refrigerant passes through the vapour compression cycle as mentioned earlier resulting in cooling in evaporator chamber or freezer
6. Run the system for some period so that the temperature of water falls down say by 4 to 5^0C.
7. Note down the temperatures, pressure gauge readings, Rota meter reading, Current, and Voltage readings for a drop of every 5^0C in evaporator temperature.

T1 = Temperature at compressor inlet (°C)
T2 = Temperature at compressor outlet (°C)
T3 = Temperature at condenser outlet (°C)
T4 = Temperature at evaporator inlet (°C)
T5 = Temperature inside freezer
P1 = Pressure upstream of the compressor, Kg/Cm²
P2 = Pressure downstream of the compressor, Kg/Cm²
V = Voltage of the compressor, Volts
I = Current to the compressor, Amps
The temperature T5 in the freezer denotes the refrigeration process

8. Using the measured temperatures, pressures and power input to the compressor, the co-efficient of performance and the capacity of the refrigerator can be determined using the formulae given.
9. Once experimentation is completed switch off the Compressor

OBSERVATIONS:

Sl. No	TEMPERATURE, °C						Energy reading. m		P1 in Bar	P2 in Bar
	T1	T2	T3	T3	T4	T5	Voltage (V)	Current (A)		

CALCULATIONS:

1. Pressure ratio = P1 / P2
   P1 : Discharge Pressure
   P2 : Suction Pressure

2. Latent Heat of Vaporization : H1 - H4

Where,

H1 = Enthalpy of the refrigerant at exit of the evaporator.
H4 = Enthalpy of the refrigerant at exit of the throttle valve/capillary tube.

The values of enthalpies of the refrigerant at different states are obtained from pressure-enthalpy chart provided.

Note;
H1 is obtained for Temperature T1 and Pressure P1
H3 is obtained for Pressure P2
H4 = H3

3. Freezing Point of R134a = -103.3^0C
4. Lowest Temperature observed in refrigeration system =

PRECAUTIONS:

- While doing Capillary, switch off the Solenoid Valve and when doing with Throttle Valve Switch on the Solenoid Valve and close the valves at the Capillary. This is most important task before starting the experiment.
- Minimum of 10min has to be maintained b/w switching off and on of the compressor, otherwise the compressor diaphragm may be damaged.

RESULT :

- Suction Pressure is greater than Atmospheric pressure.
- Discharge Pressure is within permissible limits.
- Latent Heat of Vaporization is large.
- Freezing point of refrigerant is lower than lowest temperature in the system.

LOAD CALCULATIONS FOR AIR CONDITIONING

AIM:

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

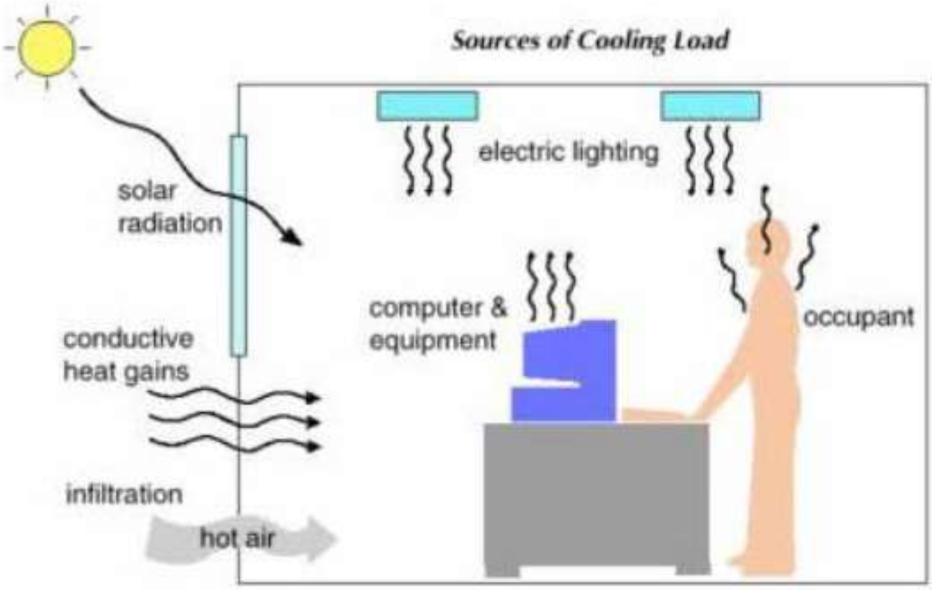
INTRODUCTION:

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.

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 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

COOLING LOAD CALCULATION METHOD

a. Transfer Function Method (TFM): This is the most complex of the methods proposed by ASHRAE and requires the use of a computer program or advanced spreadsheet.

b. Cooling Load Temperature Differential/Cooling Load Factors (CLTD/CLF): This method is derived from the TFM method and uses tabulated data to simplify the calculation process. The method can be fairly easily transferred into simple spreadsheet programs but has some limitations due to the use of tabulated data.

c. Total Equivalent Temperature Differential/Time-Averaging (TETD/TA): This was the preferred method for hand or simple spreadsheet calculation before the introduction of the CLTD/CLF method.

Outdoor Design Weather Conditions

ASHRAE Handbook 1993 Fundamentals (Chapter 26) list tables of climate conditions for the US, Canada and other International locations: In these tables:

The information provided in table 1a, 2a and 3a are for heating design conditions that include:
a. Dry bulb temperatures corresponding to 99.6% and 99% annual cumulative frequency of occurrence.
b. Wind speeds corresponding to 1%, 2.5% and 5% annual cumulative frequency of occurrence,
c. Wind direction most frequently occurring with 99.6% and 0.4% dry-bulb temperatures and
d. Average of annual extreme maximum and minimum dry-bulb temperatures and standard deviations.

Indoor Design Conditions and Thermal Comfort

The indoor design conditions are directly related to human comfort. Current comfort standards, ASHRAE Standard 55-1992 [4] and ISO Standard 7730 [5], specify a “comfort zone,” representing the optimal range and combinations of thermal factors (air temperature, radiant temperature, air velocity, humidity) and personal factors (clothing and activity level) with which at least 80% of the building occupants are expected to express satisfaction. The environmental factors that affect the thermal comfort of the occupants in an air-conditioned space are mainly:

a. Metabolic rate, expressed in met (1 met = 18.46 Btu/hr.ft2) determines the amount of heat that must be released from the human body and it depends mainly on the intensity of the physical activity.
b. Indoor air temperature (Tr) and mean radiant temperature (Trad), both in °F. Tr affects both the sensible heat exchange and evaporative losses, and Trad affects only sensible heat exchange.
c. Relative humidity of the indoor air in %, which is the primary factor that influences evaporative heat loss.
d. Air velocity of the indoor air in fpm, which affects the heat transfer coefficients and therefore the sensible heat exchange and evaporative loss.
e. Clothing insulation in clo (1 clo = 0.88 h.ft2.°F/Btu), affects the sensible heat loss. Clothing

insulation for occupants is typically 0.6 clo in summer and 0.8 to 1.2 clo in winter.

CALCULATIONS:

Name of Project:					
Address:					
Space used for:					
Area in sq.ft =		Length in Ft.		Height in ft.=	
Volume in cu.ft	0	Width in Ft.		Contact factor :	0.88
Bypass factor :	0.12			**Btu/hour**	
	Area x	Temp.diff. x	Factor =	**Sensible Load**	**Latent Load**
SOLAR GAIN-GLASS					
Glass (N)	0	11	0.56	0	-
Glass (E)	0	11	0.56	0	-
Glass (S)	0	11	0.56	0	-
Glass (W)	0	165	0.56	0	-
Glass (NE)	0	11	0.56	0	-
Glass (SW)	0	113	0.56	0	-
Glass (NW)	0	118	0.56	0	-
Glass (SE)	0	11	0.56	0	-
SOLAR & TRANSMISSION GAIN-WALLS & ROOF					
Wall (N)	0	14	0.35	0	-
Wall (E)	0	28	0.35	0	-
Wall (S)	0	26	0.35	0	-
Wall (W)	0	22	0.35	0	-
Wall (NE)	0	20	0.35	0	-
Wall (SW)	0	24	0.35	0	-
Wall (NW)	0	16	0.35	0	-
Wall (SE)	0	28	0.35	0	-
Exposed Roof	0	45	0.48	0	-
TRANSMISSION GAIN-EXCEPT WALLS & ROOF					
All Glass	0	22	1.13	0	-
Partition Wall	0	17	0.40	0	
Partition Glass	0	17	0.43	0	-
Ceiling	0	17	0.48	0	-
Floor	0	17	0.48	0	-
INTERNAL HEAT					
People	0	276	224	0	0
Lights (I) - W	0	3.41	1.0	0	-
Lights (F) - W	0	3.41	1.25	0	-
Equip.Load - W	0	3.41	1.0	0	-

-do- in HP	0	2545	1.0	0	-
Others				0	0
Subtotals				0	0
Safety Factors (12.5% & 5% respectively)				0	0
Room Sensible & Latent Loads				**0**	**0**
Outdoor Air	cfm =	0		0	0
Effective Room Sensible Heat (ERSH)				0	-
Effective Room Latent Heat (ERLH)				-	0
Effective Room Total Heat (ERTH)				**0**	
OUTDOOR AIR (O.A.)					
Sensible Load				0	-
Latent Load				-	0
Effective Room Total Heat + O.A Heat				0	
Other Heat Gains @ 3%				0	
GRAND TOTAL HEAT				0	
			TR	**0.00**	

RESULT :