Hall Ticket Number:

IV/IV B.Tech., (Regular) DEGREE EXAMINATION

November 2022 **Mechanical Engineering**

Seventh Semester **Refrigeration & Air conditioning**

Time: Three Hours **Maximum:** 50 Marks

NOTE: Refrigerants and Psychrometric properties by M.L. Mathur and F.S. Mehta data book must be supplied in the examination hall.

Answer Question No. 1 Compulsorily. (10X1 = 10 Marks)

Answer ***ANY ONE*** *question from each Unit.* (4X10=40 Marks)

1.	a)	List some of the important applications of refrigeration.	CO1	L1	1M
	b)	Show the Bell Coleman cycle on P-v and T-s diagrams.	CO1	L1	1M
	c)	List the main components of the Vapor Compression Refrigeration system.	CO2	L1	1M
	d)	List out the factors that affect the heat transfer capacity of evaporators.	CO2	L1	1M
	e)	What are the refrigerant and absorbents in the Li-Br H_2O refrigeration system?	CO3	L1	1M
	f)	Outline the applications of the Vortex tube refrigeration system.	CO3	L2	1M
	g)	Define Room Sensible Heat Factor.	CO3	L1	1M
	h)	Define Apparatus Dew Point temperature.	CO4	L1	1M
	i)	What is the necessity of aircraft refrigeration?	CO4	L1	1M
	j)	List any two advantages of the Vapor Absorption Refrigeration system.	CO4	L1	1M

Unit -I

2.	a)	Explain air refrigerator working on Bell – Coleman cycle with the help of line diagram, p – v diagram and T – s diagram. Deduce an expression for its COP.	CO1	LI	5M
	b)	List out the properties of an ideal refrigerant.	CO1	LI	5M

(OR)

3.	a)	Explain the working of a Simple Air Evaporative cooling system with the help of a neat sketch.	CO1	L2	4M
	b)	Determine the temperature of the air at the entry of the turbine and the power supplied by the turbine to the fan when. a simple operating air refrigeration system that circulates air at the rate of 7.5 kg/min. The air pressure entering the turbine is 4.4 bar and the cabin pressure is 1 bar. The air discharge temperature is -6^{0}C and turbine efficiency is 80%.	CO1	L3	6M

Unit -II

4.	a)	Discuss the relative advantages and disadvantages of the VCR system over the Air refrigeration system.	CO2	L2	4M
	b)	Find (i) COP of the plant (ii) Mass flow rate (iii) Power required to run the compressor in kW for a 5-ton Freon -12 refrigeration plant that has a saturated suction temperature of -5^{0}C. The condensation takes place at 32^{0}C and there is no undercooling of refrigerant liquid. Assume isentropic compression,	CO2	L3	6M

(OR)

5.	a)	Explain the standard vapour compression cycle with the help of line diagram, p – h diagram and T – s diagram. Explain the function of various components of the system.	CO2	L1	5M
	b)	Explain the working of the automatic expansion valve with a neat sketch.	CO2	L2	5M

Unit -III

6.	a)	Explain the working of a simple ammonia – water absorption refrigeration system with a neat sketch.	CO3	L3	5M
	b)	Describe the merits and demerits of vapour absorption system compared to vapour compression system.	CO3	LI	5M

(OR)

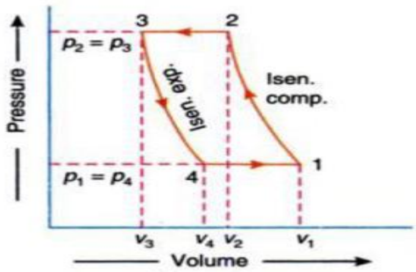
7.	a)	Show the T-s and h-s diagrams of a steam jet refrigeration system, define and write the expression for the following efficiencies (i) Nozzle efficiency (ii) Entrainment efficiency and (iii) Compressor efficiency.	CO3	LI	6M
	b)	Explain the working of a Thermoelectric refrigerator with a neat sketch.	CO3	L2	4M
		Unit -IV			
8.	a)	Define the following terms (i) Dew point temperature (ii) Specific humidity (iii) Relative humidity (iv) Degree of saturation	CO4	LI	4M
	b)	Estimate the following (i) Partial pressure of water vapor (ii) Specific humidity (iii) Relative humidity (iv) Dew point temperature for a sample of moist air which has a dry bulb temperature of 40^0C and a wet bulb temperature of 25^0C.	CO4	L3	6M
		(OR)			
9.	a)	Explain the working of the summer air conditioning system used for hot and wet weather conditions.	CO4	L4	4M
	b)	Determine the following: (i) The DBT and WBT of supply air (ii) The DBT and WBT of mixed air before the cooling coil. (iii) The apparatus dew point and bypass factor of the coil. (iv) The refrigeration load on the cooling coil and the moisture removed by the coil for the following data: Room conditions: 26^0C DBT, 19^0CWBT Outside conditions: 35^0C DBT, 27^0C WBT Room heat gains: Sensible heat: 11.1 kW Latent heat: 3.9 kW ADP= 12^0C The conditioned air supplied to the room is 25 % fresh air and 75% recirculated room air.	CO4	L4	6M

Refrigeration & Air conditioning (18 MED 33)

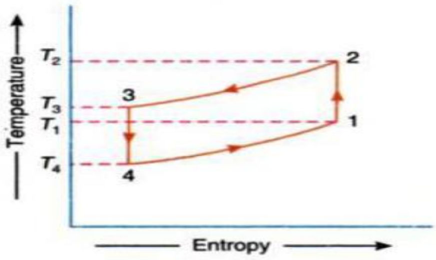
November 2022 (Seventh Semester)

1a) Domestic refrigerators, Chilling of water, storage of food & vegetables,milk and milk products, cryogenics etc.

b) Bell Coleman cycle on P-v and T-s diagrams.



(a) p-v diagram.



(b) T-s diagram.

c) 1. Evaporator 2. Compressor 3. Condenser 4. Expansion valve.

d) Factors that affect the heat transfer capacity of evaporators

1. HT coefficient 2. Surface area 3. Pressure drop 4. LMTD of evaporator

e) Refrigerant and absorbents in the Li-Br H_2O refrigeration system

Water is the refrigerant & Li-Br salt solution as absorbent.

f) Applications of the Vortex tube refrigeration system.

It uses air as refrigerant, so there is no leakage problem.
It is simple in design and does not require any control system to operate it.
There are no moving parts in the vortex tube.
It is light in weight and occupies much less space.
The initial cost is low and its working expenses are also less, whereas compressed air is readily available.
Maintenance is simple and no skilled labour is required.

g) Define Room Sensible Heat Factor. = (RSH/ RTH)

h) Define Apparatus Dew Point temperature: It is the temperature of air recorded by a thermometer when the moisture present in it start condensing.

i) Necessity of aircraft refrigeration: At higher altitudes both atmospheric pressure and temperature decreases. Still there are external and internal heat loads & temperatures of the order of -5^{o}C is required to preserve food and cool drinks.

j) Two advantages of the Vapor Absorption Refrigeration system:

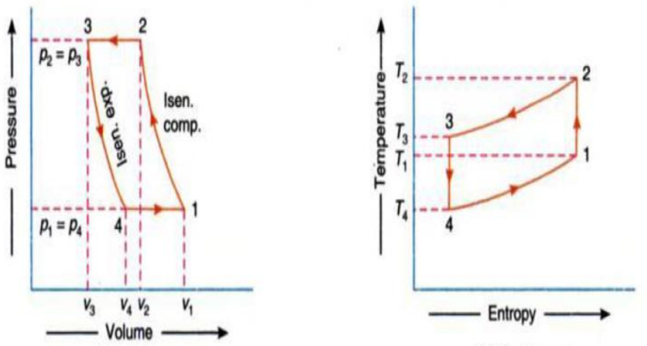
1. It uses heat energy.

2. The only moving part of the system is a pump which has small motor.

3. can be built up to large capacities.

4. Load variations do not affect the performance of the system.

2a) Explain air refrigerator working on Bell – Coleman cycle with the help of line diagram, p – v diagram and T – s diagram. Deduce an expression for its COP.



(*a*) *p-v* diagram. (*b*) *T-s* diagram.

4. *Constant pressure expansion process*. The cold air from the expander is now passed to the refrigerator where it is expanded at constant pressure p_4 (equal to p_1). The temperature of air increases from T_4 to T_1. This process is shown by the curve 4-1 on the *p-v* and *T-s* diagrams. Due to heat from the refrigerator, the specific volume of the air changes from v_4 to v_1. We know that the heat absorbed by the air (or heat extracted from the refrigerator) during constant pressure expansion per kg of air is

$$q_{4-1} = c_p (T_1 - T_4)$$

1. *Isentropic compression process*. The cold air from the refrigerator is drawn into the compressor cylinder where it is compressed isentropically in the compressor as shown by the curve 1–2 on *p-v* and *T-s* diagrams. During the compression stroke, both the pressure and temperature increases and the specific volume of air at delivery from compressor reduces from v_1 to v_2. We know that during isentropic compression process, no heat is absorbed or rejected by the air.

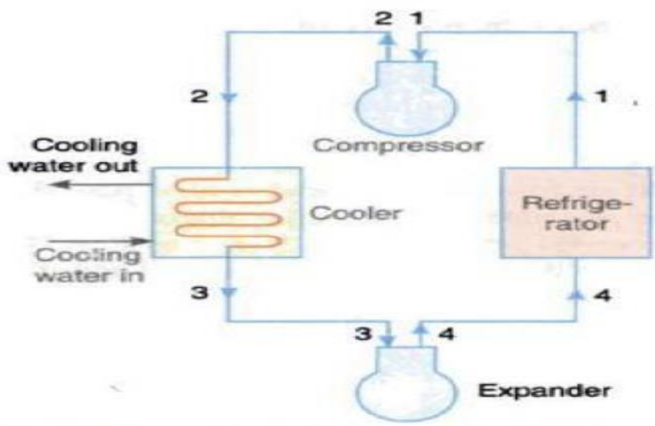
2. *Constant pressure cooling process*. The warm air from the compressor is now passed into the cooler where it is cooled at constant pressure p_3 (equal to p_2), reducing the temperature from T_2 to T_3 (the temperature of cooling water) as shown by the curve 2-3 on *p-v* and *T-s* diagrams. The specific volume also reduces from v_2 to v_3. We know that heat rejected by the air during constant pressure per kg of air,

$$Q_{2-3} = c_p (T_2 - T_3)$$

3. *Isentropic expansion process*. The air from the cooler is now drawn into the expander cylinder where it is expanded isentropically from pressure p_3 to the refrigerator pressure p_4 which is equal to the atmospheric pressure. The temperature of air during expansion falls from T_3 to T_4 (*i.e.* the temperature much below the temperature of cooling water, T_3). The expansion process is shown by the curve 3-4 on the *p-v* and *T-s* diagrams. The specific volume of air at entry to the refrigerator increases from v_3 to v_4. We know that during isentropic expansion of air, no heat is absorbed or rejected by the air.

4. *Constant pressure expansion process*. The cold air from the expander is now passed to the refrigerator where it is expanded at constant pressure p_4 (equal to p_1). The temperature of air increases from T_4 to T_1. This process is shown by the curve 4-1 on the *p-v* and *T-s* diagrams. Due to heat from the refrigerator, the specific volume of the air changes from v_4 to v_1. We know that the heat absorbed by the air (or heat extracted from the refrigerator) during constant pressure expansion per kg of air is

$$q_{4-1} = c_p (T_1 - T_4)$$



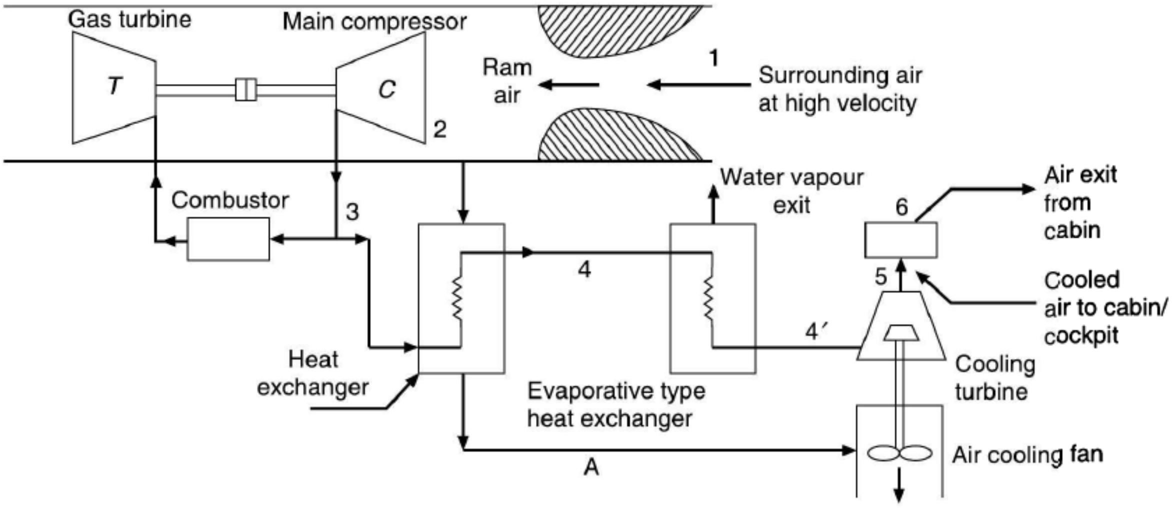
$$\text{C.O.P.} = \frac{\text{Heat absorbed}}{\text{Work done}} = \frac{c_p(T_1 - T_4)}{c_p(T_2 - T_3) - c_p(T_1 - T_4)}$$

$$= \frac{1}{(r_p)^{\frac{\gamma-1}{\gamma}} - 1}$$

2b) List out the properties of an ideal refrigerant:

(a) It should have zero ODP and zero GWP.
(b) It should be non-toxic and non-flammable.
(c) It should be non-corrosive with most common materials.
(d) It should have high latent heat.
(e) It should have high critical pressure and temperature.
(f) It should have low condensing pressure, and the evaporating pressure should be slightly above the atmospheric pressure.
(g) It should not be miscible with lubricating oil.
(h) It should be easily available at cheap rate.
(i) The leak detection should be easy.

3a)



The simple air evaporative cooling system is similar to the simple air cooling system with just one modification. *The system has an additional evaporative type heat exchanger to cool the air to a large extent before it is expanded in the cooling turbine.* A simple air evaporative cooling

Is shown in figure.

In the evaporative type heat exchanger, water evaporates and cools the air to a greater extent (i.e. from point 4 to point 4′). At high altitudes, the evaporative cooling may be obtained by using alcohol or ammonia. Water, alcohol and ammonia all have different refrigerating effects at different altitudes. At the altitude of the aircraft, atmospheric pressure is of the order of 0.8 to 0.9 bar. Water boils and provides a cooling effect to the air.

3b)

3(b) Problem on Simple air craft Refrigeration System

Determine: i) The temperature of air at entry to the turbine
ii) Power supplied by the turbine to the fan

Given: mass flow rate of air, $\dot{m}_a$ = 7.5 kg/min
Entry pressure to the turbine, P_3 = 4.4 bar
Cabin pressure = Turbine exhaust pressure = P_4 = 1 bar
The discharge temperature, T_4 = −6°C = −6+273 = 267 K
Turbine efficiency, η_t = 0.80

Sol: For 3-4′ isentropic expansion through the turbine we can write

$$\frac{T_3}{T_{4'}} = \left(\frac{P_3}{P_4}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{4.4}{1}\right)^{\left(\frac{1.4-1}{1.4}\right)}$$

= 1.527

Isentropic efficiency of the turbine can be written as

$$\eta_t = \frac{T_3 - T_4}{T_3 - T_{4'}} = \frac{T_3\left(1 - \frac{T_4}{T_3}\right)}{T_3\left(1 - \frac{T_{4'}}{T_3}\right)} = \frac{\left(1 - \frac{T_4}{T_3}\right)}{\left(1 - \frac{1}{1.527}\right)}$$

$\therefore \frac{T_4}{T_3} = 0.7239$

$\therefore$ i) Turbine entry temperature, $T_3 = \frac{267}{0.7239} = 368.83$ K
= 369 K Ans

ii) Power supplied by the turbine to the fan
$P_t = \dot{m}_a c_p (T_3 - T_4) = \frac{7.5}{60} \times 1.005 (369 - 267)$
= 12.81 kW Ans

4a) Discuss the relative advantages and disadvantages of the VCR system over the Air refrigeration system.

Advantages

1. It has smaller size for the given capacity of refrigeration.
2. It has less running cost.
3. It can be employed over a large range of temperatures.
4. The coefficient of performance is quite high.

Disadvantages

1. The initial cost is high.
2. The prevention of leakage of the refrigerant is the major problem in vapour compression system.

4b) Find (i) COP of the plant (ii) Mass flow rate (iii) Power required to run the compressor in kW for a 5-ton Freon -12 refrigeration plant that has a saturated suction temperature of -5^{0}C. The condensation takes place at 32^{0}C and there is no undercooling of refrigerant liquid. Assume isentropic compression,

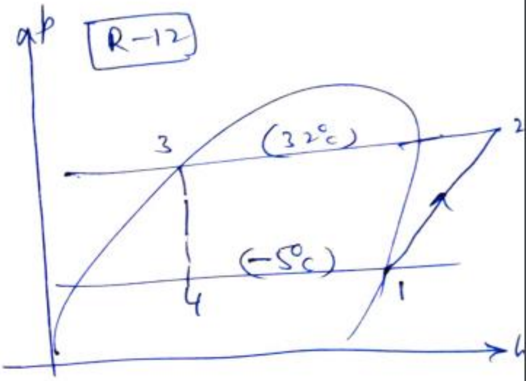
From chart

$h_1 = 350$

$h_2 = 385$ kJ/kg

$h_3 = h_4 = 235$

$v_1 = 0.067$ m^3/kg.



(i) $COP = \frac{\text{Refrigerating effect}}{\text{work input}} = \frac{h_1 - h_4}{h_2 - h_1}$

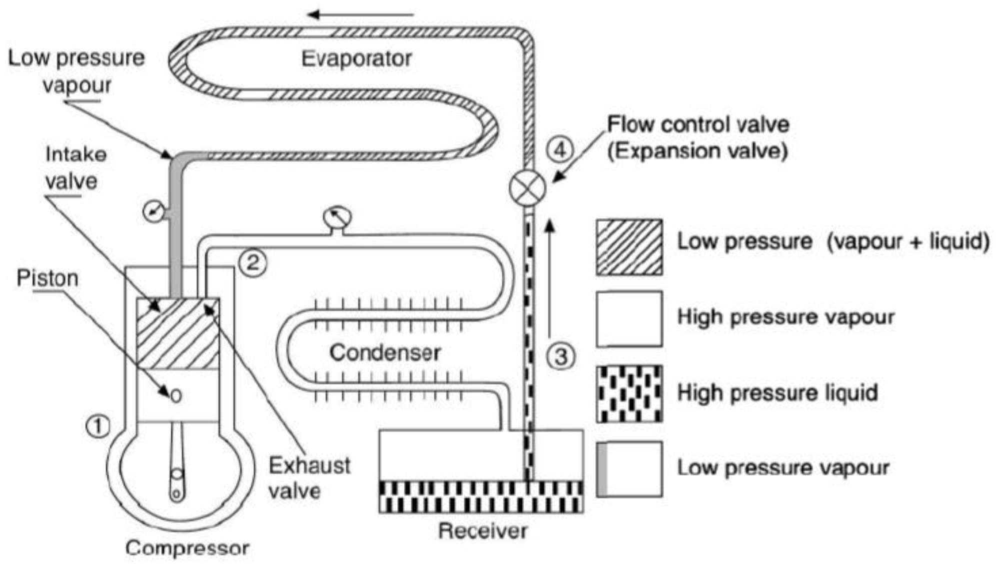
$= \frac{350-235}{385-350} = \frac{115}{35} = 3.286$

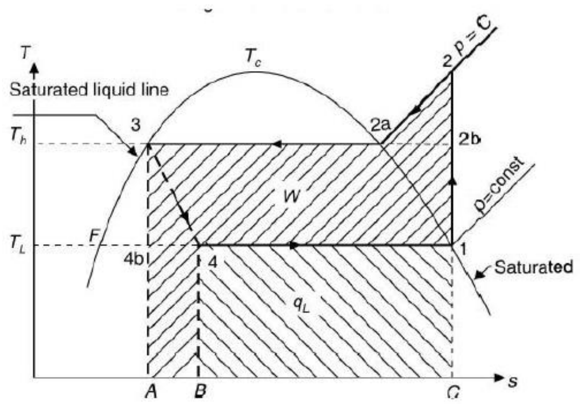
(ii) mass flow rate $= \frac{\text{Refrigerating capacity}}{\text{Refrigerating effect}} = \frac{5 \times 210}{115} = 9.13$ kg/min

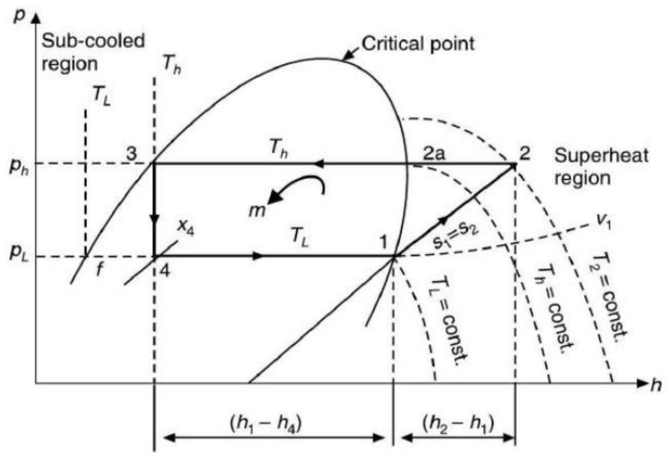
(iii) Power required to run the compressor $=$ mass flow rate $\times (h_2 - h_1)$

$= \frac{9.13}{60} \times (385 - 350) = 5.325$ kW.

5a) Explain the standard vapour compression cycle with the help of line diagram, p – h diagram and T – s diagram. Explain the function of various components of the system.







Compression process (1–2)

Refer to Figures 4.1 through 4.4. The compressor takes the dry saturated refrigerant vapour during its suction stroke at pressure p_1. Then the vapour is compressed to pressure p_2 isentropically during its compression stroke. Therefore, the compressor needs external power. The vapour at pressure p_2 and temperature T_2 enters the condenser. The vapour at the discharge of the compressor is in superheated state as shown by point 2. Basically, the question arises as to why should the vapour be taken to higher pressure p_2. The answer is that the refrigerant at temperature T_2 corresponding to pressure p_2 will condense. This is all due to the properties of the refrigerant.

Expansion process (3–4)

The high pressure liquid from state point 3 is expanded through an expansion valve, also called throttle valve, during which the enthalpy remains constant. This process is represented by line 3–4. At the end of this process (point 4), the refrigerant is again a mixture of liquid and vapour phases.

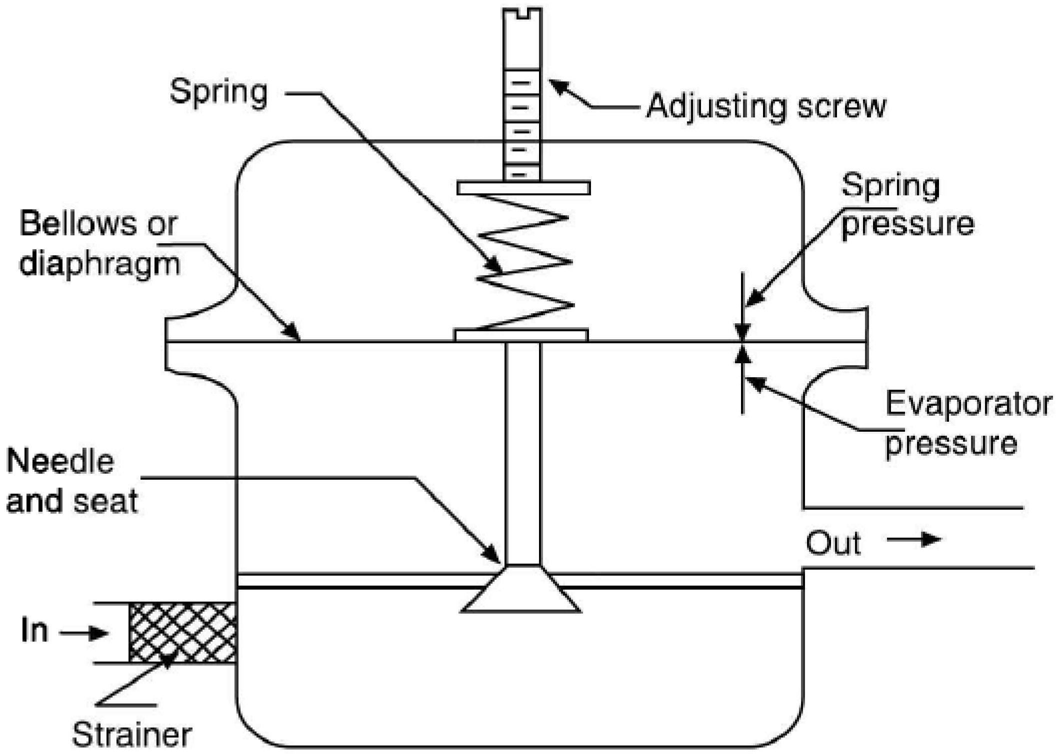
Evaporation process (4–1)

Evaporation of liquid refrigerant takes place in a heat exchanger called evaporator. The function of an evaporator is to transfer heat from its space to the refrigerant. The refrigerant at state point 4 enters the evaporator, takes the heat from space and slowly changes into saturated vapour as it flows towards the end of evaporator, i.e. state point 1. This point 1 indicates the starting and end points of the cycle.

Condensation process (2–3)

The function of the condenser is to remove heat from vapour refrigerant so that it changes to liquid phase. In this unit, superheated vapour from state point 2 is first cooled so that it reaches the dry saturated vapour condition (point 2a), where the vapour starts condensing and further removal of heat would result in a liquid refrigerant at state point 3. The condenser may be either air- or water-cooled. Small capacity refrigeration units are air-cooled and large capacity refrigeration units are water-cooled.

5b) Explain the working of the automatic expansion valve with a neat sketch.



The AEV is generally so termed because it opens and closes automatically without the aid of an external device. It maintains a constant refrigerant pressure in the evaporator. Therefore, its working is fully dependent on evaporator pressure but not on the load on it. The schematic diagram of AEV is shown in Figure 13.2. This type of valve consists of a diaphragm (bellow), a control spring and the basic valve needle and seat.

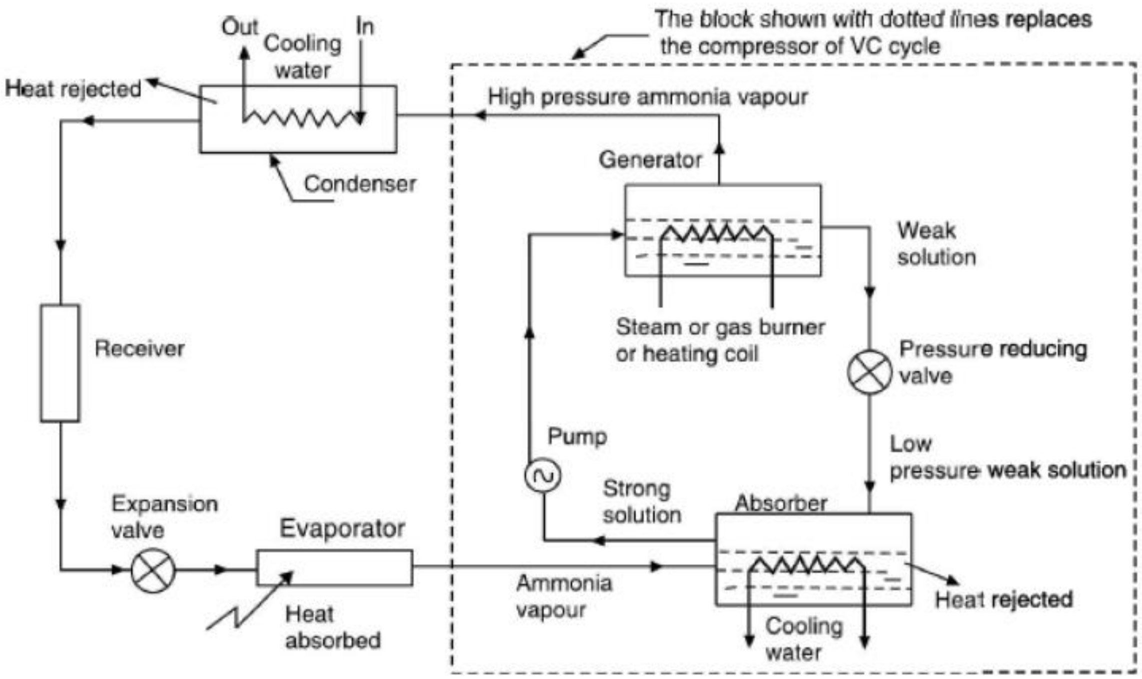
The control spring exerts a force to move the diaphram downwards to open the valve. But the evaporator pressure exerts a force on the diaphragm upwards to close the valve. These two forces oppose each other. The difference of these two forces will cause the particular diaphragm position. The position of the diaphragm causes the needle position to adjust and allows a definite rate of liquid refrigerant to flow to the evaporator. The spring force is constant as per the initial setting. The evaporator pressure is the only variable according to which the valve is required to function.

During the off cycle, the valve closes slowly when pressure is on the evaporator side and exceeds the spring force. It remains in the closed condition till the system starts again. When the refrigeration system starts, the pressure in the evaporator starts falling and when this pressure is lower than that exerted by the control spring then the valve opens. It opens wide to meet the required flow of the system.

The tension of the control spring above the diaphragm can be increased or decreased by setting the adjusting screw. So the valve can be made to operate at a pressure lower or higher than the normal setting. If one needs to set the valve at any new evaporator pressure, then the refrigeration unit should be run for more than 24 hours. During this time the refrigerant and the oil in the system get distributed and the evaporator becomes cold enough. Valve setting can be adjusted to open at a predetermined pressure within the range of control spring.

UNIT – III

6a) Explain the working of a simple ammonia – water absorption refrigeration system with a neat sketch.



The strong solution of ammonia in the generator is heated by some external source such as gas or steam. During the heating process, the ammonia vapour is driven off the solution at high pressure leaving behind the hot weak ammonia solution in the generator. This weak ammonia solution flows back to the absorber at low pressure after passing through the pressure reducing valve. The high pressure ammonia vapour from the generator is condensed in the condenser to a high pressure liquid ammonia. This liquid ammonia is passed to the expansion valve through the receiver and then to the evaporator. This completes the simple vapour absorption cycle.

The heat required for the operation of generator can be supplied by burning kerosene or using solar energy or waste heat from process industry in the case of industrial applications.

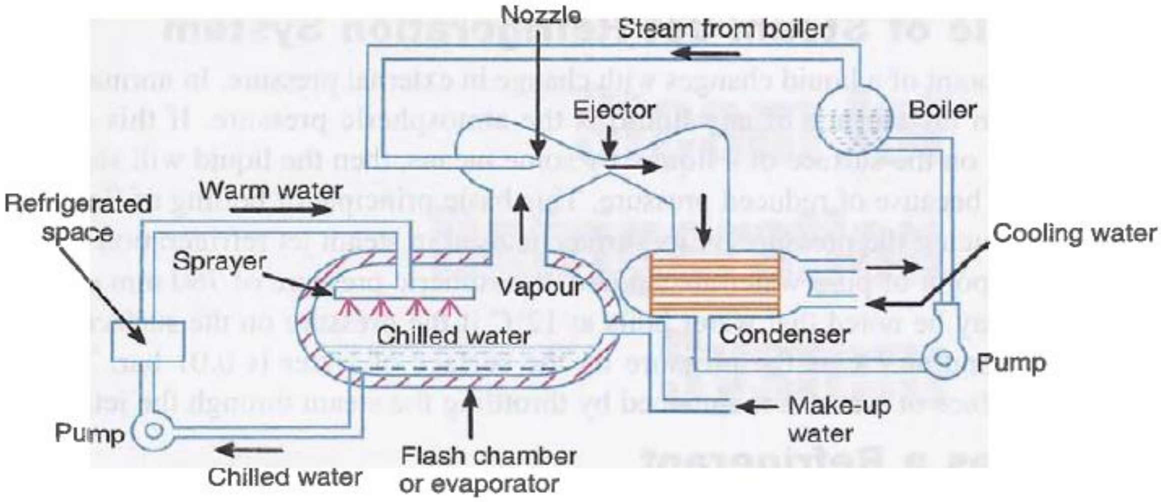
The electrical energy required for the operation of aqua pump in this system is extremely small compared to the electrical energy needed for the compressor of a vapour compression cycle. The basic difference here is that aqua pump handles the liquid ammonia while the compressor has to work with the refrigerant vapour of high specific volume.

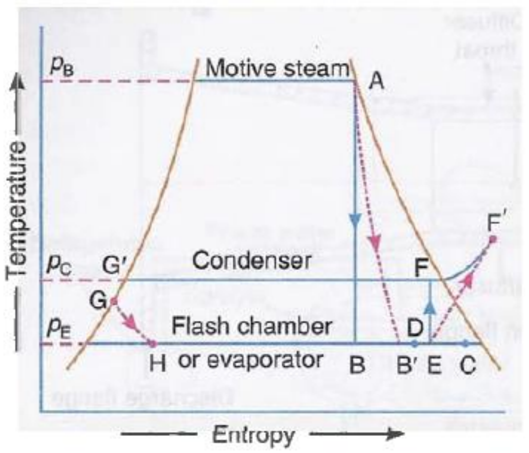
6b) Describe the merits and demerits of vapour absorption system compared to vapour compression system.

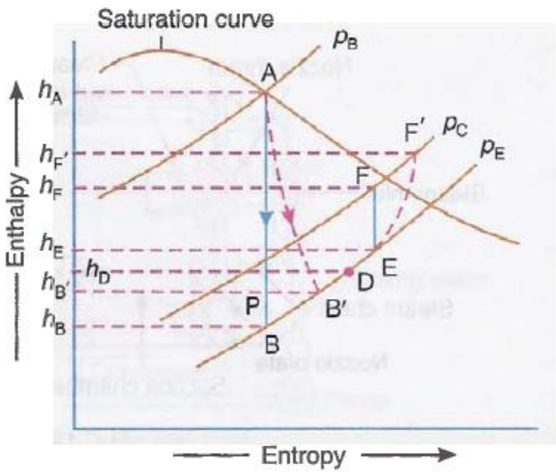
Following are the advantages of the vapour absorption system over the vapour compression system:

1. In the vapour absorption system, the only moving part of the entire system is a pump which has a small motor. Thus, the operation of this system is essentially quiet and subjected to little wear. The vapour compression system of the same capacity has more wear, tear and noise due to moving parts of the compressor.
2. The vapour absorption system uses heat energy to change the condition of the refrigerant from the evaporator. The vapour compression system uses mechanical energy to change the condition of the refrigerant from the evaporator.
3. The vapour absorption systems are usually designed to use steam, either at high pressure or low pressure. The exhaust steam from furnaces and solar energy may also be used. Thus, this system can be used where the electric power is difficult to obtain or is very expensive.
4. The vapour absorption systems can operate at reduced evaporator pressure and temperature by increasing the steam pressure to the generator with little decrease in the capacity. But the capacity of a vapour compression system drops rapidly with lowered evaporator pressure.
5. The load variations do not affect the performance of a vapour absorption system. The load variations are met by controlling the quantity of aqua circulated and the quantity of steam supplied to the generator. The performance of a vapour compression system at partial loads is, however, poor.
6. In the vapour absorption system, the liquid refrigerant leaving the evaporator has no bad effect on the system except that of reducing the refrigerating effect. In the vapour compression system, it is essential to superheat the vapour refrigerant leaving the evaporator so that no liquid may enter the compressor.
7. The vapour absorption systems can be built in capacities well above 1000 TR of refrigeration. The same is not the case with the vapour compression cycle using compressors.
8. The space requirements and automatic control requirements favour the absorption system more as the desired evaporator temperature drops.

7a) Show the T-s and h-s diagrams of a steam jet refrigeration system, define and write the expression for the following efficiencies (i) Nozzle efficiency (ii) Entrainment efficiency and (iii) Compressor efficiency.





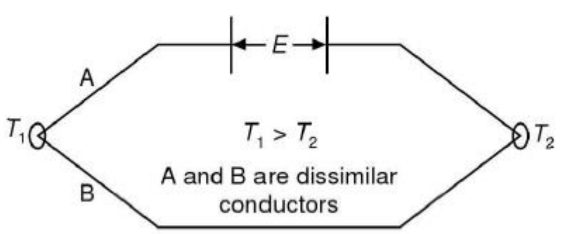


$$\eta_N = \frac{\text{Actual enthalpy drop}}{\text{Isentropic enthalpy drop}} = \frac{AP}{AB} = \frac{h_A - h_{B'}}{h_A - h_B}$$

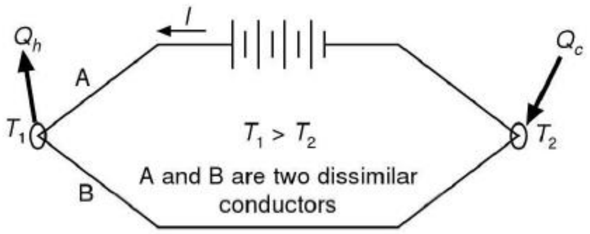
$$\eta_E = \frac{h_A - h_D}{h_A - h_{B'}}$$

$$\eta_C = \frac{\text{Isentropic enthalpy increase}}{\text{Actual enthalpy increase}} = \frac{h_F - h_E}{h_{F'} - h_E}$$

7b) Explain the working of a Thermoelectric refrigerator with a neat sketch.



(a) Seebeck effect



(b) Peltier effect

It is one of the non-conventional refrigeration methods used for producing low temperature on the basis of the reverse Seebeck effect. When the junctions of two dissimilar conductors are maintained at two different temperatures T_1 and T_2, an electromotive force (emf) E is generated. This phenomenon is called *Seebeck effect*. This principle is used in thermocouples for measuring temperatures.

When a battery is connected between the junctions of two dissimilar conductors which are initially maintained at the same temperature and a current is made to flow through the circuit, it is observed that the junction temperatures are different, one junction becoming hot (T_1) and the other becoming cold (T_2). This principle is reverse of the Seebeck effect and called *Peltier effect*. In this case the refrigeration effect is obtained at the cold junction and heat is rejected to the surrounding at the hot junction. This principle is the basis for thermoelectric refrigeration systems. The position of cold and hot junctions can be reversed by reversing the direction of current through the conductor.

UNIT – IV

8a) Define the following terms (i) Dew point temperature (ii) Specific humidity (iii) Relative humidity (iv) Degree of saturation.

Dew Point Temperature (DPT): It is the temperature of air recorded by a thermometer when the moisture present in it starts condensing. It is denoted by T_{dp} or DPT.

Humidity ratio (specific humidity): It is the ratio of mass of water vapour to the mass of dry air contained in the sample air. It is denoted by 'w'. It is normally expressed in g/kg of dry air.

Relative humidity (RH): It is the ratio of mass of water vapour in a given volume of air at any temperature and pressure to the maximum amount of mass of water vapour which the same volume of air can hold at the same temperature conditions. The air contains maximum amount of water vapour at the saturation conditions.

Degree of saturation (μ): It is the mass of water vapour in a sample of air to the mass of water vapour in the same air when it is saturated at the same temperature. Mathematically,

8b) Estimate the following (i) Partial pressure of water vapor (ii) Specific humidity (iii) Relative humidity (iv) Dew point temperature for a sample of moist air which has a dry bulb temperature of 40^0C and a wet bulb temperature of 25^0C.

From chart:

Specific humidity = 11 gm/kg of dry air

Relative humidity = 25 %

Dew point temperature = 16^{o}C

Partial pressure of water vapor =

$$\omega = \frac{0.622\, p_v}{p - p_v} \Rightarrow 11\times10^{-3} = \frac{0.622\, p_v}{1.01 - p_v}$$

$$\therefore (1.01 - p_v)\, 11\times10^{-3} = 0.622\, p_v$$

$$(1.01\times10^{-3}\times11) - p_v\times11\times10^{-3} = 0.622\, p_v$$

$$\therefore 1.01\times10^{-3}\times11 = p_v(0.622 + 11\times10^{-3})$$

$$\therefore p_v = \frac{1.01\times11\times10^{-3}}{0.633} = 0.01755 \text{ bar}$$

9a) Explain the working of the summer air conditioning system used for hot and wet weather conditions.

It is the most important type of air conditioning, in which the air is cooled and generally dehumidified. The schematic arrangement of a typical summer air conditioning system is shown in Fig. 18.5.

The outside air flows through the damper, and mixes up with recirculated air (which is obtained from the conditioned space). The mixed air passes through a filter to remove dirt, dust and other impurities. The air now passes through a cooling coil. The coil has a temperature much below the required dry bulb temperature of the air in the conditioned space. The cooled air passes through a perforated membrane and loses its moisture in the condensed form which is collected in a sump. After that, the air is made to pass through a heating coil which heats up the air slightly. This is done to bring the air to the designed dry bulb temperature and relative humidity.

Summer Air Conditioning System

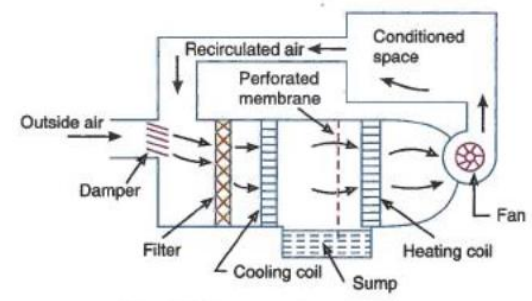


Fig. 18.5. Summer air conditioning system.

Now the conditioned air is supplied to the conditioned space by a fan. From the conditioned space, a part of the used air is exhausted to the atmosphere by the exhaust fans or ventilators. The remaining part of the used air (known as recirculated air) is again conditioned as shown in Fig. 18.5. The outside air is sucked and made to mix with the recirculated air in order to make up for the loss of conditioned (or used) air through exhaust fans or ventilation from the conditioned space.

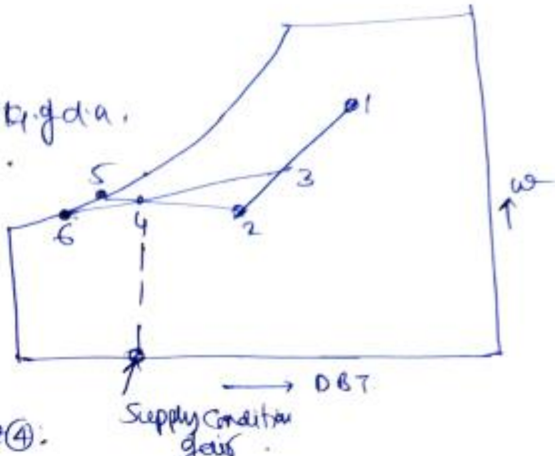
9b)

From chart

$h_1 = 84.6$ $\omega_1 = 0.0192$

$h_2 = 54.1$ kJ/kg, $\omega_2 = 0.0108$ kg/kg.d.a.

$h_3 = 61.7$ $\omega_3 = 0.0129$



$T_3 = (0.25 \times T_1) + (0.75 \times T_2)$

$\therefore T_3 = 28.25^\circ C$

$DSHF = \frac{RSH}{RSH + RLH} = \frac{11.1}{11.1 + 3.9} = 0.74$

(i) From chart Supply Condition of air (i.e.) point ④.

$DBT = 15.12^\circ C$ & $WBT = 14^\circ C$.

(ii) Mixed air condition (i.e.) point ③.

$DBT = 28.25^\circ C$ & $WBT = 21.25^\circ C$

(iii) ADP = point ⑥ $\Rightarrow T_6 = 12^\circ C$

(iv) Refrigeration load on cooling coil $= m_a (h_3 - h_5)$ where $h_5 = h_4 = 39.5$

$= 1349.4$ kJ/min $= 22.5$ kW

Moisture removed by the coil $= m_a(\omega_3 - \omega_5) = 0.2168$ kg/min