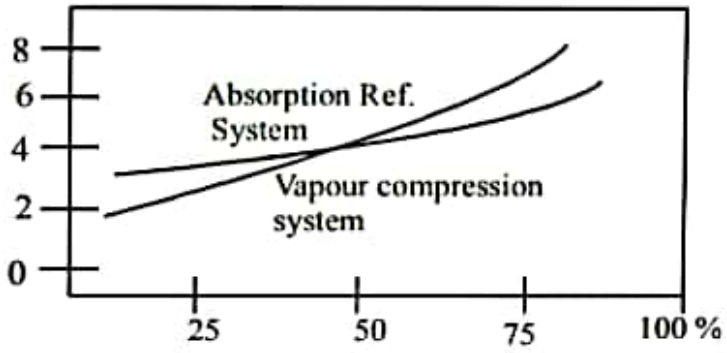
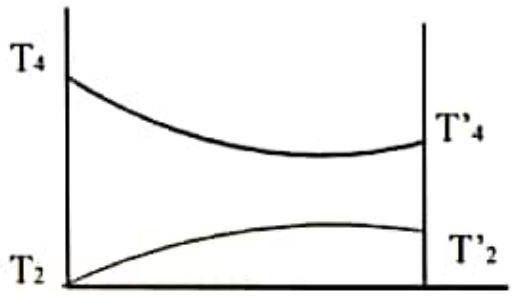
Advantage of Absorption Refrigeration system over compressor Ref. System :-

(1) There in no moving part in the entire system so less wear and tear thus so low maintenance cost.
(2) Absorption system may use any readily available source of thermal energy so these can be used where electrical power is hard to obtain.
(3) Absorption unit can be build in capacities well above 1000 tons. each which is largest size for single compressor unit.
(4) Space requirement favor the absorption more and more as the desired evaporator temperature.
(5) Steam which is bled from the turbine is used for winter heating the same steam can be used for in summer supplying the generator.
(6) In vapour absorption system the presence of liquid in vapour leaving the evaporator will not have any detrimental effect.
(7) At reduced load (at the same temp) the absorption is almost as efficient as at full load. The load variation are met by controlling the quantity of steam supplied to the generator or by change the mass flow rate or oth. The C.O.P of compressor ref. system decreases as load decreases of system. **(Fig. - 31.)**



(8) The absorption ref. unit can operate at reduced evaporator temperature by increasing the steam pressure



(Under cooling the liquid by vapour).

The temperature of vapour referent coming out of the evaporator is less than the temperature of liquid coming out of condenser. The liquid refrigerant can be cooled giving its heat to the vapour.

$4-4^{1}$ sub-cooling the liquid refrigerant

$2-2^{1}$ super heating of vapour refrigerant

→ considering the energy balance in heat exchanger heat lost by liquid = heat gained by vapour.

$$C_{pl}\omega_l(T_4-T_4^{1})=C_{pv}\omega_v(T_2^{1}-T_2)$$

Where l and V suffix are for liquid and vapour.

$$\omega_e=\omega_v \quad \text{and} \quad c_{pl}>c_{pl}$$

$$\therefore \quad (\Delta T)liq. \; < (\Delta T)\text{vap}$$

By energy balance.

$$h_2-h_2=h_4-h_4$$

Under ideal cond. of heat transfer in heat exchanger.

$$T_4-T_2=T_m$$

→ Weight of Ref. required tok be passed in evaporator of T tons of load for sub cooled cycle is

$$W_R=\frac{3.5T}{(h_2-h_1)}$$

→ Work done of compressor

$$W_R=(h_3-h_2)=\frac{3.5T}{(h_2-h_1)}.(h_3-h_2)$$

Work done by compressor without heat exchanger

$$W_R=(h_3-h_2)=\frac{3.5T}{(h_2-h_1)}(h_3-h_2)$$

Extra work done in sub-cooled cycle.

$$\Delta W=\frac{3.5T}{(h_2-h_1^{1})}[(h_3-h_2)-(h_3-h_2)]$$

This shows that by sub-cooling with vapour the C.O.P of cycle is reduced. Even with theoratical loss resulting from above type of cooling.

sub-cooling the ref. and by removing the flashed vapour the expansion by removing the flashed vapour the expansion can be brought close to liquid line.

Incorporating the flash chamber in the working cycle the size of evaporator will be reduced as un wanted vapour formed is removed before entering the evaporator.

$$C.O.P = \frac{R}{W}$$

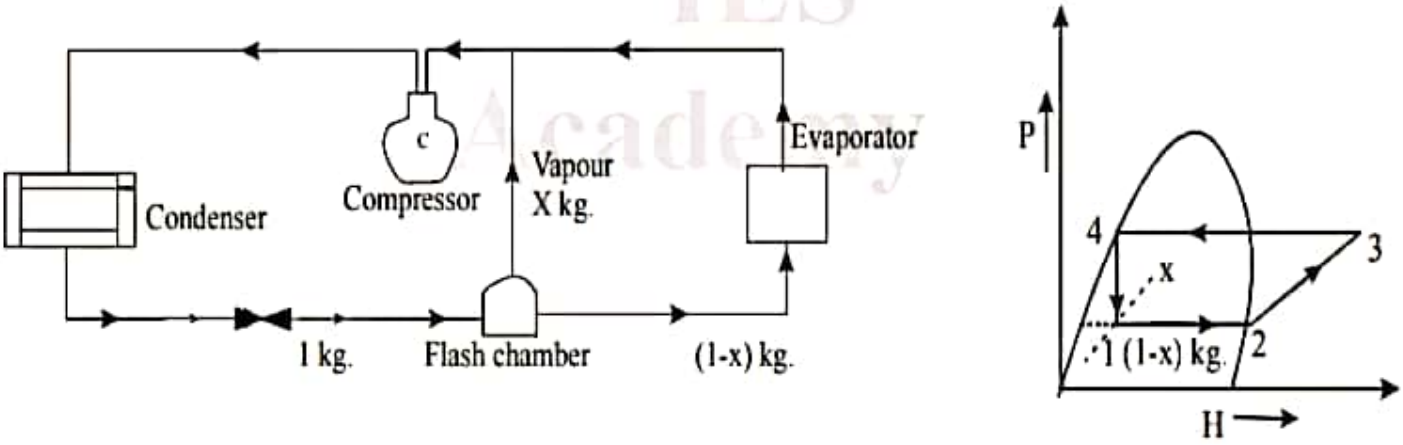
$R \rightarrow$ Re *frigeration effect*

$W \rightarrow$ *Work required for compression*

Method of Improving C.O.P

1. Flash chamber:— Flash is defined as weight of vaporised refrigerant per bg after leaving the throttle valve. This formed vapour does not take part in refrigeration because liquid refrigerant carries the heat in form of latent heat. A tank is provided before evaporator which is known as flash chamber. This separates liquid and vapour and thus reduces the weight of refrigerant passing through evaporator. The H.P and C.O.P of the simple saturation cycle will remain same but, reduces the size of evaporator used providing better

condition for heat transfer. **(Fig.- 25)**



Sub cooling of liquid Refrigerant by using vapour refrigerant:— (Fig. 26)

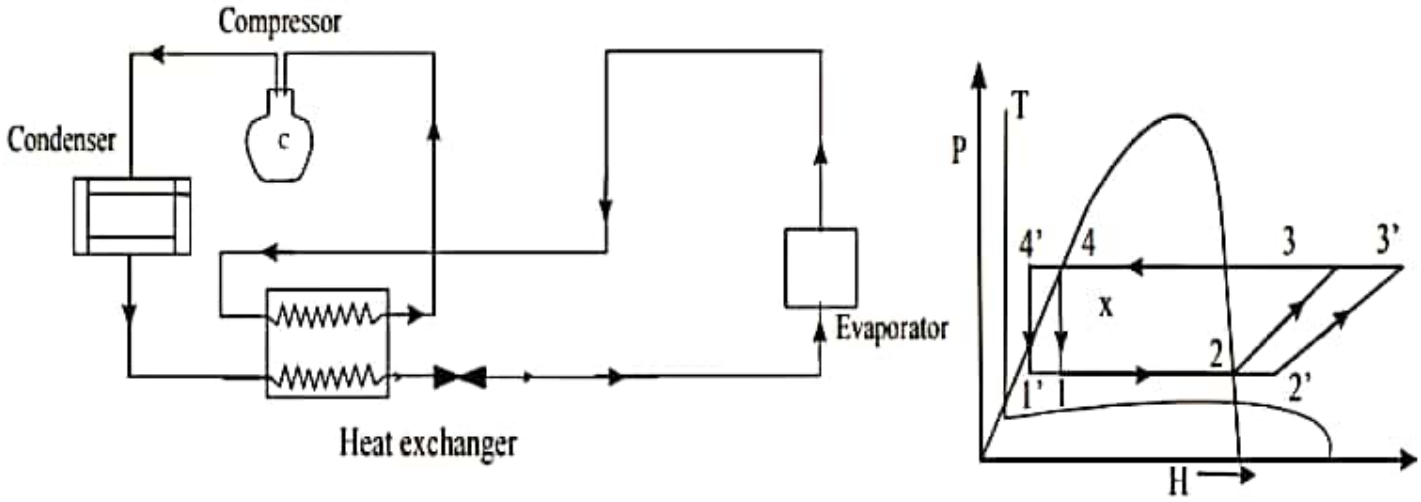
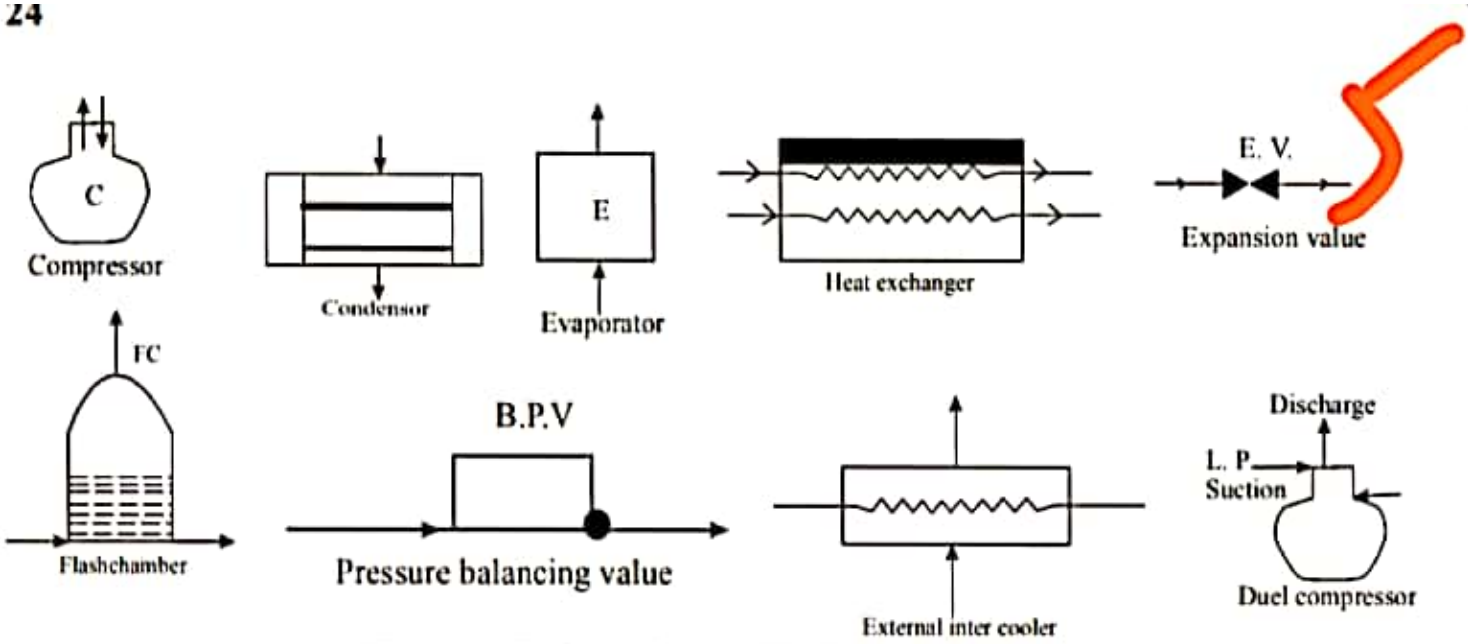


Fig 24



Compressor : The function of compressor is to take the refrigerant vapour at low pressure and low temp and compress it to a high pression and high temp.

Condenser:- The function of condenser is to convert high pressure refrigerant vapour into high pressure refrigerant liquid.

Expansion valve: The function of expansion valve is to reduce the pressure of liquid refrigerant beeping its total enthalpy constant

Flash chamber: In the flash chamber the refrigerant vapour is separated from refrigerant liquid and it prevents the flow of vapour into evaporator and allow only liquid refrigerant to flow through evaporation.
Evaporator: It is refrigerator or actual cooler where the cooling is required. Heat is removed from the evaporator by the low temperature refrigerant in the form of latent heat.

Pressure Balancing valve: The function of back pressure value is to reduce the pressure of vapour from high pressure to low pressure (low pressure is the down ward side of back pressure valve)

Intercoolers: The function of inter cooler or heat exchanger is to disuperheat the vapour coming out of compressor in multi compression system.

Dual compressor: It is a compressor having low pressure inlet valve, medium pressure inlet part and high pressure discharge valve. The function of dual compressor is to take the vapour from two different sources which are at different pressure and deliver the mix at some common high pressure.

◆ Better performance of refrigeration system is defined as higher C.O.P of the system. Coefficient of performance of system can be increased either by decreasing the work of compression or increasing the refrigeration effect or both. Compression work of a system can greatly reduced by compressing the refrigerant very close to refrigerator line. This can be achieved by compressing the refrigerant in more stages with intermediate inter cooler.

◆ The Ref. effect can be increased by maintaining the condition of refrigerant in more liquid stage at the entrance of evaporator. This can be achieved by expanding the refrigerant very close to liq. line. By

Advantage and disadvantages of vapour Refrigeration system over Air refrigeration system:

Advantages:-

(1) As working cycle is near the carnot cycle the C.O.P is quite high. The C.O.P of vapour cycle lies between 3 to 4 where as the C.O.P of air cycle is less than 1.

(2) Running cost of vapour refrigeration system is only 1/5 th of air refrigeration system used on ground level.

(3) As heat is carried away by latent heat of vapour the amount at liquid refrigerant is circulated is less per ton of refrigeration.

(4) Just by adjusting the throttle valve of same unit the req.temp can be maintained.

Disadvantages:-

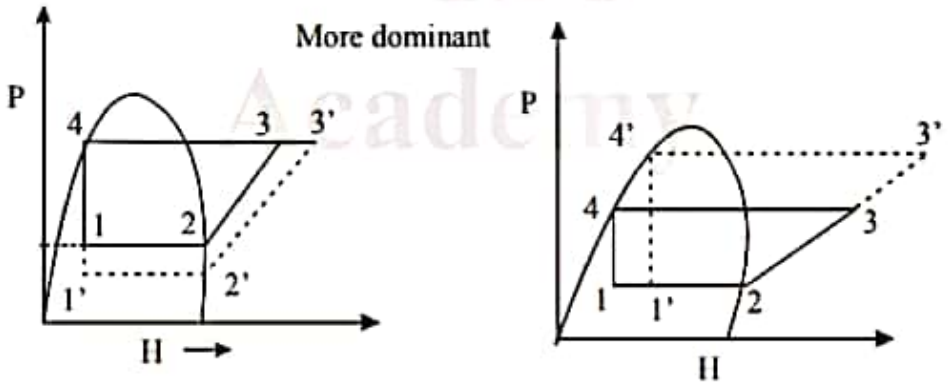
(i.) First investment cost is high

(ii.) Major problem is to prevent package of refrigerant.

Performance of simple vapour compression refrigerant cycle & effect of suction and delivery pressure:----

(a) effect of suction Pressure (b) effect of Delivery Pressure.

Fig 23.



(a) The COP of C.O.P of original cycle.

$$C.O.P = \frac{h_2 - h_1}{h_3 - h_2}$$

- The value of C.O.P when the suction pressure is decreased.

$$C.O.P = \frac{h_2' - h_1'}{h_3' - h_2'}$$ This shows that refrigeration effect is decreased and work required is increased.

The net effect is to reduce the refrigeration capacity of the system (with the same amount of refrigerant flow) and COP of system will decrease therefore refrigeration cost is increased.

- The value of C.O.P is given by the following equation when the discharge pressure is increased.

$$C.O.P = \frac{h_2 - h_1'}{h_3' - h_2}$$

The effect of increasing the discharge pressure is just similar to effect of decreasing the suction pressure. The only difference is the effect of decreasing the suction pressure is more predominant than the effect of increasing discharge pressure.

Vapour compression Refrigeration system with multiple evaporator and compressor:—

• The Refrigeration system can be analysed if the following factors are known.

(1) load in tons of refrigeration plant.

(2) The temp at which refrigeration take place.

(3) Atmospheric temperature .

Analysis :-

(a) If T is tons of refrigeration load, weight of refrigerant required.

$$\omega_r = \frac{3.5T}{(h_2 - h_1)}$$

(b) Horse power required to run the compressor

$$H.P = \omega_r (h_3 - h_2)$$

(c) Weight of cooling medium required in condenser

$$W_c.C_p \Delta T = W_r (h_3 - h_2)$$

$W_c \Rightarrow$ weight of coolant

$C_p \Rightarrow$ specific heat respectively

$\Delta T \Rightarrow$ rise in temperature.

(d) for the design of compressor.

$$\left(\frac{\pi}{4} D^2 L\right) \eta_v \frac{N}{60} = Wr.V_{s2}$$

where L => stroke of cylinder D => Dia of stroke.

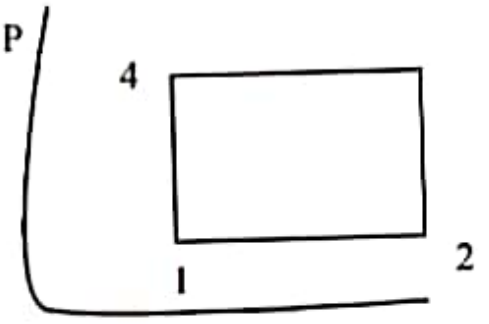
N => R.P.M of compression η_v => volumetric efficiency of compressor.

v_s =speechify volume of refrigerant vapour at suction condition of vapour.

ω_r = mass flow rate (kg /s)

(e) The C.O.P of the system is given by

$$C.O.P = \frac{h_2 - h_1}{h_3 - h_2}$$ **(Fig -22)**



• **All the calculation are done on the following assumption :-**

(1) There is no pressure loss in condenser, evaporator, connecting pipe and compressor valve.

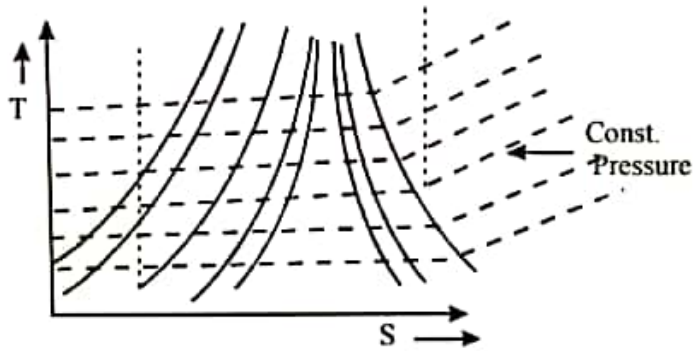
(2) There is no transfer of heat except in condenser and evaporator.

(3) Compression is isentropic .

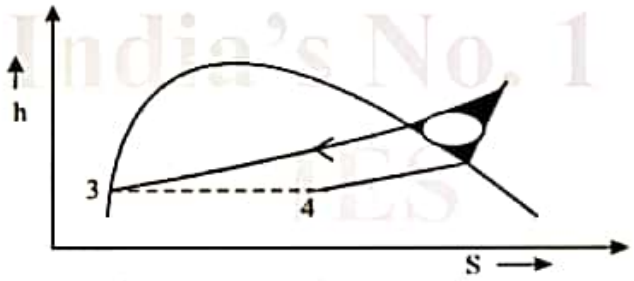
(4) Transmission-efficiency from motor to compressor is 100%

T-s h-s and ph diagram for Refrigerant

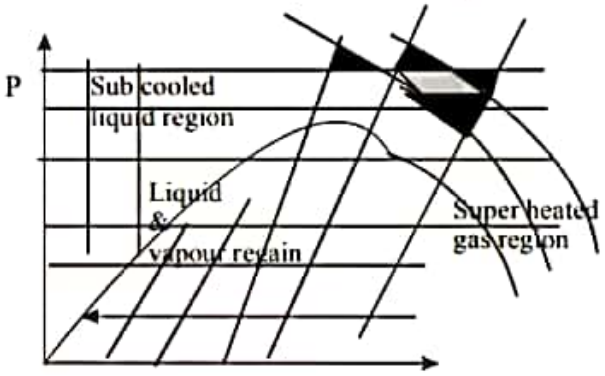
T-S diagram (Fig:18)



(ii) h-s chart (Fig 19)



(iii) P-h diagram (Fig. 20)



Analysis of vapour com- pression system : (Fig 21.)

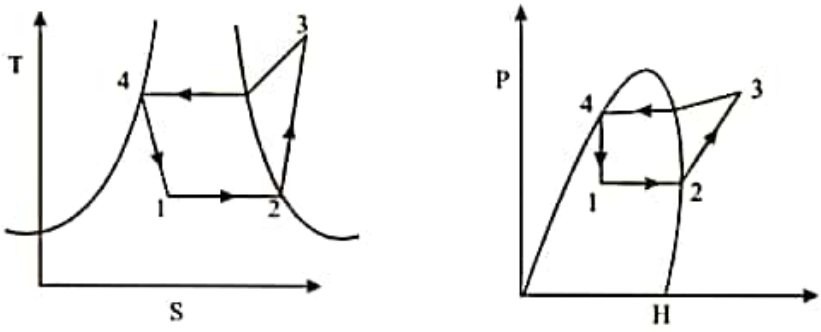


Fig represent the vapour compression system when the liquid coming out of condenser is saturate liquid and vapour coming out of evaporator is saturated vapour.

Simple vapour compression Refrigeration system:-

The modern refrigerating plant of vapour compression have several advantage over the air refrigeration system.

(1) → The principal advantages are smaller size for given capacity and less running cost.

(2) → The disadvantage of air refrigeration system are being eliminated by improvements in design which results in greater safety and prevention of leak.

(3) → With the development of nontoxic and non-inflammable refrigerants this is generally used for all purpose refrigeration from the comfort cooling in air conditioning plant and food preservation.

Vapour-Compression Refrigerator :--

The major difference in theory and treatment of vapour refrigeration system as compared to air refrigerator system is that the vapour alternately undergoes a change of phase from vapour to liquid and liquid to vapour during the completion of cycle. The latest heat of vapourisation is utilized for carrying heat from the refrigerating space which is quite high compared with the air cycle which depends upon the sensible heat of air.