3. The weight of the air refrigeration system per ton of refrigerant is quite low as compared to other refrigerant system.
4. Low maintenance cost.

Disadvantages:

1. As the heat is carried by air in the form of sensible heat only. The weight of air required to be circulated is more compared with refrigerant used in other system.
2. The C.O.P of this system is very low compared with other system because the overall temp to range. $(T_3 - T_6)$ In the cycle is very high in comparison with the temp difference between the refrigerator and atmosphere $(T_5 - T_2)$

   As $T_3 > T_5$ & $T_6 < T_2$

3. The major disadvantage of this machine is the freezing of moist air. The deposit of snow is liable to choke the value. This difficulty has been over come by the use of closed system.

Applying the isentropic law to the compression and expansion process:-

$$\frac{T_3}{T_2}=\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} \quad \& \quad \frac{T_5}{T_6}=\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

$$\frac{T_3}{T_2}=\frac{T_5}{T_6}\Rightarrow\frac{T_5}{T_3}=\frac{T_6}{T_2}$$

$$\text{C.O.P}=\frac{1}{\frac{T_3}{T_2}-1}=\frac{T_2}{T_3-T_2}$$

$$\text{C.O.P (isentropic process)}=\frac{T_2}{T_3-T_2}$$

$$\text{C.O.P (Polytropic process)}=\frac{T_2}{\frac{n}{(n-1)}\frac{(\gamma-1)}{\gamma}[T_3-T_2]}$$

Actual Analysis of Bell-coleman cycle:--

Actual cycle is operation differs from the theoretical in following respect.

(i) The compression and expansion process do not follow isentropic law due to internal friction. There fore the process can be considered as irreversible adiabatic (increase in entropy)

(ii) The pressure drop takes place in cooler due to fluid friction particularly. When the velocity of flow is considerably large.

(iii) The pressure drop also take place in the refrigerant therefore the pressure at the outlet of expansion cylinder is greater than the pressure in refrigerator or evaporator.

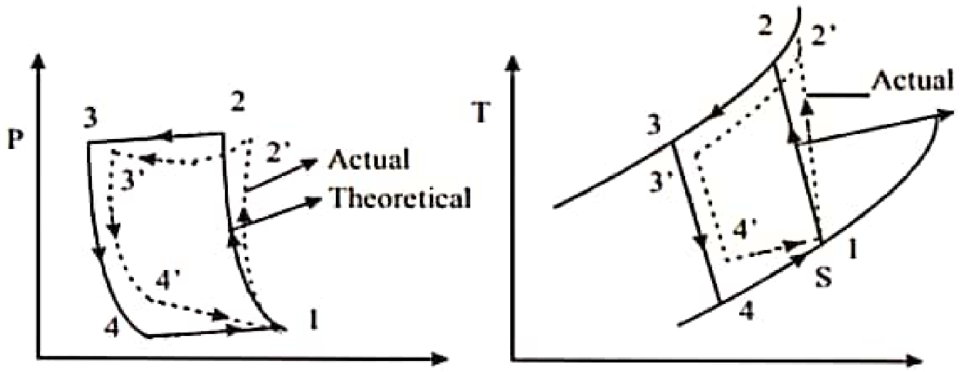


Fig.-6

◆ **Advantage & Disadvantage of air Refrigeration system:---**

Advantages-

1. As the air is easily available compared with the other refrigerant. It is cheap.
2. The air used is nonflammable. so there is no danger of fire as in NH_3

But in Actual practice perfect isotropic process is not possible so assuming compression and expansion are polytropic and follow the same law as :-

$$PV^n = C \text{ (const)}$$

- W_c (work required by the compressor per kg of air) →

$$W_c = \frac{n}{(n-1)}[p_3v_3 - p_2v_2] = \frac{n}{n-1}R[(T_3 - T_2)]$$

- We => work delivered by the expander per kg of air

$$W_e = \frac{n}{(n-1)}[p_5v_5 - p_6v_6] = \frac{n}{n-1}R[(T_5 - T_6)]$$

Work done from the external source

$$W_n = W_c - W_e$$

$$= \frac{n}{n-1}.R.[(T_3 - T_2) - (T_5 - T_6)]$$

$$= \frac{n}{n-1}\frac{(\gamma - 1)}{\gamma}.Cp[(T_3 - T_2) - (T_5 - T_6)]$$

$$W_n = \frac{n}{n-1}\frac{(\gamma - 1)}{\gamma}.cp[(T_3 - T_2) - (T_5 - T_6)]$$

$$C.O.P = \frac{Q_a}{W_n} = \frac{Cp(T_2 - T_6)}{(\frac{n}{n-1})(\frac{\gamma-1}{\gamma})Cp[(T_3 - T_2) - (T_5 - T_6)]}$$

$$C.O.P = \frac{1}{(\frac{n}{n-1})(\frac{\gamma-1}{\gamma})\left[\frac{(T_3 - T_5)}{(T_5 - T_6)} - 1\right]}$$

As $T_2 = T_5$ for perfect inter-cooling

$$C.O.P = \frac{1}{(\frac{n}{n-1})(\frac{\gamma-1}{\gamma})\left[\frac{(T_3 - T_5)}{(T_5 - T_6)} - 1\right]}$$

If compression becomes isentropic ie. $n = \gamma$

$$C.O.P = \frac{1}{\frac{(T_3 - T_5)}{(T_2 - T_6)} - 1} = \frac{1}{(\frac{T_3}{T_2})\frac{(1 - \frac{T_5}{T_2})}{1 - \frac{T_6}{T_2}} - 1}$$

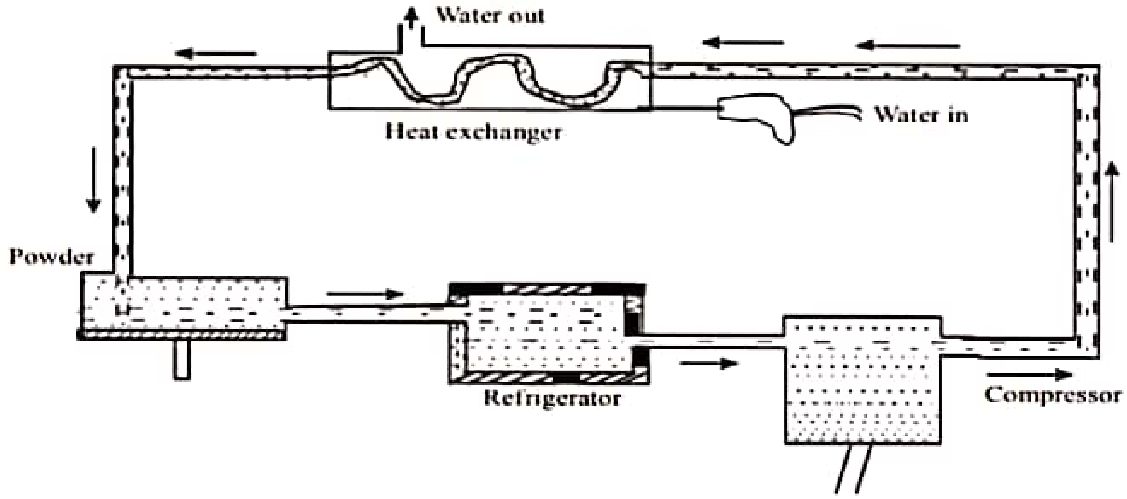
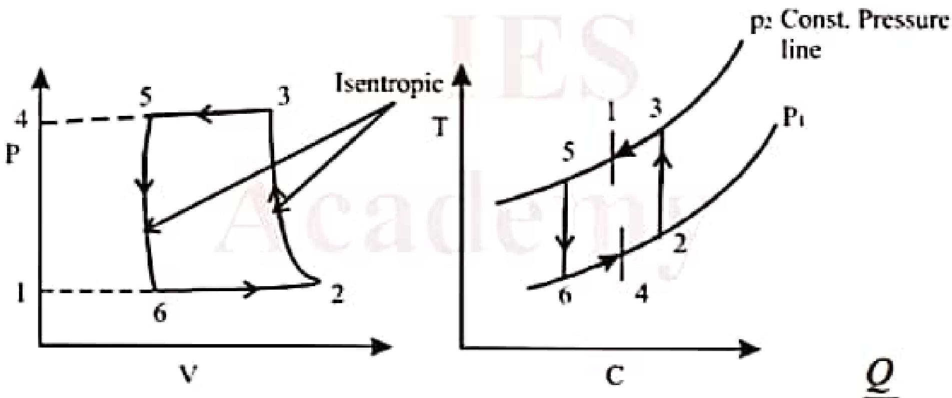


Fig -4.

Closed cycle air refrigerator working on Bell coleman cycle.

V & T s diagram =



$\frac{Q}{w}$

Fig -5.

The net refrigerating effect is heat absorbed from the cold storage chamber.

$$C.O.P = \frac{\theta}{w}$$

Q = heat carried from the refrigerator (absorbed)

W = net work supplied by the electric motor.

$$W = \oint W = \oint Q$$

= Heat rejected - Heat absorbed

Q1 Q2

$$W = Cp(T_3 - T_5) - Cp(T_2 - T_6)$$

Because there is no heat transfer during the isotropic compress, and expansion.

$$C.O.P = \frac{C_p(T_2 - T_6)}{C_p(T_3 - T_5) - C_p(T_2 - T_6)} = \frac{(T_2 - T_6)}{(T_3 - T_5) - (T_2 - T_6)}$$

$$C.O.P = \frac{1}{\frac{(T_3 - T_5)}{(T_2 - T_6)} - 1}$$

Temp. Limitation:—

$$C.O.P = \frac{T_1}{T_2 - T_1}$$

Low value of T_2 will make C.O.P high, high value of T_1 increases the numerator and decreases the denominator therefore increases the coefficient of performance. The value of T_1 has more pronounced effect upon C.O.P than T_2.

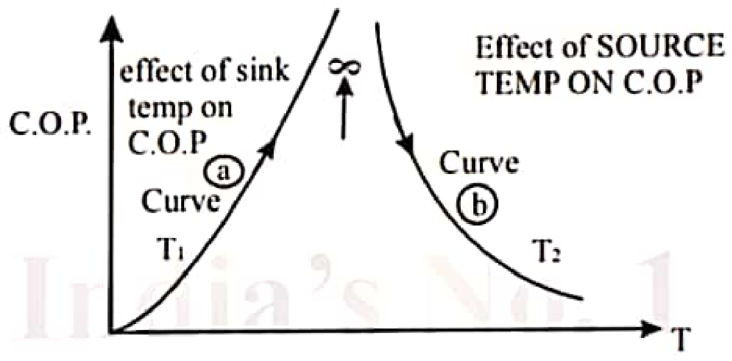


Fig - 2.

The curve (a) shows the effect of T_1 on C.O.P when T_2 is constant

The curve (b) shows the effect of T_2 on C.O.P when T_1 is constant.

- * If the refrigeration system has maintain a room at $0\ C$ and refrigerant reject heat to atmosphere at 25°C, then temp must be greater than 25°C during heat rejection process and during the heat absorption process the temperature of refrigerant must be lower than $0\ C$
  The value of ΔT should be as small as possible because increase in ΔT will decrease C.O.P

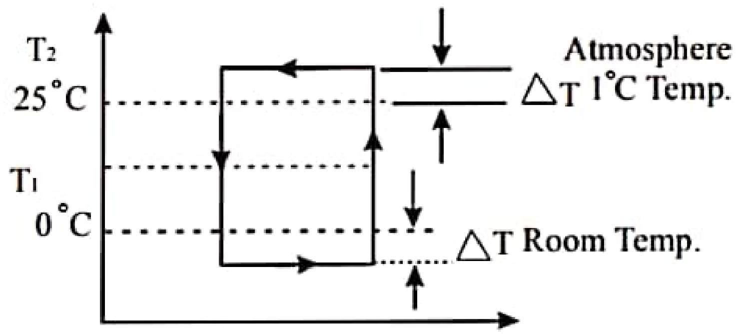


Fig- 3.

- * T_2 in winter < T_2 in summer.
  Carnot refrigerator works more efficiently in winter than in summer because.
  C.O.P in winter > C.O.P in summer
- * The carnot cycle is most efficient between the fixed temp limits and is therefore useful as a criteria of perfection. It posses undesirable characteristic because isentropic process of the cycle requires high speed while the isothermal process requires an extremely low speed. This variation in flow of air is not possible in practical.

Bell coleman Air Refrigerator:—

Modification of the ideal reversed carnot cycle as to make it practiable has resulted in this cycle The isothermal process are replaced by constant pressure processes.

AIR REFRIGERATION SYSTEM

Introduction:

In air cycle refrigeration air is used as working fluid. As the air is not changing its phase throughout the cycle the heat carrying capacity per kg by of air is very small compared with vapour compression machine.
As high pressure air is already available in the aeroplane, it has been applied recently to aircraft system with low equipment weight.

The air refrigeration cycle can be divided into a closed and open system. The difference between these two system is that air used in refrigerator is thrown into the atmosphere instead of recirculating as it in closed system.

Carnot cycle and most efficient Refrigerator:-

Carnot cycle considered in refrigeration system in the reversed, camot cycle used for engines.

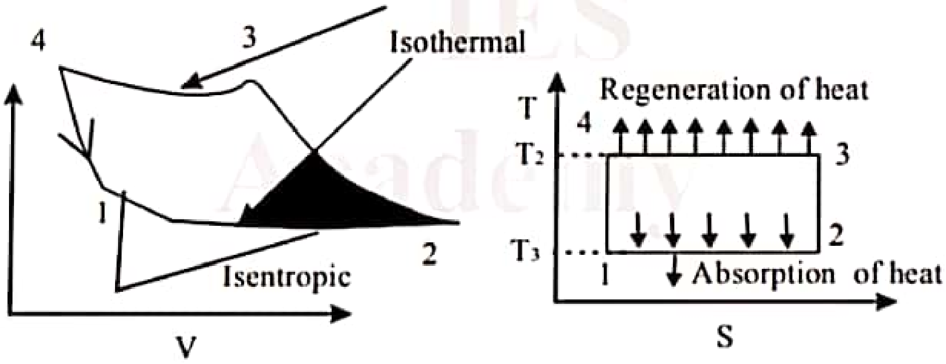


Fig 1.

The performance of camot cycle is independent of physical properties of working medium.

T_1= Temperature to be maintained in refrigerator

T_2= Temp of atmosphere to which heat is rejected.

In the carnot cycle refrigerator it is assumed that the heat absorption and rejection take place at constant temp and compression and expansion are isentropic.

- In cyclic process $\oint Q = \oint W$

w (network done) $\Rightarrow \oint W = \oint Q$

$$= T_2(S_2 - S_1) - T_1(S_2 - S_1)$$

$$W = (T_2 - T_1)\ (S_2 - S_1)$$

$$C.O.P = \frac{Q_a}{W} = \frac{T_1(S_2 - S_1)}{(T_2 - T_1)(S_2 - S_1)} = \frac{T_1}{T_2 - T_1}$$

$$C.O.P = \frac{T_1}{T_2 - T_1}$$ where $T_2 > T_1$