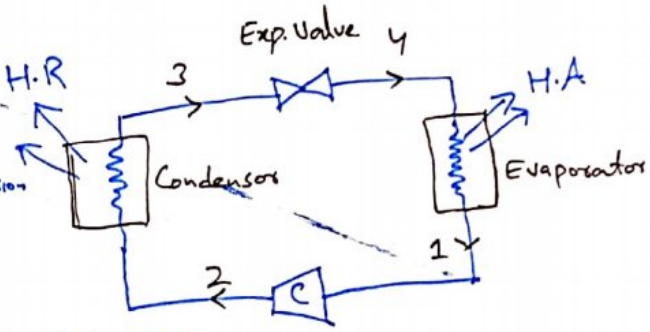
Vapour Compression Cycle

- Given the name as vapour compression cycle because
  - → working substance is fluid or vapour.
  - → It rapidly evaporates and condensed.
  - → Change alternatively by it state from vapour and liquid without leaving the refrigeration plant.

Simple Vapour Compression Cycle:-



Processes:-

a):- Compression

Reversible adiabatic compression

b):- Condensation:-

→ Superheated vapour converted to saturated vapour

→ Saturated vapour to saturated liquid.

Heat rejection takes place in condensor. vapour is converted into liquid.

c):- Expansion / Throttling valve :-

Process is adiabatic but not reversible.

i.e irreversible adiabatic process.

d):- Evaporator :-

Heat is absorbed and refg effect is produced.

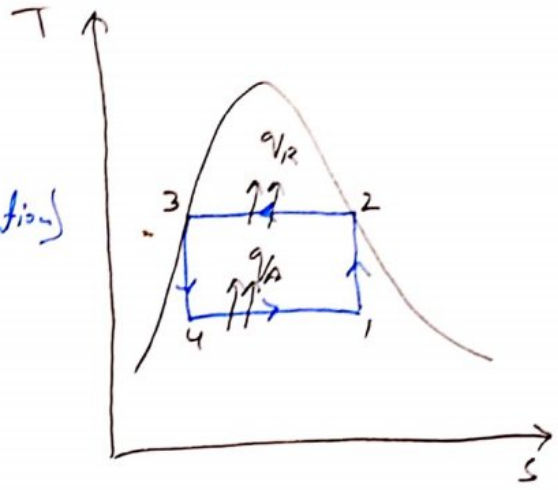
Revision of Reverse Carnot cycle:-

→ To get max COP, it is desired that rectangular shape of the cycle must be maintained.

→ Cycle must operate as refrigerant b/w

- Saturated liquid line
- Saturated vapour line.

Conventional vapour compression cycle



1-2 :-
Reversible adiabatic compression

2-3 :-
Reversible isothermal Heat rejection (condensation)

3-4 :-
Reversible adiabatic expansion
or " isentropic "

4-1 :-
Reversible Isothermal Heat absorption.

NOTE :-

- Above cycle is a repetition of reverse carnot cycle which maintains rectangular shape b/w saturated liquid line and saturated vapour line.
- This render max COP.

→ In actual vapour compression cycle

Process 3-4 is not reversible adiabatic expansion rather it is irreversible adiabatic expansion.

Modification of Carnot cycle :-

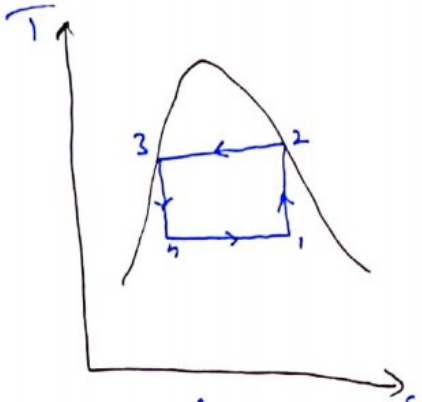
There are two main factors which lead to modify the carnot cycle used in vapour compression system.

± Add of superheated Horn (Dry vs wet compresson)

± Throttling process (3-4) will modify itself to irreversible isenthalpic process

DRY Vs WET COMPRESSION :-

1-2 :- **Wet compression** :- The whole of compression occurs in the liquid region and at the inlet of compressor liquid droplets are present.



Liquid droplets at the inlet of compressor was not desireable owing to the following reasons.

- Liq droplets may be trapped in head of cylinder. Thereby damaging the walls of cylinder.
- Corrosion / Rusting
- Wash away the lubrication oil of compressor causing wear & tear and shorter life of compressor.

DRY Compression :-

→ Compression should start at the vapour saturated line and ends at the superheated region is known as dry compression

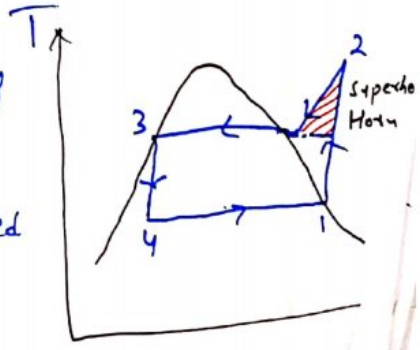
→ This is achieved by shifting point 1 to the saturated vapour line.

→ With dry compression cycle losses rectangular shape of carnot cycle.

→ And the area above the condensing temp of the cycle is superheated horn.

→ Hence more compressor work is required for superheating the vapour to achieve point 2.

→ Refrigerant will now leave the compressor at superheated vapour to condensor.



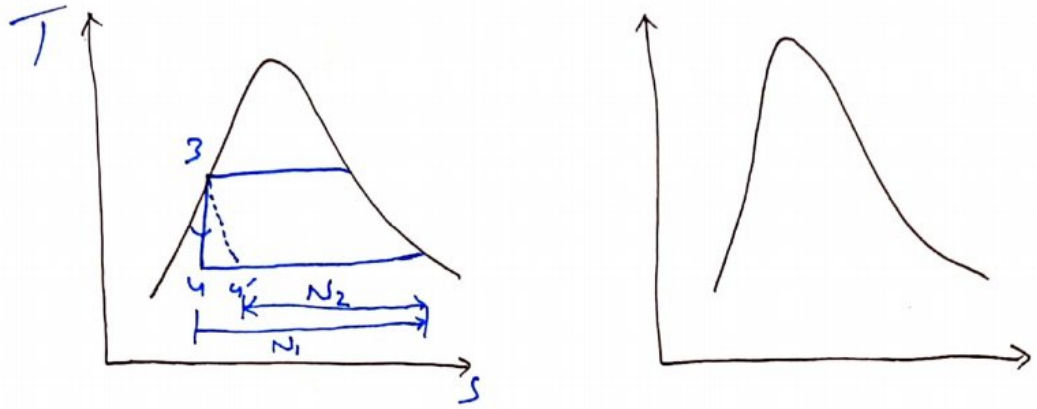
Irreversible Throttling Expansion :-

The expansion undertaken in

a) Throttling valve or

b) Expansion valve or

c) Capillary tube.



3-4' ; Throttling Process :-

It is constant enthalpy process it is also called isenthalpic process

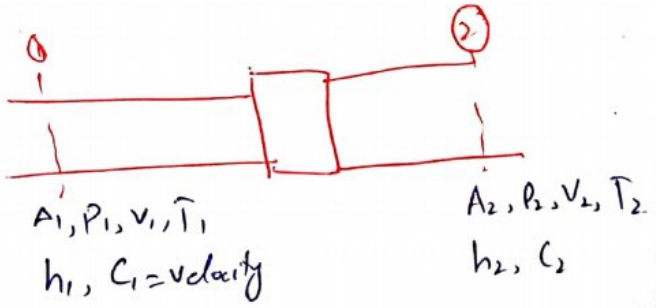
or we can say that

Process 3-4 (Reversible adiabatic expansion)

had been replaced

irreversible isenthalpic (How) with entropy increase.

An irreversible steady flow expansion process in which expansion takes place through an orifice of smaller dimension



Applying the energy eq

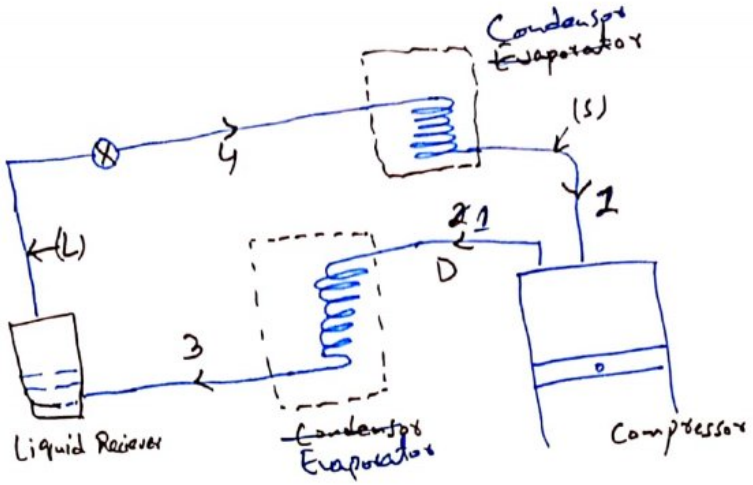
$$h_1 + \frac{C_1^2}{2} + gZ_1 + q = h_2 + \frac{C_2^2}{2} + gZ + W$$

$$h_1 + \frac{C_1^2}{2} = h_2 + \frac{C_2^2}{2}$$

when $P_2 < P_1$ and $V_2 > V_1$

then $h_1 = h_2$.

Functia parts of vapour compression cycle:-



Compressor :-
Remove vapour from evaporator
To raise its temp & Pressure so that vapour can be condensed.

Discharge line :-
It delivers high Ps and high temp vapour from compressor to condensor.

Condensor :-
A device to provide heat tfs surface through which heat is rejected to condensing media (Air or H_2O).

Recievers Tank :-
Serve as storage tank for condensed liquid to ensure supply of refrigerant.

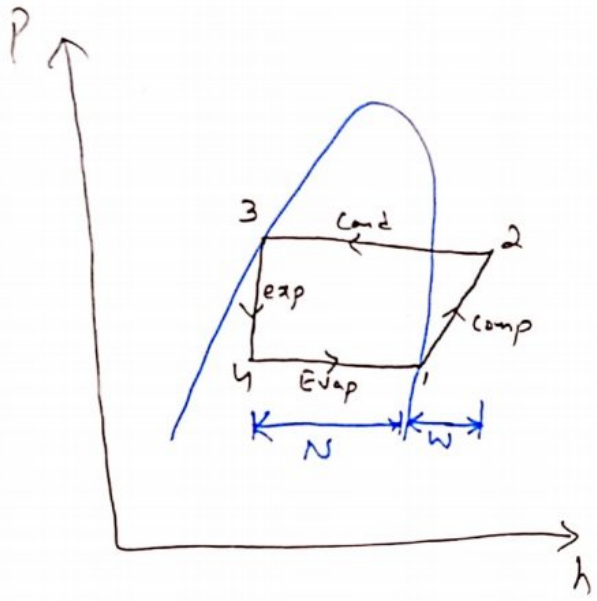
Liquid line :-
It carries liquid refg from reciever tank to expansion value.

Expansion Valve :-
To meter the amount of refg to the evaporator.
To provide a low pressure and low temp refrigerant to evaporator.

Evaporator :- A refgerated space where the heat is added to the refrigerant to produce cooling effect.

Suction line :- Carries low pressure vapour from Evaporator to the suction inlet of compressor.

SATURATED Vapour Compression Cycle:-



Work of compression = $W = h_2 - h_1 \left(\frac{kJ}{kg}\right)$

or

Heat of compression

2) H.R by the Refg = $q_c = h_2 - h_3 \left(\frac{kJ}{kg}\right)$

3) Refrigeration effect = $N = h_1 - h_4$

4) $COP = \frac{N}{W} = \frac{h_1 - h_4}{h_2 - h_1}$

5) Volume flow rate at the compressor inlet = $V = \dot{m} v_1$

$V = \frac{m^3}{sec} \times 1000$

$= l/sec$

6) System capacity or cooling capacity = $\dot{m} N = Q_c$

$= \frac{kg}{sec} \times \frac{kJ}{kg} = kW$

7) Power per KW of the refrigerant = $\frac{1}{COP} = \frac{W}{N}$

Hence Power $\propto \frac{1}{COP}$

- It is also known as work of refrigeration per KW of compressor.

8) Refrigeration circulation rate = $\dot{m} = \frac{Q_c}{N}$

9) Theoretical discharge displacement = $m v_1$

10) Power consumption = $\dot{W} = \dot{m}$ Work

$= \dot{m} (h_2 - h_1)$