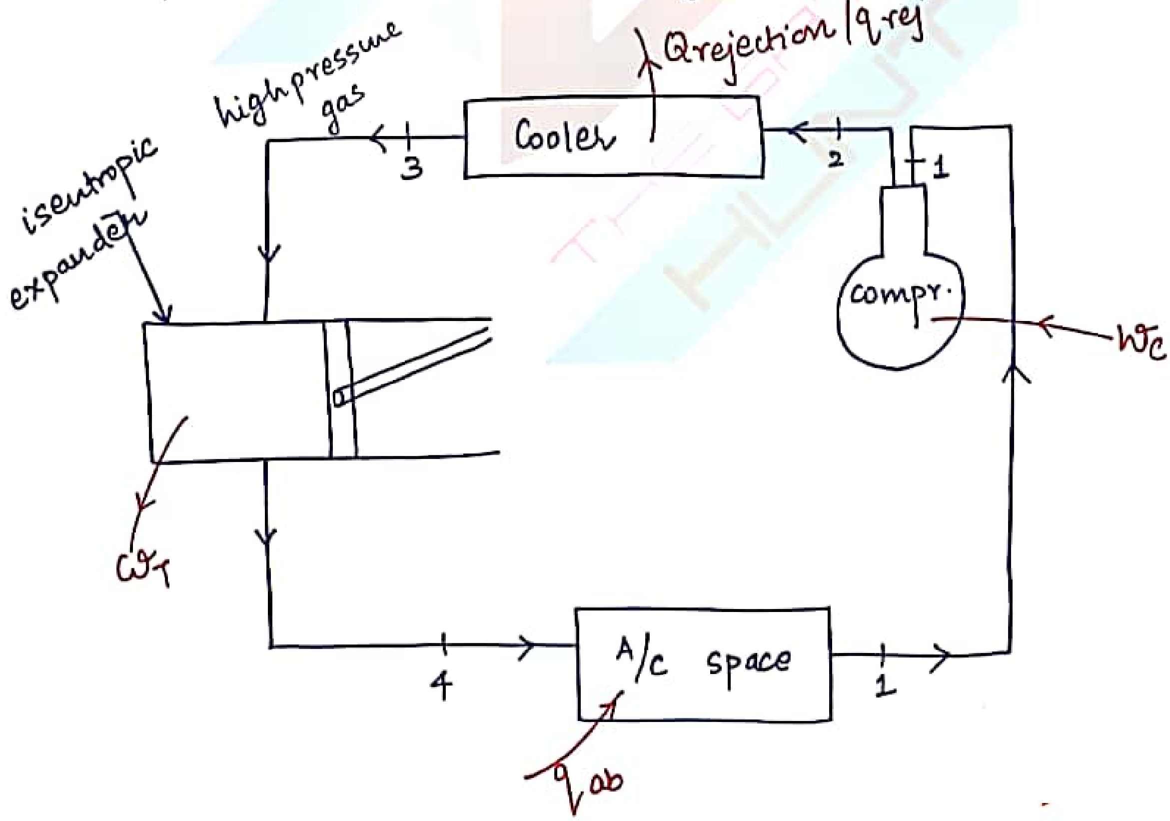
GAS Refrigeration Cycle (or) Reversed Brayton Cycle (or) Bell coleman cycle (or) Aircraft Air Conditioning Cycle. (or) Gas Liquification Cycle.

• This cycle is used for the air conditioning in aircraft because of its low weight per tonn of refrigeration. since, the air can be taken from the compressor of gas turbine eliminating the need for a separate compressor.

• The air is used as refrigerant, hence it can be directly sent to the air conditioned space. This helps us in maintaining the cabin pressure as the air can be sent at a desired pressure in the air conditioned space.

• The COP of the gas cycle is low because all the heat transfer takes place in the sensible region.

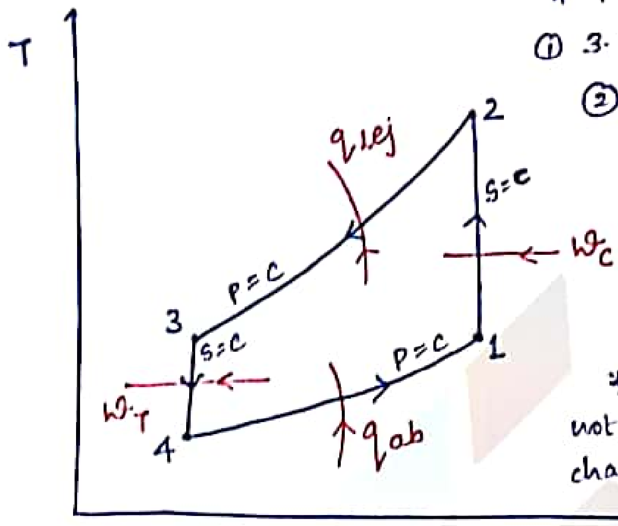


1 → 2 isentropic compr. (Reversible adiabatic)

2 → 3 isobaric heat rej.

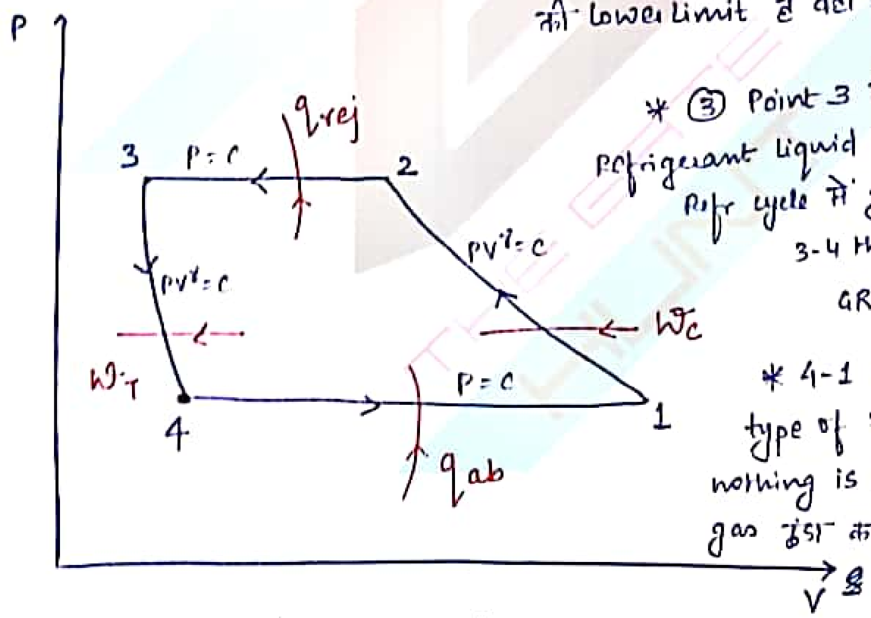
3 → 4 isentropic exp. (Reversible adiabatic)

4 → 1 isobaric heat absorption/addition



* Fundamental diff. VCRS से यहाँ है:
① 3-4 → expansion (isentropic)
② यहाँ Phase change ऐसा कुछ नहीं होता (VCRS में evaporator और condenser में phase change होते थे) (gas का phase throughout gaseous phase ही रहेगा)

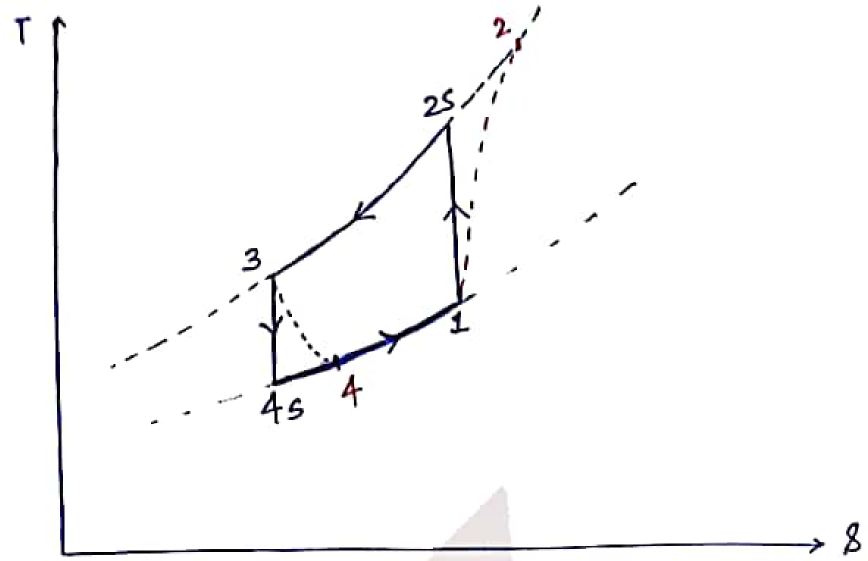
* 2-3 → isobaric heat Rejection not condensation (since gas is not changing its phase) और heat Reject करदेगा ambient को जो ambient की lower limit है वहाँ तक



* ③ Point 3 में VCRS में Refrigerant liquid था जबकि gas Refr cycle में gas है (and also 3-4 throttling नहीं होगी GRC) में।

* 4-1 → evaporator type of space but nothing is evaporating. only gas ठंडा कर रहा है space को।

Isentropic Efficiency of compressor and turbine:-



$$\eta_{s,c} = \frac{W_{isen}}{W_{actual}}$$

$$\eta_{s,T} = \frac{W_{actual}}{W_{isent.}}$$

$$\eta_{s,c} = \frac{h_{2s} - h_1}{h_2 - h_1}$$

$$\eta_{s,T} = \frac{h_3 - h_4}{h_3 - h_{4s}}$$

$dh = C_p dT$ (ideal gas)

$$\boxed{\eta_{s,T} = \frac{T_3 - T_4}{T_3 - T_{4s}}}$$

$$\boxed{\eta_{s,c} = \frac{T_{2s} - T_1}{T_2 - T_1}}$$

REFRIGERANTS → (chemicals)

Naming of the refrigerant :-

(I) Saturated hydrocarbons :-

$C_m H_n F_p Cl_q$

$$2m + 2 = n + p + q$$

(m → C, n → H, p → F, q → Cl)

$$R(m-1)(n+1)p$$

(m−1 → C, n+1 → H, p → F)

→ chlorine is not used since 3 elements fixed, then 4th → already fixed.

Ex :- (1) CCl_2F_2

$m = 1, \quad m-1 = 0$

$n = 0, \quad n+1 = 1$

$P = 2$

$R(0)(1)(2)$

R 012
↓ (0) can be dropped

R 12 ✓

(2) R 22

R 0 2 2
↑ m−1, ↑ n+1, ↑ P

$m-1 = 0, \quad m = 1$

$n+1 = 2, \quad n = 1$

$P = 2$

$C_1 H_1 F_2$

(one bond more)

hence, $C_1 H_1 F_2 Cl$ ✓

PROPERTIES of Refrigerants :-

① Normal Boiling Point (NBP) → The Boiling point corresponding to 1 atm is NBP.

- We design the refrigeration so as the pressure should be above atmosphere in the entire cycle. hence the evaporator which is the minm. pressure region is design slightly above 1 atmosphere.
  This is done to avoid air leaking in the system in case of leakage.

- Air entering in the system will bring water vapour which may freeze at the exit of the throttling valve, hence choking the system.

- The air gets trapped in the condenser because it does not condensed. hence, it has following effects :-

ⓐ Increase in condensor pressure.
ⓑ Increase in compressor power.
ⓒ Increase in water-jacket temperature.

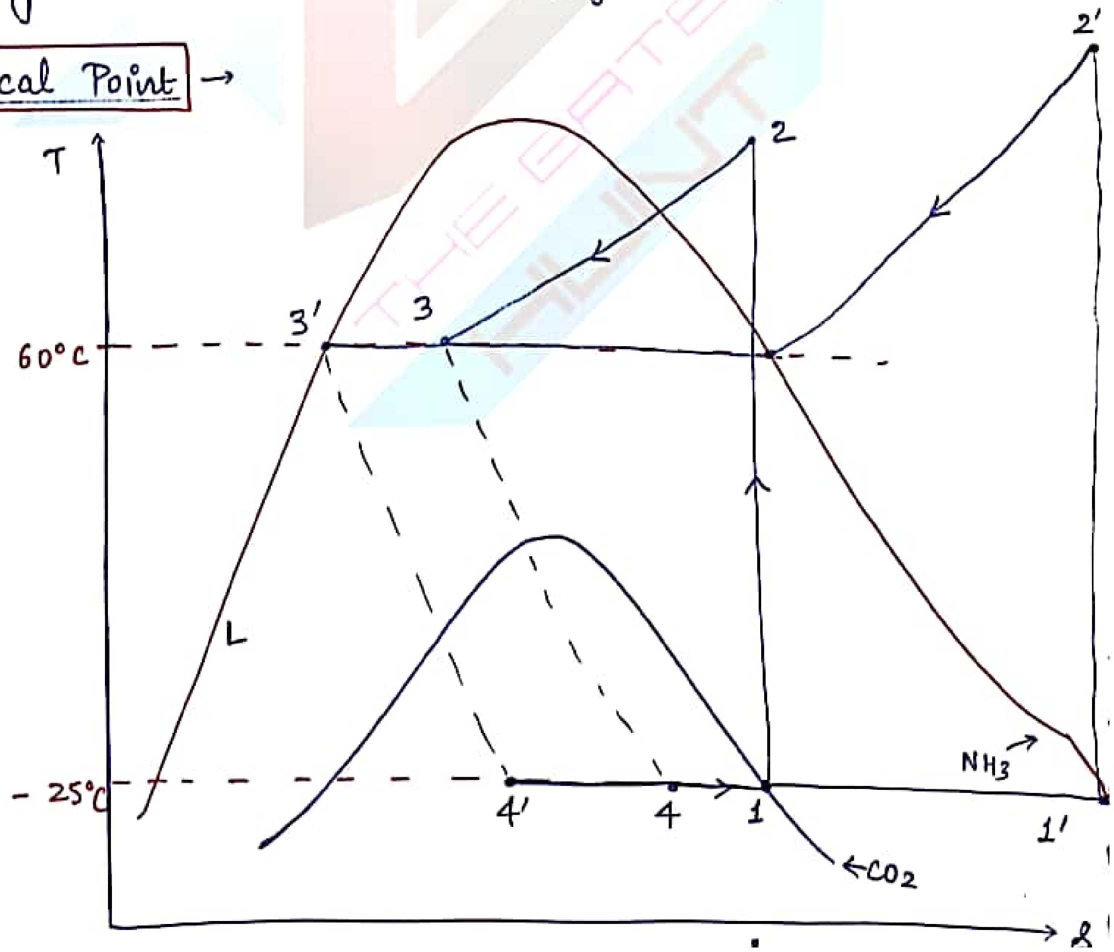
- The Refrigerants with low NBP should be selected.
- low NBP refrigerants are high pressure refrigerants and high NBP refrigerants are low pressure refrigerants.

② **Freezing point (F.P.)** → • The F.P. of the refrigerant should be sufficiently low so as to avoid freezing of refrigerant in the refrigeration system.

③ **Specific Volume at the compressor inlet** → The refrigerant should have low specific volume at compressor inlet. high specific volume will result in large sized compressors.

NOTE :→ R-11 and R-113 have high specific volume, hence they are used with centrifugal compressors.

④ **Critical Point** →

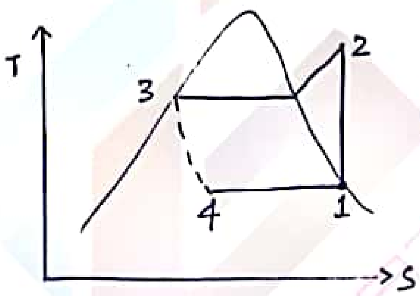


The Refrigerant should have high critical tempr. so as to have the heat transfers during the phase change.

⑤ Latent Heat (LH) and Specific Heat (SH) :- The latent heat of the refrigerant should be high because refrigeration effect is obtained through the latent heat. high refrigeration effect results in lower mass flow rates.

- Specific heat in the liquid phase should be low whereas in the vapour phase, it should be high.

$R.C = \dot{m}\downarrow \times R.E.\uparrow$



C	B
$C_{liq}\downarrow$	$C_{liq}\uparrow$
③ → 1kg, $Q\downarrow$	1kg
4 → $m_v = 0.1$	4 → $m_v = 0.3$
$m_l = 0.9$	$m_l = 0.7$

⑥ Pressure Ratio :- The Refrigerant should have low pressure ratios so as to have high volumetric 'η'.

⑦ Compressor discharge Temperature :- The refrigerant should have low compressor discharge temperature.

• NH_3 has high compressor discharge temperature hence NH_3 compressors are water cooled.

(chemical Prop.)

⑧ Toxicity and Flammability :- • The Refrigerant should be non-Toxic and non-flammable.

• NH_3 has very good thermodynamic properties but it is not used in domestic applications because of its toxic and flammable nature.

⑨ Action with the lubricating oil :- Case A :- completely immiscible.

Refrigerants like NH_3 and CO_2 are completely immiscible with the lubricating oil, hence an oil separator is installed between compressor and condensor. The lubricating oil which is washed away by the flow of the refrigerant is separated in the oil separator and brought back to the compressor.