[Isothermal तो possible है ही नहीं क्योंकि Tempr. change हो ही जाता है phir फिर किसी तरीके से हम Process को करना चाहता हैं तो एक Term use हुआ था → Quasistatic process
↓
almost रुका हुआ
↓
∞ time के बाद कई सदियों के बाद तो Process खत्म होगा]

Basic - Thermodynamics

① Thermodynamic Properties

② 2nd law of T.D.
- → Clausius Statement ↓ Refrigeration
- → Kelvin Plank statement ↓ Heat Engine

③ Enthalpy (h) and Entropy (s)

[Heat का exchange नहीं होता means हम process को इतना fast कर देते हैं कि heat exchange के लिए Time ही नहीं मिलता]

1) Adiabatic Process ($PV^{\gamma} = c$) → no heat Exchange ($\Delta Q = 0$)

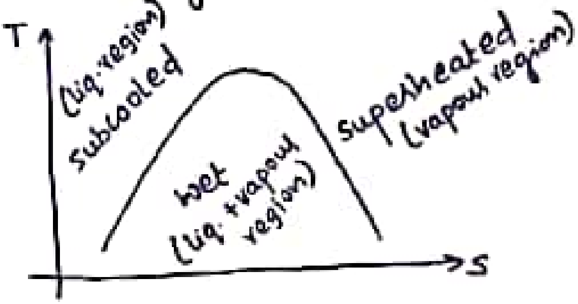
hence $h_1 + q^0 = h_2 + W_{cv}$

$$W_{cv} = h_1 - h_2$$

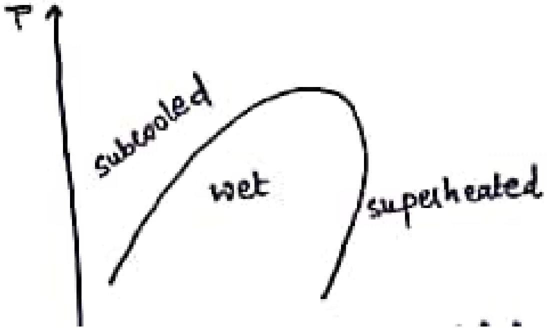
2) Polytropic Process ($PV^{n} = c$) → some heat Exchange ($\Delta Q \neq 0$)

* Important Curves

ⓘ T-S diagram



ⓘⓘ P-h diagram



Open System work

① Steady flow. → No changes wrt time

② $\Delta KE = 0$ and $\Delta PE = 0$ → Assumption

S.F.E.E.

$$h_1 + q = h_2 + w_{c.v.}$$

Adia → Rev
Adia → irrev.

$$w_{c.v.} = h_1 - h_2$$

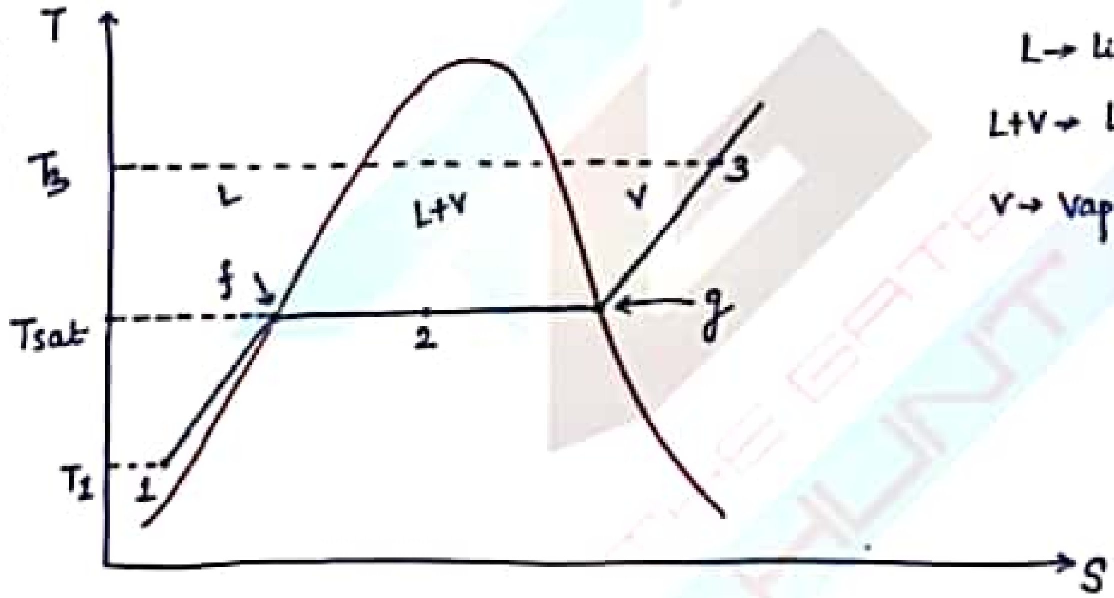
$$w_{c.v.} = -\int v\,dP$$

Polytropic

$$PV^n = C$$

$$w_{c.v.} = \frac{n}{n-1}(P_1v_1 - P_2v_2)$$

Enthalpy and Entropy at various points :-



L → Liquid

L+V → Liquid + Vapour

V → Vapour

① Subcooled

$$h_f - h_1 = C_{P_{Liq}}(T_{sat} - T_1)$$

$$s_f - s_1 = C_{P_{Liq}} \ln\left(\frac{T_{sat}}{T_1}\right)$$

② Wet region

$$h_2 = h_f + x_2 h_{fg} = h_f + x_2(h_g - h_f)$$

$$s_2 = s_f + x_2 s_{fg} = s_f + x_2(s_g - s_f)$$

$$Q_{Phase} = h_g - h_f$$

⇓

L.H.

$$S_g - S_f = \frac{L.H.}{T_{sat}} = \frac{h_{fg}}{T_{sat}}$$

③ **Superheated (Ideal gas)**

$$h_3 - h_g = C_{p_v}(T_3 - T_{sat})$$

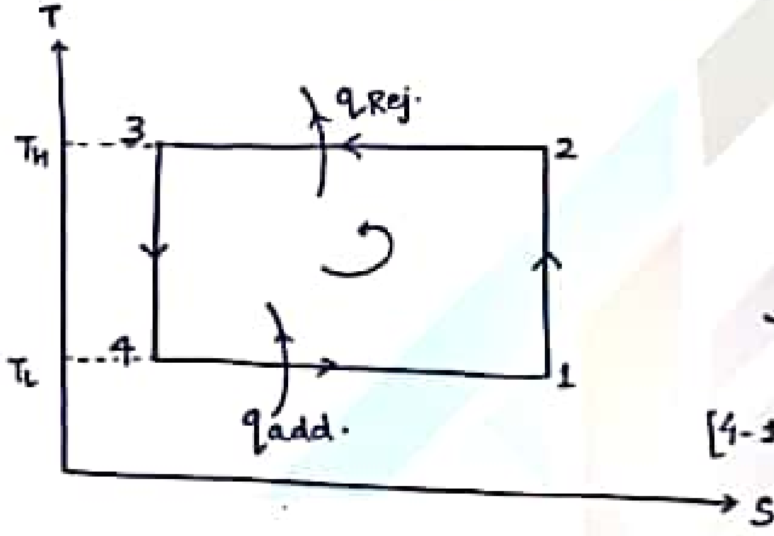
$$S_3 - S_g = C_{p_v} \ln \frac{T_3}{T_{sat}} - R \ln \frac{P_3}{P_{sat}} \rightarrow 0$$

$$S_3 - S_g = C_{p_v} \ln\left(\frac{T_3}{T_{sat}}\right)$$

* **Problem of Reversed carnot cycle** → we can't eliminate (essential problems)

① Isothermal Process is very slow & Adiabatic is very process
⇓
mechanically not possible

② Isothermal is very tough to achieve → impossible
⇓
thermally impossible



Reversed carnot cycle → not practically possible

(Ideal Refrigeration Cycle)

↻ → anticlockwise चलेगी

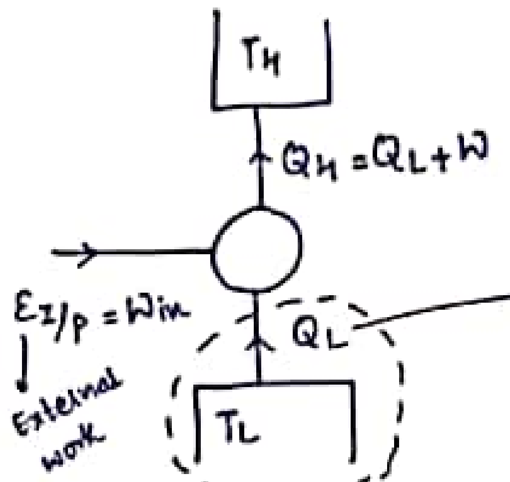
[4-1 में fluid होगा → Refri. process → RE fluid ने Room की heat absorb की और Room ठंडा होने लगा But isothermal होना चाहिए Fluid किसी भी device में flow करेगा]

1-2 → isentropic compression (entropy constant) (T↑, P↑)

2-3 → isoth. heat. Rejection (tempr. constant) (T. const)

3→4 → Isentropic exp. (entropy constant) (T↓, P↓)

4-1 → isotherm. heat add. (tempr. constant) → RE



Heat को lower tempr. से high tempr. पे जाएगी

lower tempr. heat (Q_L)
(इसको lower tempr. से बाहर निकालना है)

$\Rightarrow (COP)_{Ref.} = \frac{Q_L}{W}$ → for finding the performance of Refrigeration system

[ठंडी जगह को और कितना ठंडा कर पाए हैं i.e. T_L lower tempr से lower heat को निकालना है]

actual COP

$\Rightarrow (COP)_{H.P.} = \frac{Q_H}{W}$

HP तब बनेगा जब हमारा desired output T_H होगा → higher tempr की तरफ Heat को फेंकना

[हमारा Desired output means हम कितनी Heat higher tempr. को supply कर पाए क्योंकि हमारे पास एक Room होगा जिसकी गर्मी हमें बढ़ानी होगी means already एक गर्म जगह है जिसको हमें गर्म करना है और Heat हमें ठंडे area से लेना है]

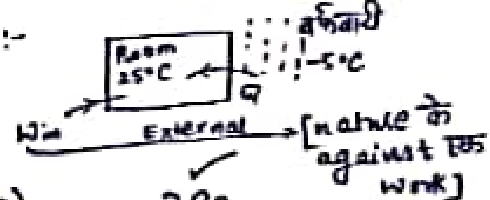
$\Rightarrow (COP)_{H.P.} = 1 + (COP)_{Ref.}$

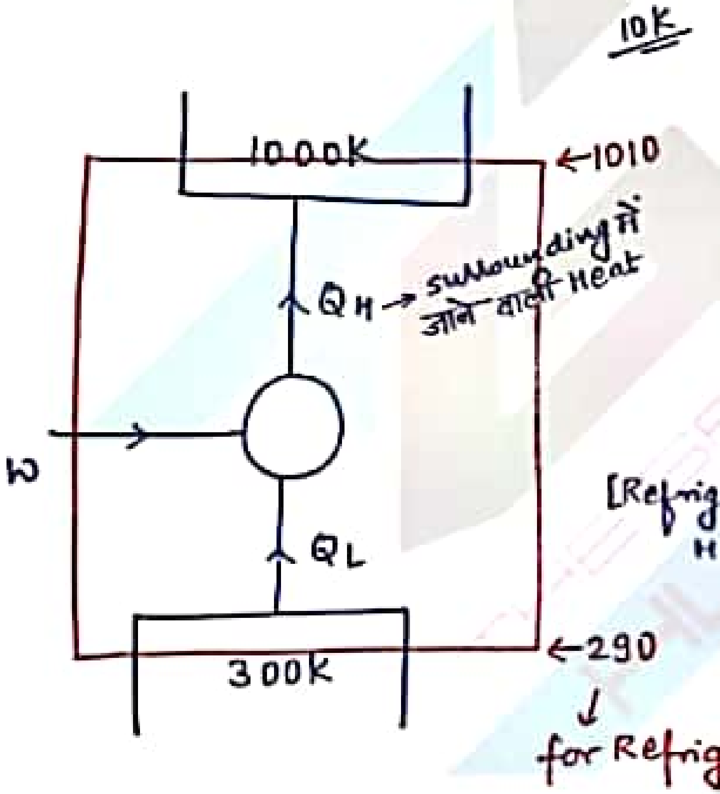
$\Rightarrow \left[(COP)_{Ref.}\right]_{Rever.} = \frac{T_L}{T_H - T_L}$

$(COP)_{max}$ → means ideal COP

$\Rightarrow \left[(COP)_{H.P.}\right]_{Rev.} = \frac{T_H}{T_H - T_L}$

Ex:-





$(COP)_{Ref} = \frac{290}{1010 - 290}$

$\frac{Q_H}{Q_L} = \frac{T_H}{T_L}$

[Refrigeration का काम है Lower Tempr. से Heat निकालनी है हमको]

for using the expressions developed in terms of temperatures, following conditions are required :-

ⓐ The cycle should be internally reversible cycle.

ⓑ Tempr's should be the tempr's of working fluid.

ⓒ Process of heat addition and heat Rejection should be isothermal.

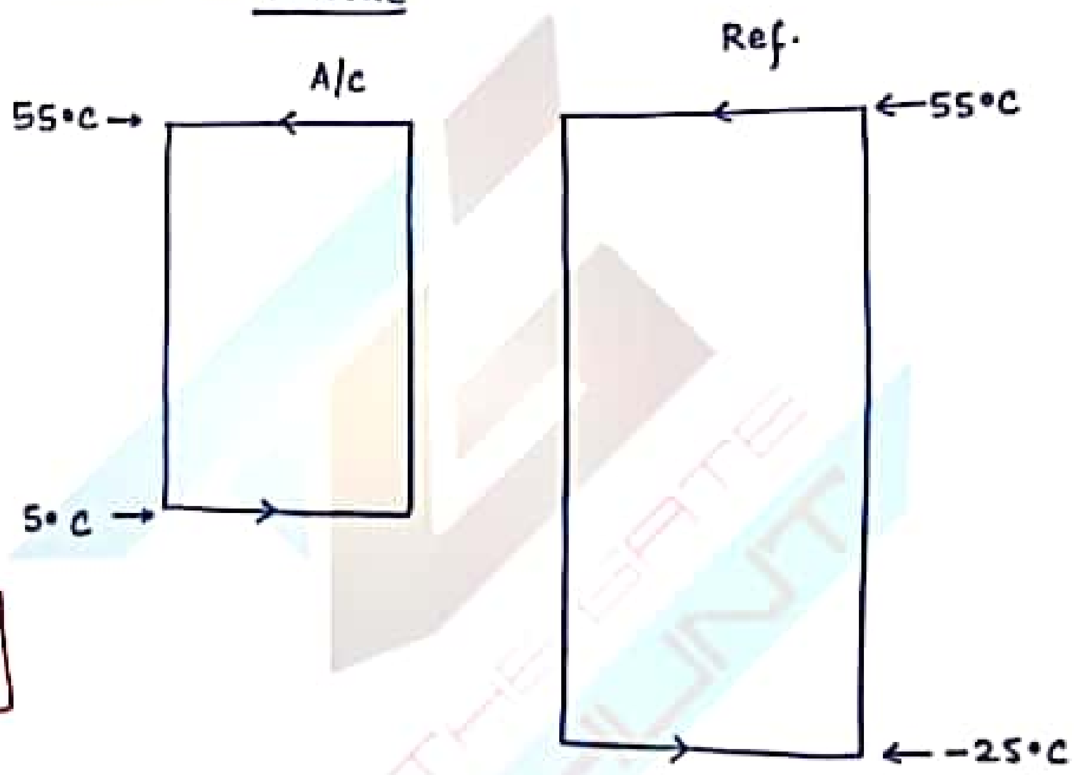
* efficiency of the engine increases by increasing T_H and decreasing T_L. But the increement is more in case of decreasing T_L.

* The COP of heat pump and Refrigerator increases by decreasing T_H and increasing T_L. But the increement is more when T_L is increased. ⟶ (To less effort)

lower tempr. ⟵ T_L (↑), T_H (↓) ⟶ higher tempr.

⟶ (Room के अंदर का Temp.)

* 40°C ⟶ outside



Room

80W × 400
32 kW

$$(COP)_{AC} = 2 = \frac{\overset{100}{Q_{A/c}}}{W_{A/c}}$$

$$W_{A/c} = 50$$

$$(COP)_{Ref} = 1 = \frac{\overset{10}{Q_{Ref}}}{W_{Ref}}$$

$$W_{Ref} = 10$$

$C_p\,(H_2O) \longrightarrow 4.18\ kJ/kgK$

* The COP of A/c is more than the COP of refrigerator but the electricity Bill of air conditioner is more because the total heat removed is more.

Since :-

(a) Total space to be cooled is more.

(b) Heat Generation sources are present (light, fan, people, etc).

(c) Air conditioned space is not generally insulated so a lot of heat leakage takes place.

✓ Refrigeration is the process of maintaining space at a lower temperature compared to the surroundings.

✓ The working fluid which circulates through the refrigeration equipments to provide refrigeration is called Refrigerant.

✓ The heat absorbed from lower temperature is called Refrigeration effect.

✓ The heat removed per second is called Refrigeration capacity.

✓ The heat rejected at higher temperature is called heating effect and heat rejected/sec is called heating capacity.

* Refrigerant → Working fluid which absorbs heat from lower temperature and Reject it to higher temperature.

* Ton of Refrigeration → 1TR = 3.516 KW or 1 TR = 211 KJ/min