Refrigeration and Air Conditioning

INTRODUCTION To RAC

Refrigeration & Air Conditioning.

What is Refrigeration:

Process of maintaining lower temperature as compared to surroundings.

Difference b/w Cooling & Refrigeration?

Taking example of the cup of tea. At room temperature the cup of hot tea will lose its heat is cooling.
But if it is cooled below the atmospheric temperature then it is Refrigeration

=> How do we we maintain lower temperature than surrounding?

=> The substance used for this purpose is known as refrigerant.

Unit of Refrigeration

TON of Refrigeration = TR

TON → US = 2000 lbs = 907.7 kg (short ton)

TONNES = 1000 kgs (metric ton)

1 TON = 907.7 kg.

TR

Amount of heat required to remove from 1 ton of water at 0°C in order to convert it into ice at 0°C in one day (24 hrs).

$$1\,TR = 210\ KJ/_{min} = \frac{210\ KJ}{60\ s} = 3.5\ KW$$

if capacity is 1TR means 3.5 KW

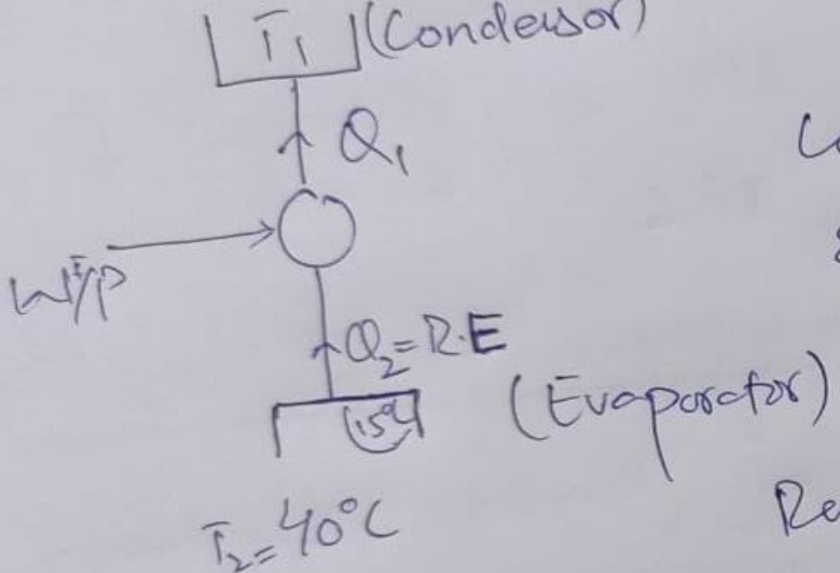
2TR means 2(3.5) KW

2ND Law of Thermodynamics:- Clausius's Statement

Impossible to construct a device which transfers heat from lower temperature to higher temperature w/o any external input.

Refrigerator

Evaporator
- ⇒ Refrigerator boils in evaporator
- ⇒ Where the refrigerant picks up heat



Condenser [condensation takes place]

Evaporator { Boiling takes place.]

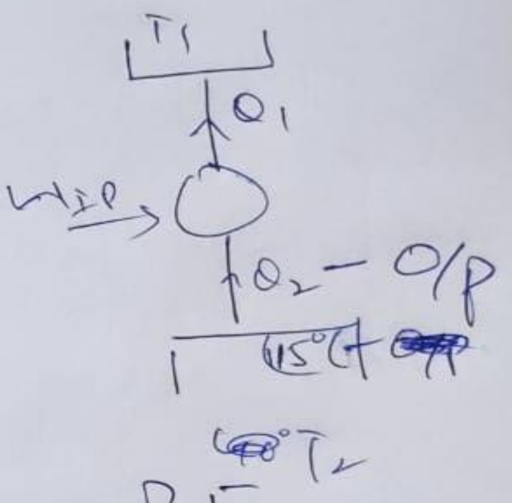
Remember in Refrigeration

Condensor o/p has the higher temperature

Evaporator o/p has the lower temperature.

COP [Coefficient of Performance]

$$\frac{R.E}{W\,I/P} = \frac{\text{Desired Effect}}{W\,I/P} = \frac{O/P}{I/P}$$



Refrigeration Capacity = mass flow rate × R.E

$= \text{kg/s} \times \text{kJ/kg}$

R.C $=$ KW

P I/P $= \dot{m} \times W\,I/P$

$=$ KW units

$$COP = \frac{O/P}{I/P} = \frac{R.C}{P\,I/P}.$$

So what COP tells us?

⇒ The more the mass flow rate of the refrigerant the higher will be the cooling effect.

⇒ Means higher will be the Refrigeration capacity.

~~⇒ higher will ... COP.~~

⇒ Capacity of fridges / Refrigerators are known.

For 1-2 person it is 50 - 200 liters. 1.7 cubft - 7 cu

3-4 " 250 - 300 liters 9 cuft - 14 cuft

Family 400 - 500 liters. 14 - 18 cuft

$$COP = \frac{R.C \rightarrow \text{Fixed/known}}{P\,I/p}$$

if $COP \uparrow$ means $P\,I/p \downarrow$

$COP \downarrow$ means $P\,I/p \uparrow$

COP signifies the running cost of the refrigerator

⇒ The higher the COP lesser will be the power input & the lesser will be the running cost

⇒ Star rating of refrigerators

P Ip ≠ 2-star ★★ > 3-star ★★★ > 5-star ★★★★★

$COP_{AC} > COP_R$ (As we know COP defines running cost. so it means

Running cost AC < Running cost R ✗ does AC has lower cost?

No. Why?

Why?

⇒ Refrigerated space for AC is large (A whole Room)

⇒ Continous removal heat is required.

In a room full of applians (fans, tube lights), people generate energy. AC works to reject that heat

⇒ Room is not insulated. So heat leakages take place. That also ~~need~~ is to be removed by A.C

⇒ Comparitively Refrigerator have less refrigerated space

⇒ Well insulated.

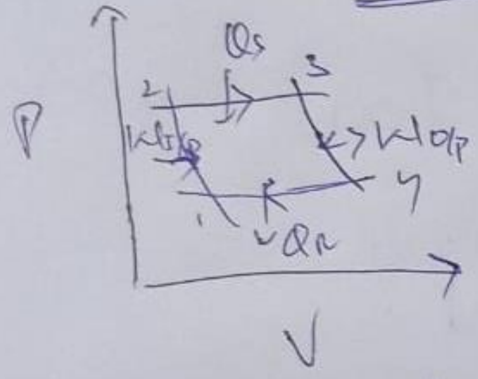
So, COP of AC is higher but it doesn't mean it will have a lower running cost.

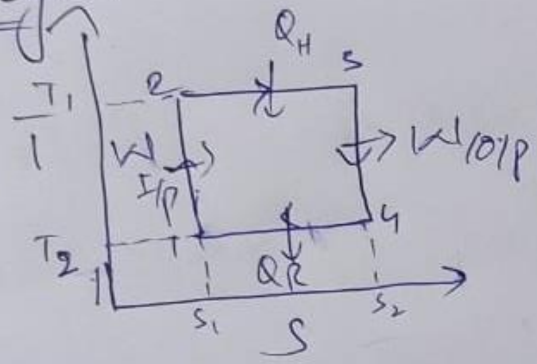
* Running ~~AC~~ cost_{AC} > Running cost Refrigerators

Ideal Refrigeration Cycle

Known as Reversed Carnot cycle.

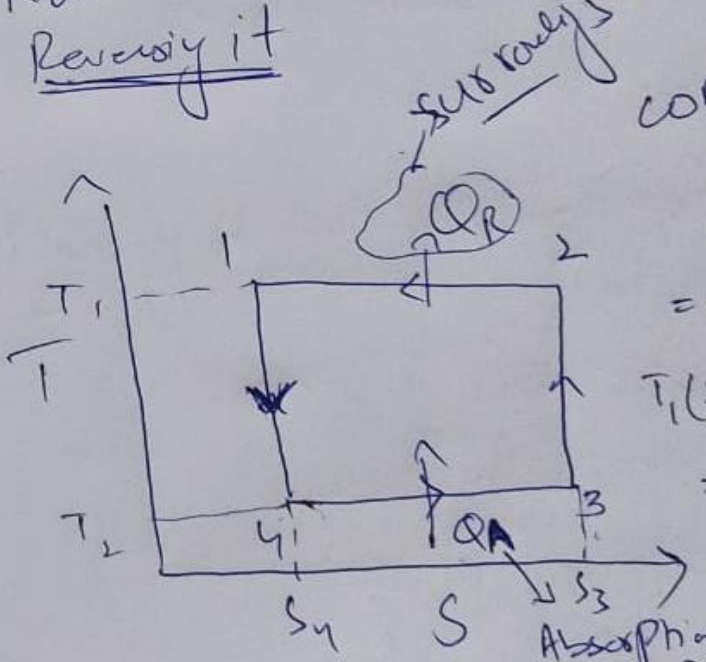
Carnot cycle





When reversing the H.E we get H.P

Now Reversing it



2 - Isothermal

2 - Rev. Adiabatic

$$\eta = \frac{O/P}{I/P} = 1 - \frac{Q_R}{Q_S}$$

$$\eta = 1 - \frac{T_2(\cancel{S_2 - S_1})}{T_1(\cancel{S_2 - S_1})} \qquad \eta_{HE} = 1 - \frac{T_2}{T_1}$$

$$COP = \frac{Q_L}{Q_H - Q_L}$$

$$= \frac{T_2 (S_4 - S_3)}{T_1(S_4 - S_3) - T_2(S_4 - S_3)}$$

$$= \frac{T_2 (\cancel{S_4 - S_3})}{T_1 - T_2 (\cancel{S_4 - S_3})}$$

$$COP = \frac{T_2}{T_1 - T_2}$$

$$COP_{RevR} = \frac{T_2}{T_1 - T_2} = \frac{T_L}{T_H - T_L}$$ (IDEAL Refrigeration cycle)

Not possible practically?

Because it has two Isothermal process & two Adiabatic Process.

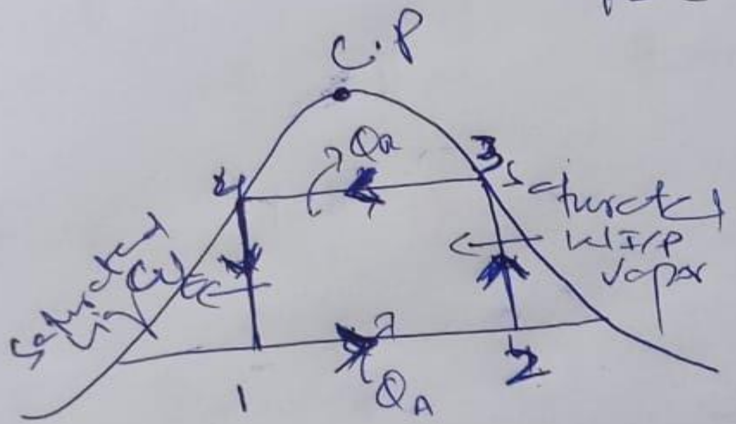
→ Isothermal Process is the slowest Process

→ Adiabatic Process is the fastest Process

This combination is not possible together.

→ During the Phase change Pressure and Temperature (Thermodynamic properties remain constant)

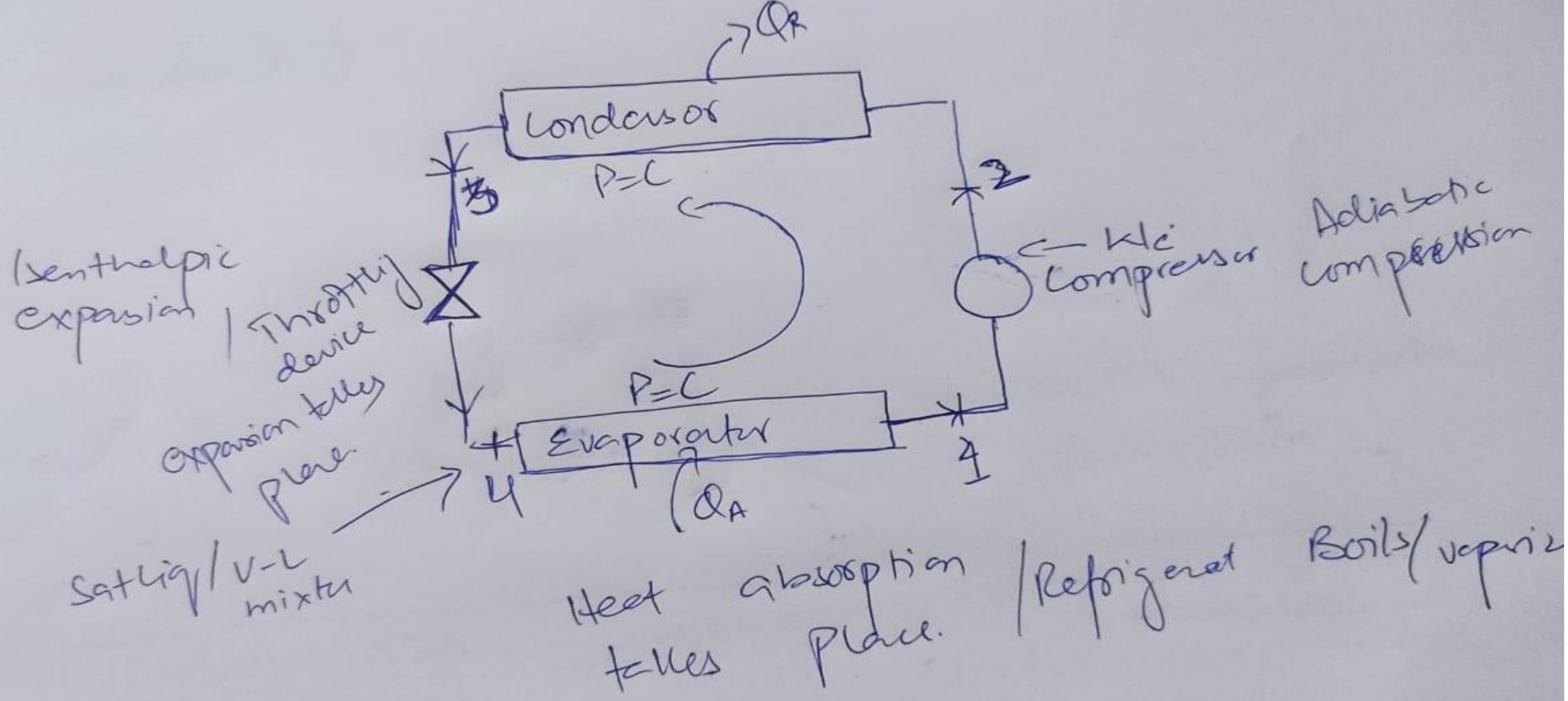
L–V V–L (T = C, P = C)



idea of VCRS generates from here

$\boxed{\text{VCRS : Vapor compression Refrigeration cycle}}$

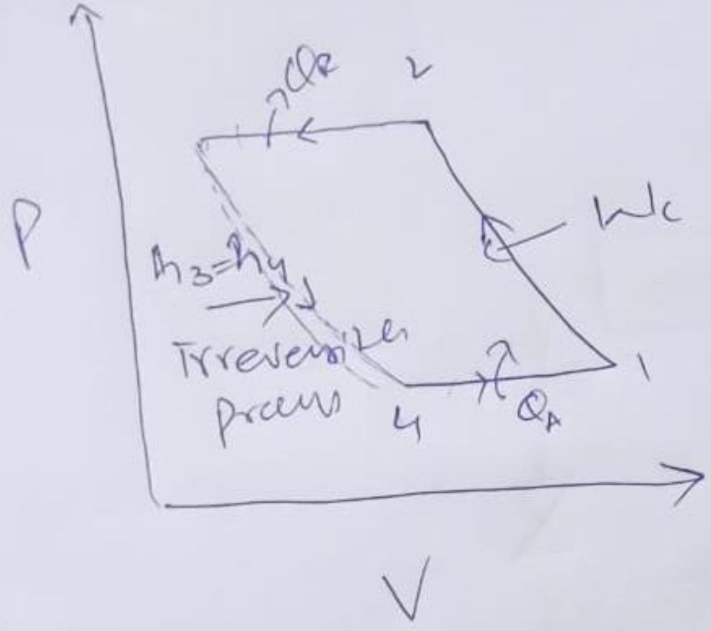
VCRS: Vapor Compression Refrigeration cycle

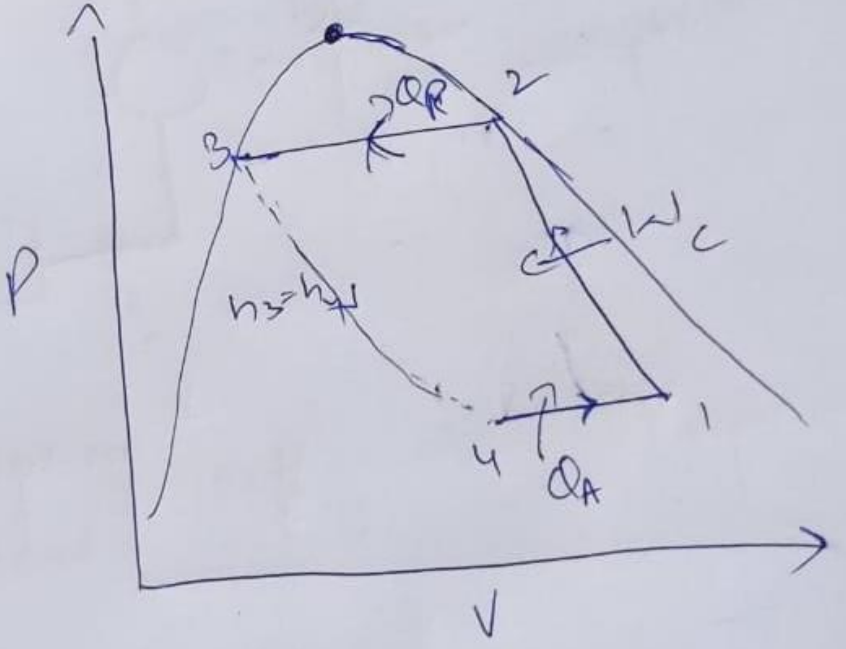


$h_3 = h_4$ so $T_3 = T_4$? NO, Why

$\boxed{h = U + PV}$

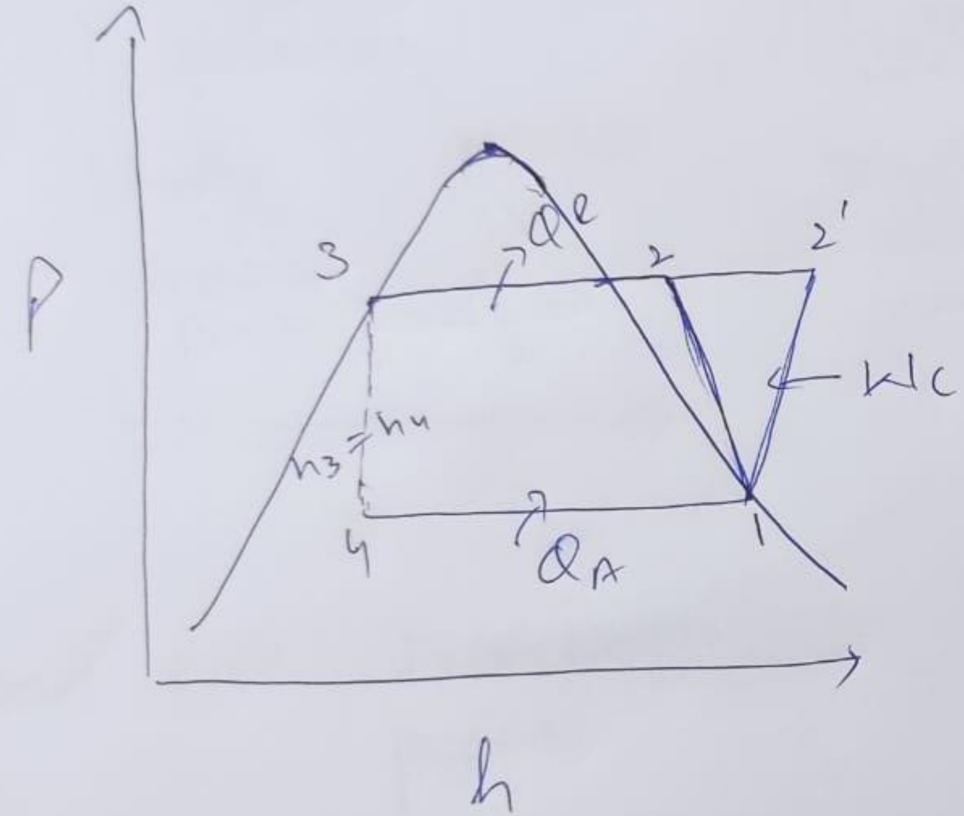
Temperature reduces so does internal energy





Dotted Line : Irreversible process

P–h Diagram

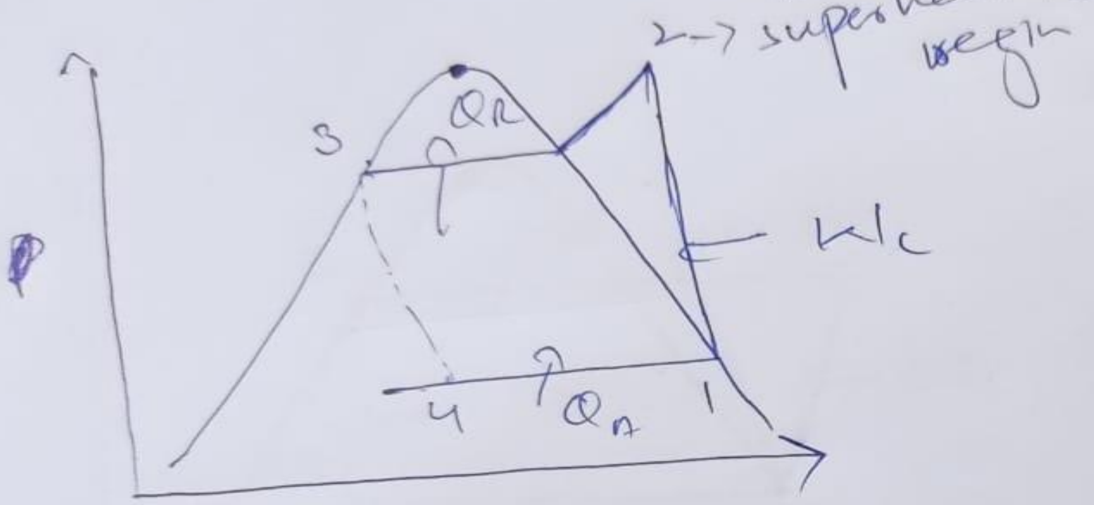


Process 1–2 False why?

$\uparrow h = \uparrow U + \uparrow PV$ in compression

So in compression process the enthalpy is increasing

T-S Diagram



Process 1 - 2
Isentropic Compression

Process 2 - 3
Constant Pressure heat rejection

Process 3 - 4
Isenthalpic Expansion

Process 4 - 1
Constant Pressure heat Absorption.

Process 1-2 :- ~~Constant~~ Rev. Adiabatic Compression

SFEE $h_1 + \cancel{\frac{c_1^2}{2}} + \cancel{g z_1} + q = h_2 + \cancel{\frac{c_2^2}{2}} + \cancel{g z_2} + W_{cv}$

Adiabatic

$h_1 + \cancel{q} = h_2 + W_{cv}$

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

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

$$\boxed{W_c = h_2 - h_1}$$

Power of compressor $= \dot{m} \times W_c = \dot{m} \times (h_2 - h_1)$

Process 2-3 :- Constant Pressure heat reject.

$$h_2 + \cancel{\frac{c_2^2}{2}} + \cancel{g z_2} + q = h_3 + \cancel{\frac{c_3^2}{2}} + \cancel{g z_2} + \cancel{w_{cv}}$$

$$h_2 + q = h_3$$

$$q = h_3 - h_2 \qquad \boxed{q_R = -q = h_2 - h_3}$$

$$\boxed{q_R = h_2 - h_3}$$

$$\text{Total } \dot{q}_R = \dot{m} \times (h_2 - h_3) = q_c$$

condenser.

Process 3-4 Throttling

$$h_3 = h_4$$

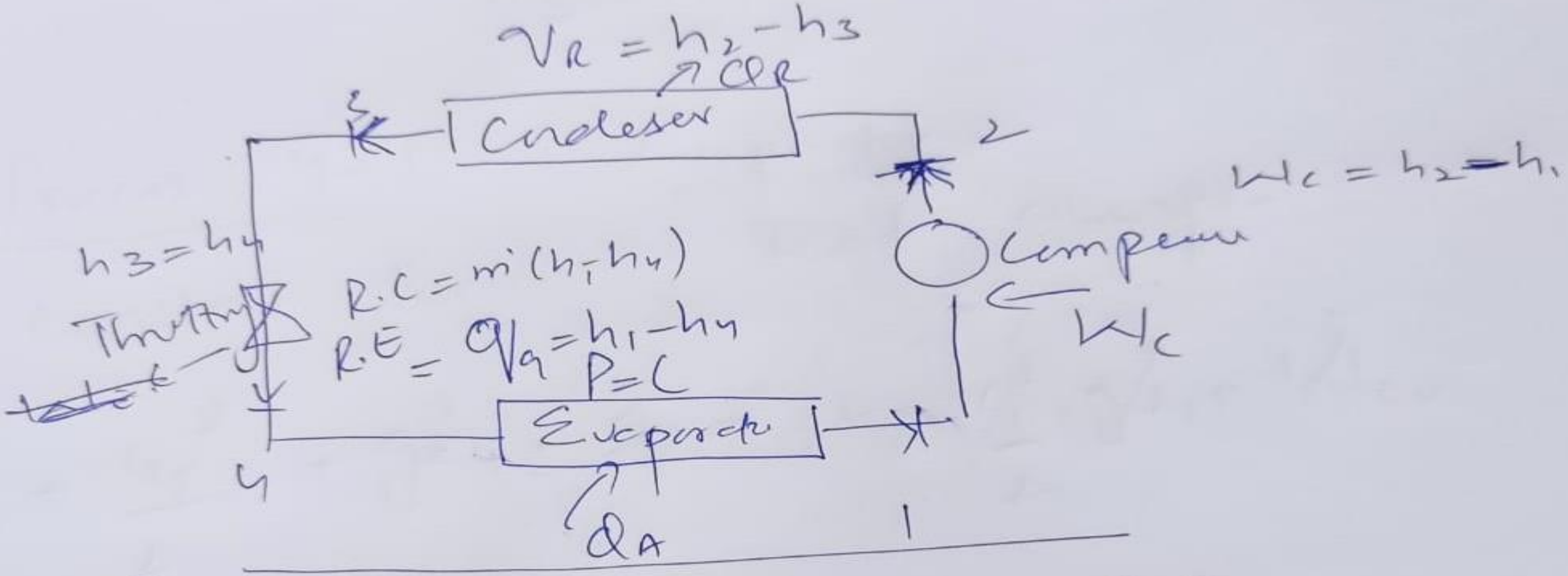
Process 4-1 ~~Evaporator~~ heat absorption

constant Pressure

$$h_4 + \frac{\cancel{C_4^2}}{2} + \cancel{g z_4} + q = h_1 + \frac{\cancel{C_1^2}}{2} + \cancel{g z_1} + \cancel{W_{cv}}$$

$$q = h_1 - h_4$$

$$\boxed{q_a = q = h_1 - h_4}$$



$$COP = \frac{Q_L}{Q_H - Q_L} = \frac{R.E}{W\,I/P}$$

$\therefore h_3 = h_4$

$$\boxed{COP = \frac{h_1 - h_4}{h_2 - h_1} = \frac{h_1 - h_3}{h_2 - h_1}}$$

$$COP = \frac{\dot{m}(h_1 - h_3)}{\dot{m}(h_2 - h_1} = \frac{R.C}{P\ I/p}$$

Theise are the basic parts of vcRS.

~~Compressor~~.