Rankine Cycle

I C Engine.

Otto Cycle Diesel Cycle Dual Cycle

Heat **Engine** :- Converts Thermal Energy into Mechanical Energy. or (K.E) or Useful Work

H.E

ICE ECE

Internal External

External Combustion Engine

=> Combustion is done in a separate chamber. Steam Power Plant

Internal Combustion Engine:-

=> Combustion takes place in the same chamber in which Piston is moving. Petrol & Diesel

Steam Power Cycle (Rankine Cycle)

Vapor Power cycle

Why? Vapor cycle

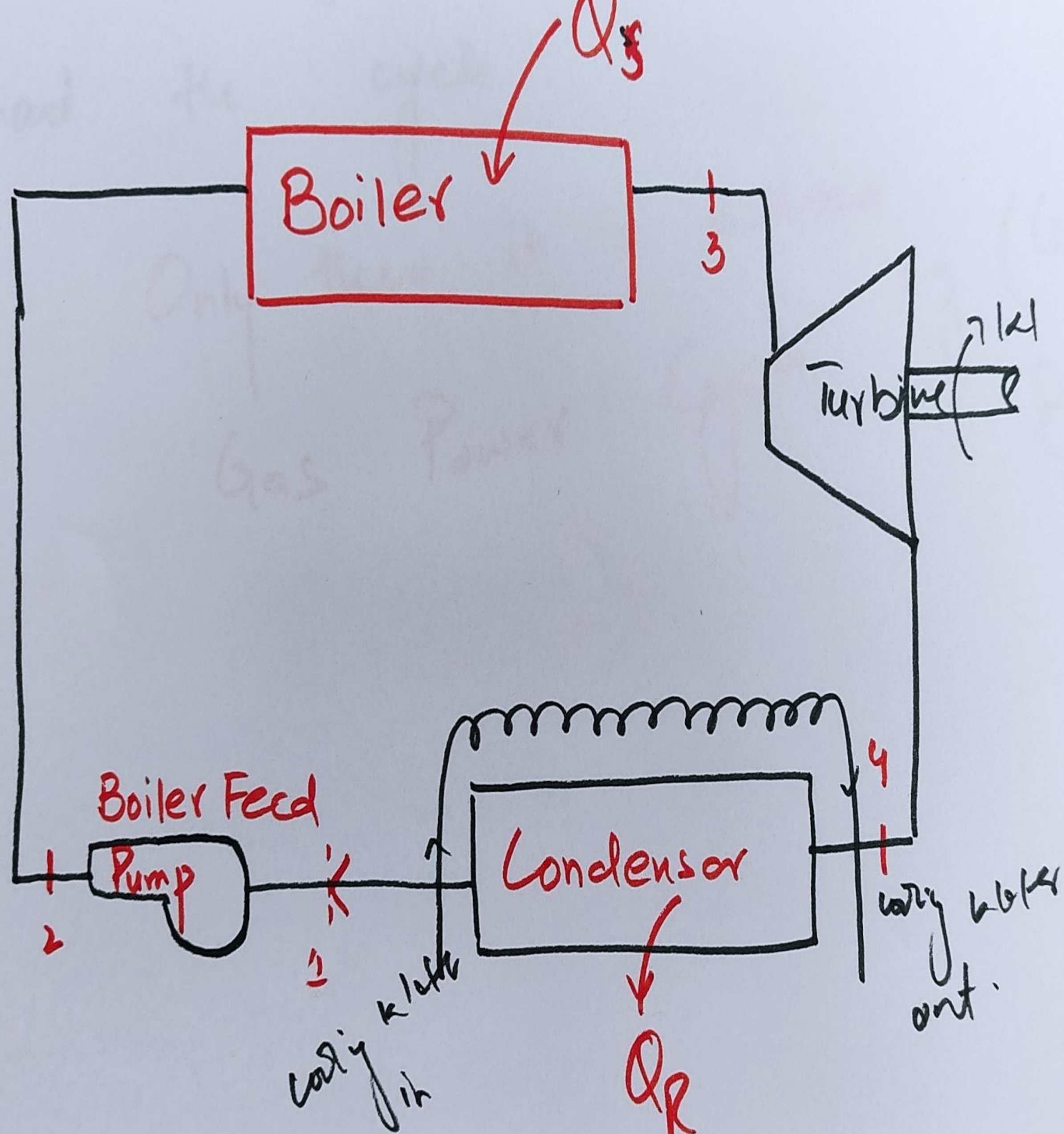
Half cycle (Working fluid) Liquid

+

Half cycle (Working fluid) Vapor

if the working fluid stays in gaseous form throughout the cycle.

Only then it is called Gas Power Cycle. e.g (Gas Turbine) Brayton Cycle


Boiler
Turbine
Boiler Feed
Pump
Condensor
1
2
3
4
Q_R

1) BFP (Boiler Feed Pump)

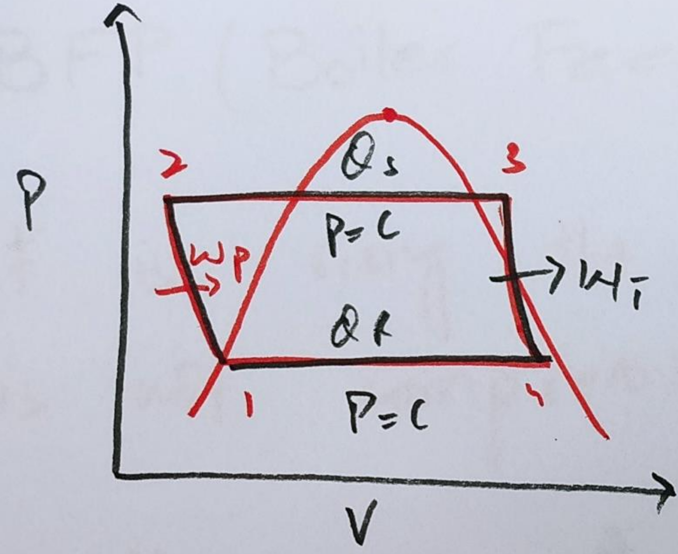
It is rising the pressure of water, but it is not compressing it.

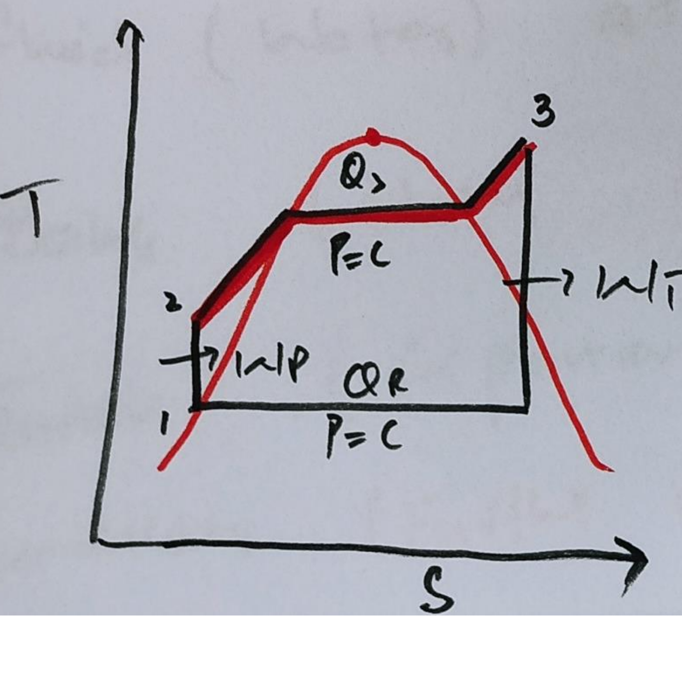
It means it is taking the thermodynamic (saturation pressure. fluid (water) at ~~that~~ pressure.

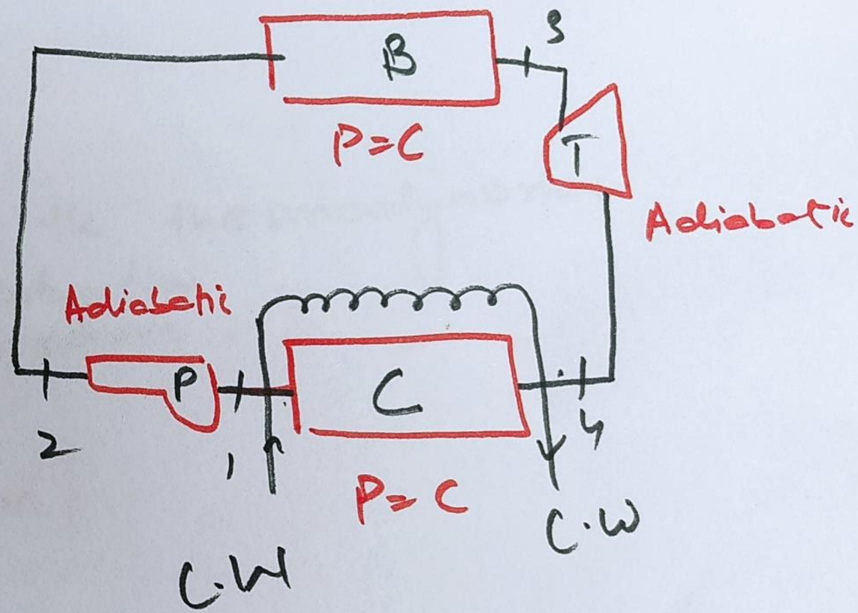
2) Boiler (Heat is supplied)

3) Turbine (Expansion lalalk)

4) Condenser (Further decreasing the temperature of working fluid.)







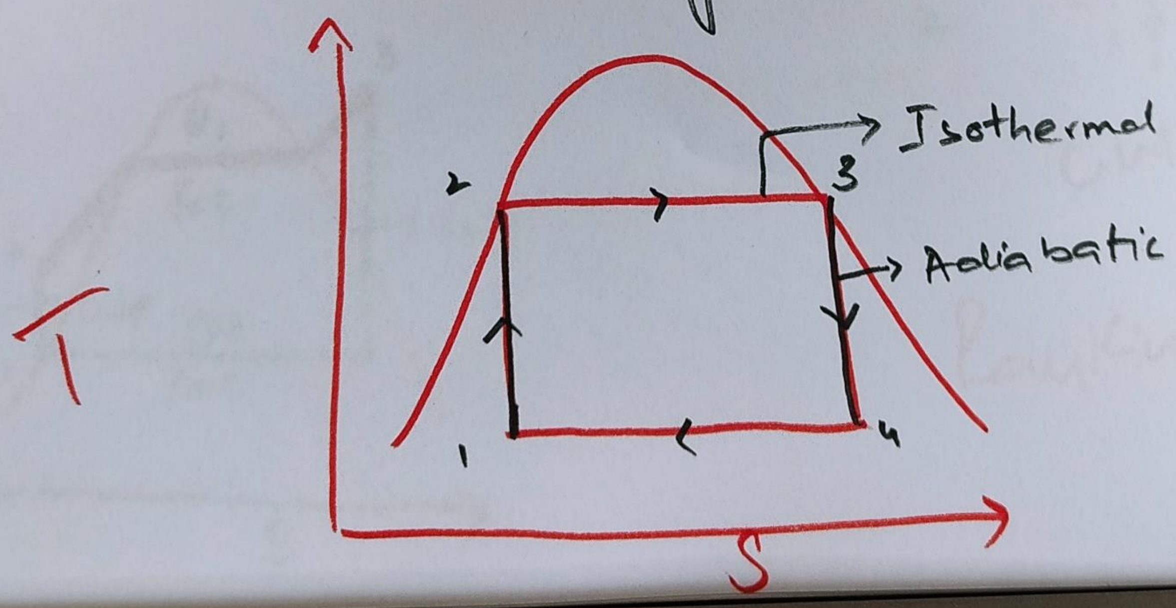
Rankine Cycle

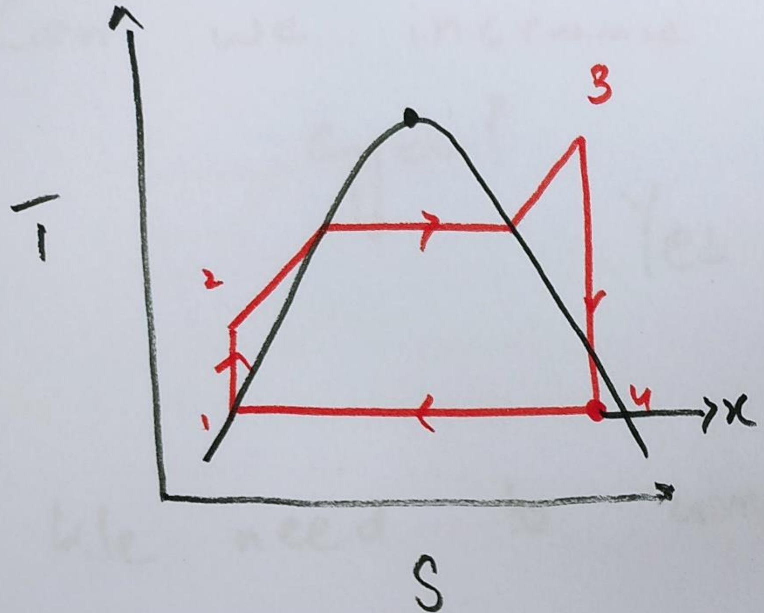
Can we increase efficiency of Rankine cycle?

Yes, but how

We need to compare it with

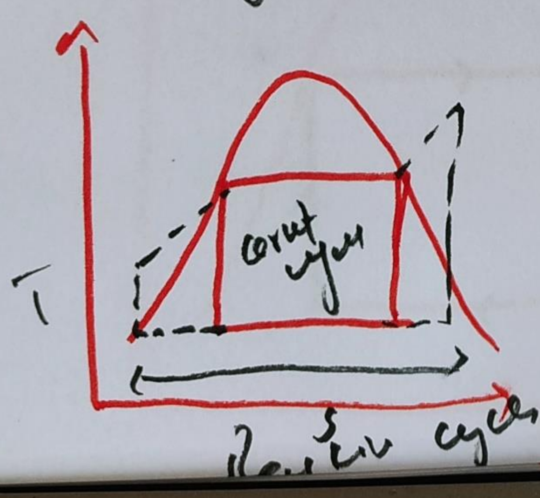
Carnot cycle.





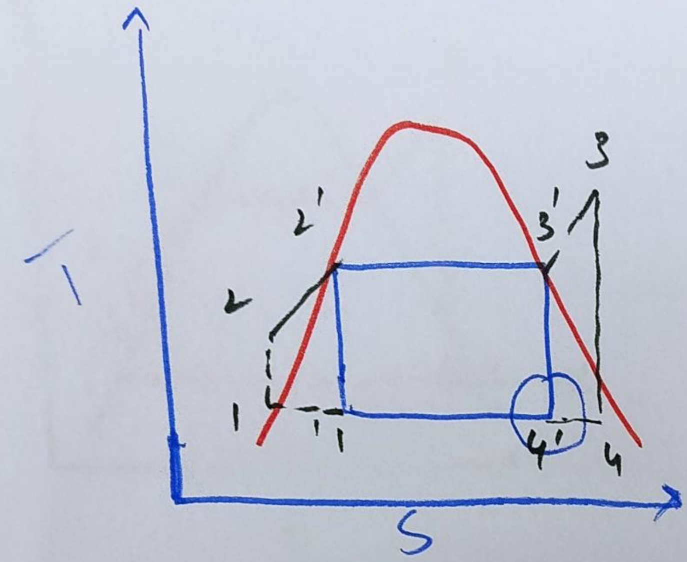
For a Rankine cycle the value of "x" at point 4 is always or almost equal to (0.8 ⟺ 0.9)

Comparing Rankine with Carnot



$\eta_{carnot} > \eta_{Rankine}$

$W_{carnot} < W_{Rankine}$



Carnot Cycle

has

two Reversible Isothermal

two Adiabatic process

=) Carnot cycle 1'-2'-3'-4'

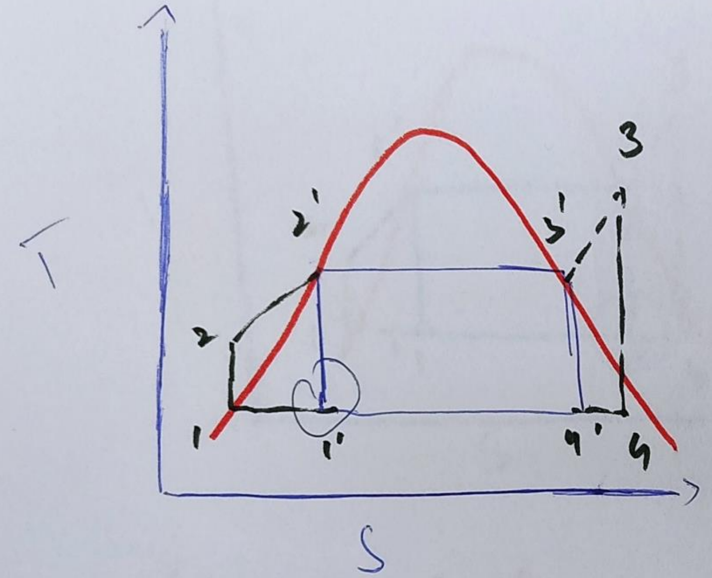
At 4'

(L+V) ↑ (Moisture) ↑

It can cause Rusting to turbin blades.

So we want the mixture at turbin exit needs to be in "superheated mixture"

Dry (Mixture has to be dry)



Carnot cycle

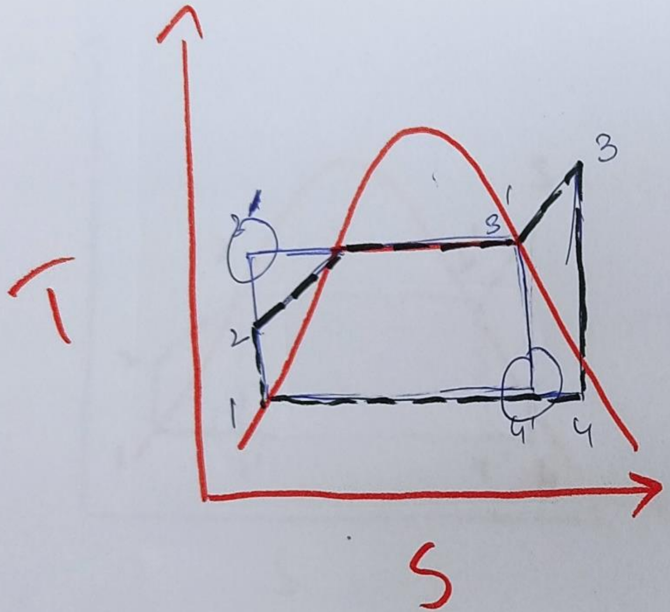
1'-2'-3'-4'

II^ND Major Reason

It cannot be applied

There is no pump or compressor in the world which deals with a L+V mixture.

Not Feasible. 1'-2'-3'-4'



Carnot cycle

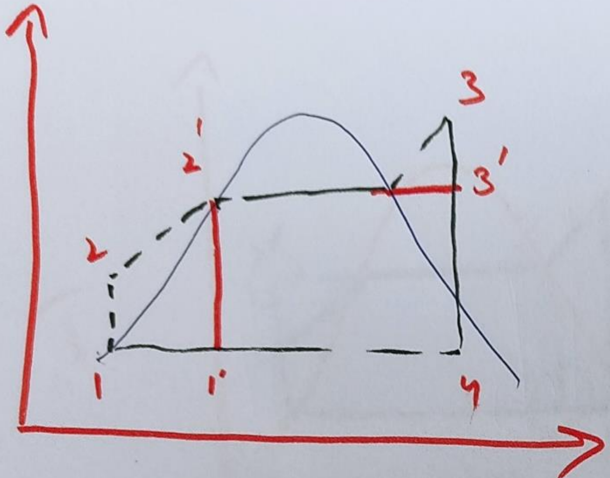
- 1-2'-3'-4'

Same problem at (4')

Not Feasible

And at 2'

There is no such fluid/liquid which could maintain a constant temperature & and pressure ~~at~~ ~~const~~ with increasing volume,



Carnot Cycle

1'-2'-3'-4

Feasible ?

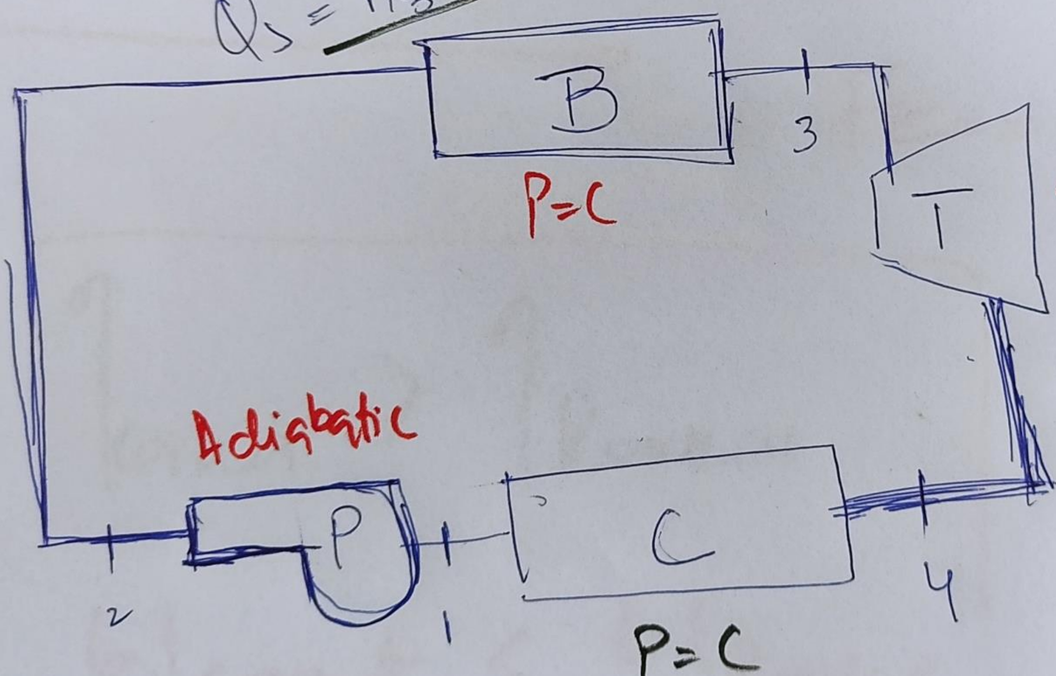
$$\boxed{\begin{array}{l} \eta_{Carnot} > \eta_{Rankine} \\ W_{Carnot} < W_{Rankine} \end{array}}$$

Efficiency of Rankine Cycle

$$\eta = 1 - \frac{Q_R}{Q_s}$$

By Steady Flow Energy Equation

$Q_s = h_3 - h_2$



$W_T = h_3 - h_4$

$W_p = h_2 - h_1$

$Q_R = h_4 - h_1$

$\eta = 1 - Q_R/Q_S$ $\quad \eta_R = 1 - \dfrac{h_4 - h_1}{h_3 - h_2}$

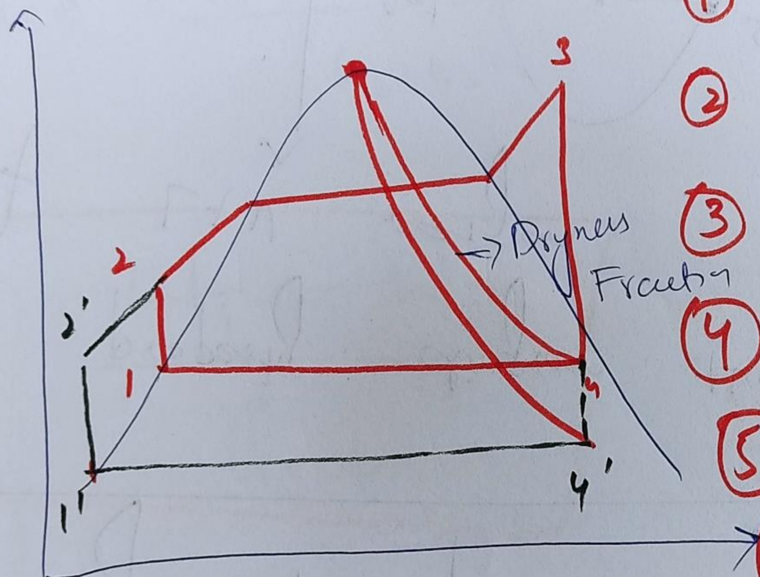
$$\eta_R = \frac{(h_3 - h_2) - (h_4 - h_1)}{h_3 - h_2} = \frac{(h_3 - h_4) - (h_2 - h_1)}{(h_3 - h_2)}$$

$$\boxed{\eta_R = \frac{W_T - W_P}{Q_S}}$$

Basic Part of Vapor Power cycle

~~To increase~~ Variations of Vapor Power Cycle w.r.t "η"

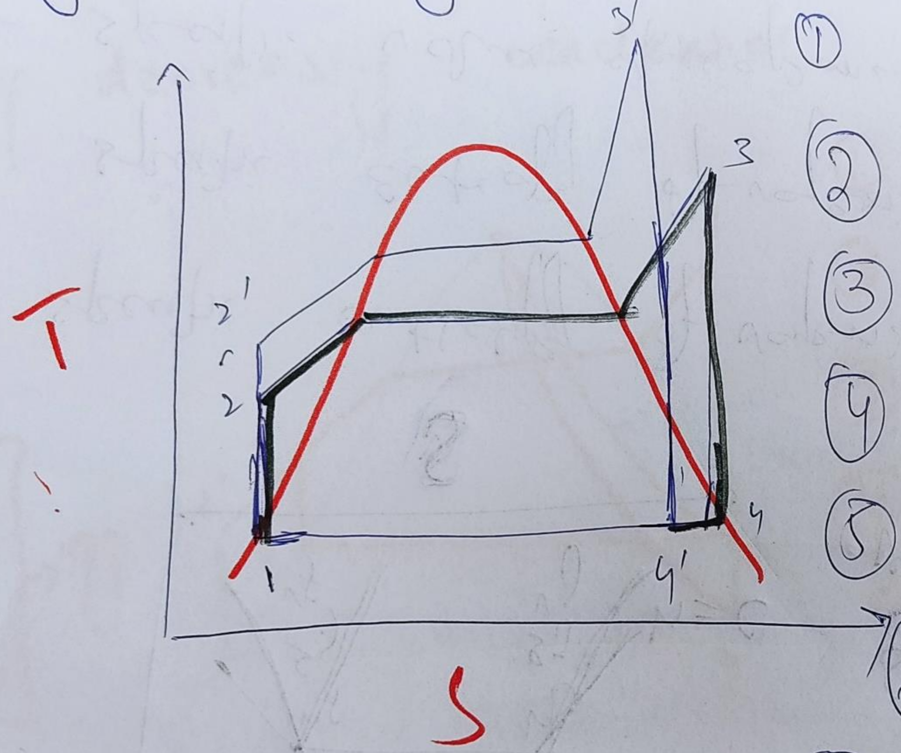
1) By decreasing condenser Pressure.



$T_{MA} \uparrow$
$T_{MR} \downarrow$ $\} \to \eta \uparrow$

1. $Q_s \uparrow$
2. $W_p \uparrow$
3. $W_T \uparrow$
4. $W_{net} \uparrow$
5. $T_{MA} \downarrow$
6. $T_{MR} \downarrow\downarrow$
7. $Q_R \downarrow$
8. $x \downarrow$
9. Moisture $\uparrow$
10. $\eta \uparrow$

② By Increasing Boiler Pressure.



① $Q_S \rightarrow$ Can't say

② $Q_R \downarrow$

③ $T_{MA} \uparrow$

④ T_{MR} (Same)

⑤ $W_T \uparrow$

⑥ $W_P \uparrow$

⑦ $W_{net} \uparrow$

⑧ $x \downarrow$

⑨ Moisture ↑

⑩ $\eta \uparrow$

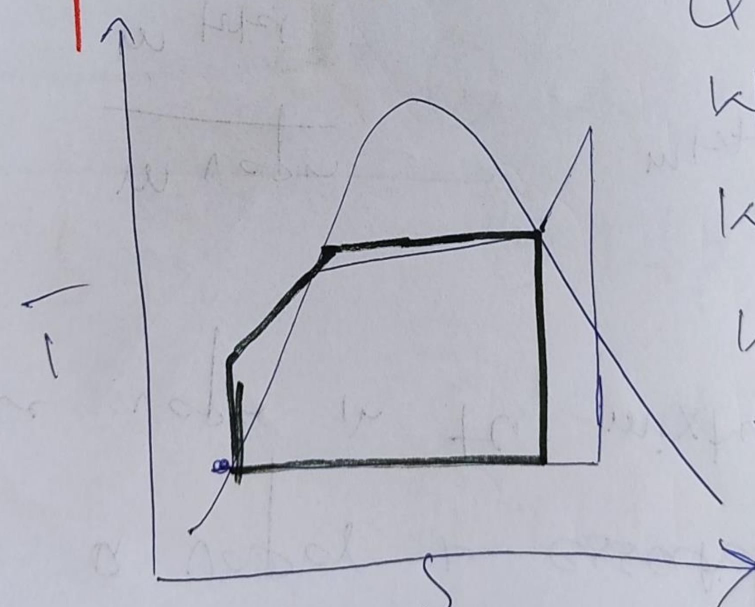
$W_p = -v\,dP$

$W_c = -v\,dP$

$v_g >> v_l$

$W_c >> W_{pump}$

(3) By Superheating.



$Q_s =$

$Q_R =$

$W_p =$

$W_T =$

$W_{net} =$

$T_{mA} =$

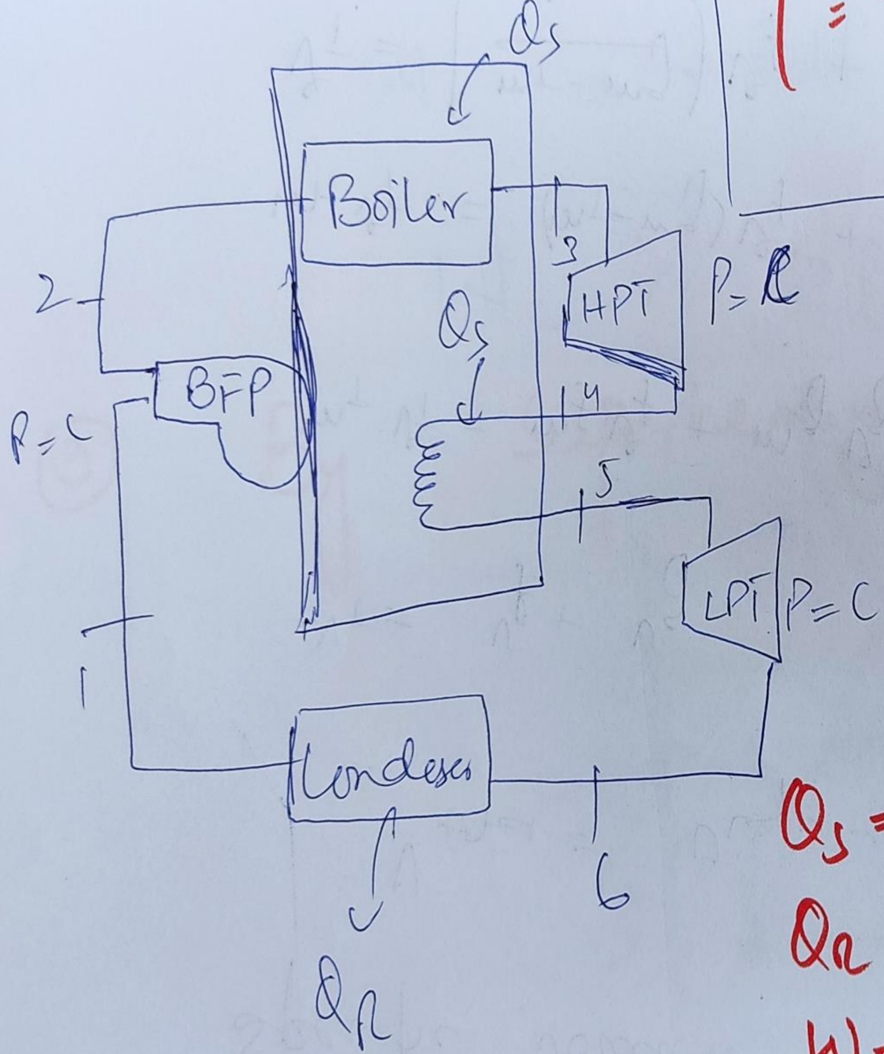
$T_{mR} =$

$x =$

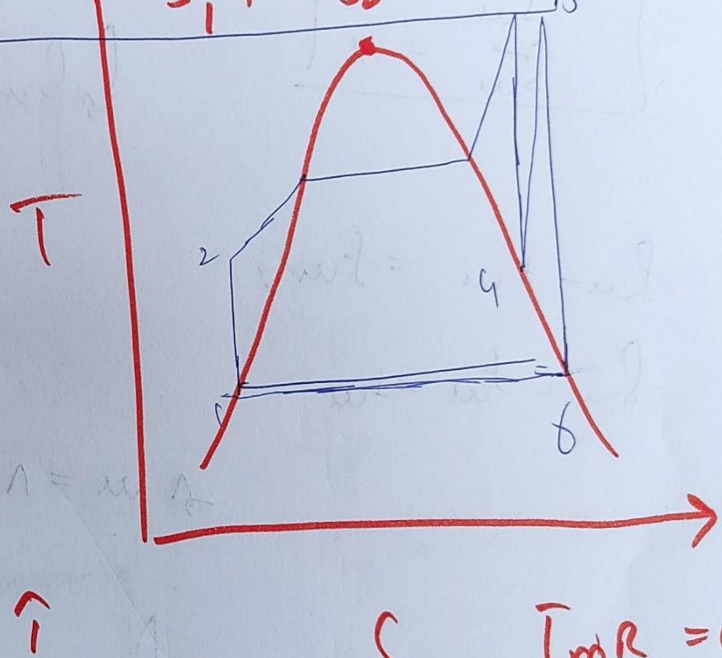
Moisture =

$\eta =$

④ Reheat



$$\eta = \frac{W|_{T_1} + W|_{T_2} - W|_P}{Q_{s_1} + Q_{s_2}}$$



$Q_s = \uparrow$

$Q_R = \uparrow$

$W_T = \uparrow$

$W|_P = C$

$T_{mA} = ?\ (\uparrow \downarrow)$

$T_{mR} = C$

$x \uparrow$

Moisture ↓

$\eta \propto T_{mA}$