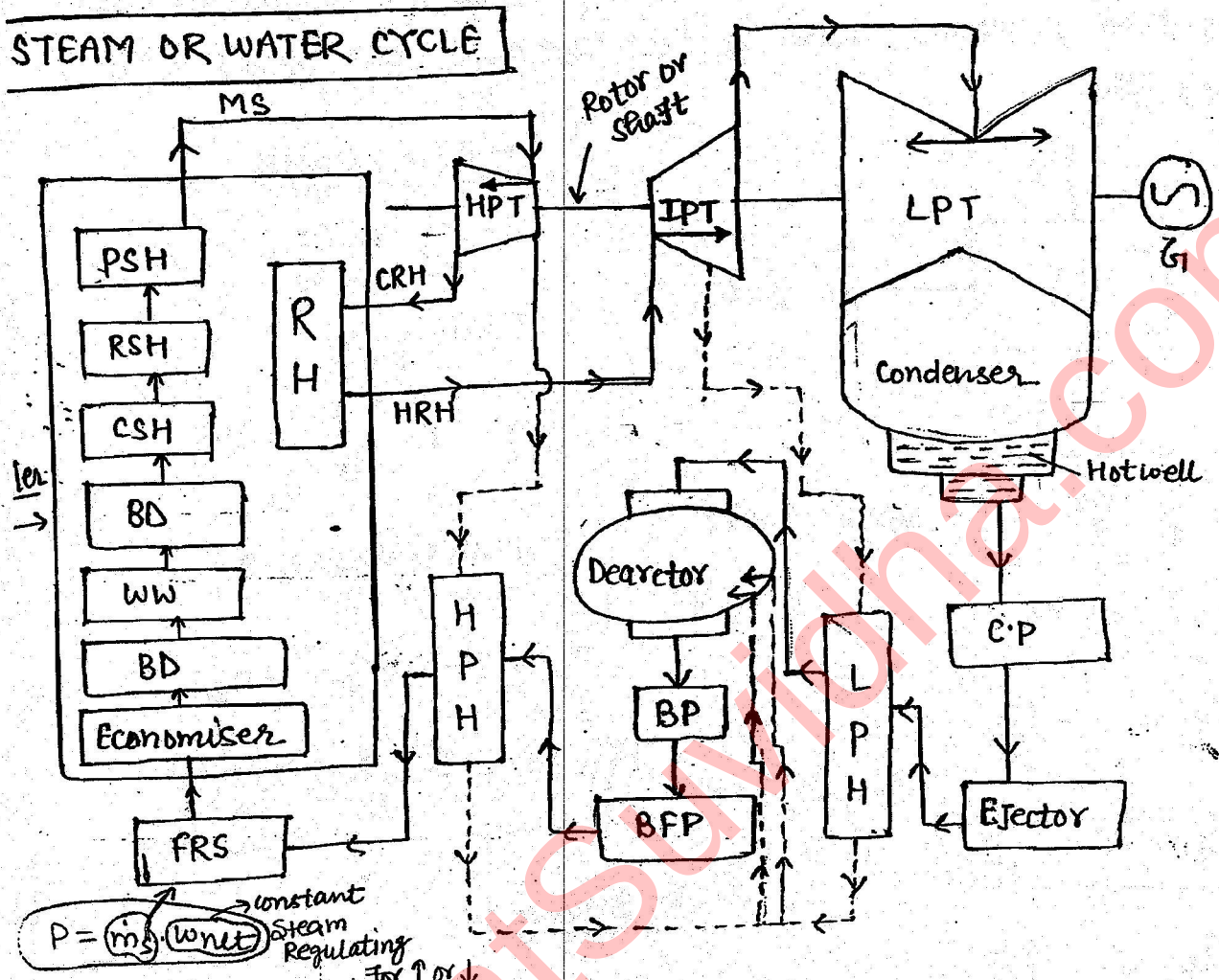
THERMAL POWER PLANT :-

STEAM OR WATER CYCLE



CP → Condensate pump.

LPH → Low pressure Heater

BP → Booster Pump

BFP → Boiler Feed pump

HPH → High pressure Heater

FRS → Feed Regulating Station

BD → Boiler Drum

WW → water walls or Riser or Radiant evaporator

RH → Reheater

HRH → Hot Reheat

IPT → Intermediate pressure turbine

CSH → Convective Super heater

RSH → Radiant Super Heater

PSH → Pendant Super Heater

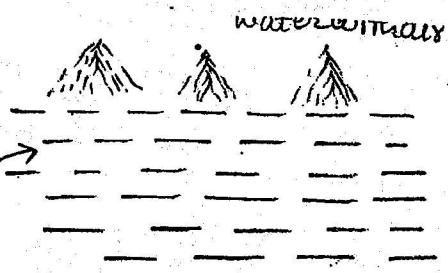
MS → Main steam

HPT → High pressure Turbine

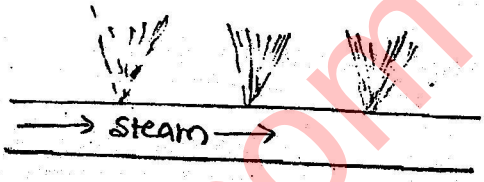
CRH → Cold Reheat

LPT → Low pressure Turbine.

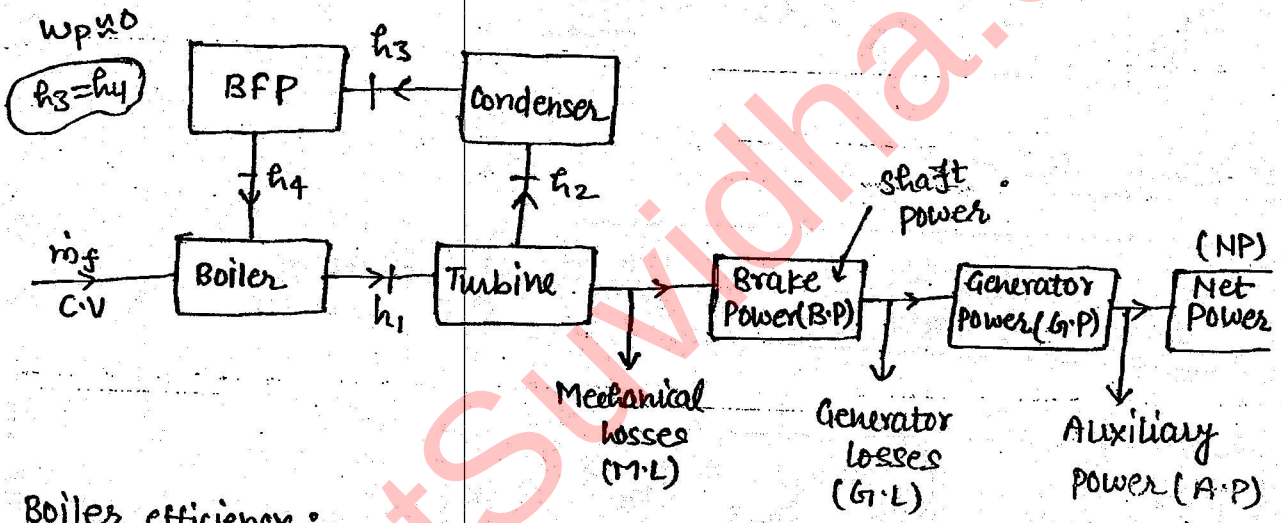
Deaerator :-



- It is used to remove air from the feed water that has mixed in the condenser due to -ve pressure.
- Extra make up water can be added to compensate for the leakage in the cycle.
- All the auxiliaries steam used in the cycle can be again mixed in Deaerator.



Efficiency in steam power plant :-



Boiler efficiency :-

$$\eta_{Boiler} = \frac{\text{Energy absorbed by water to convert into vapour}}{\text{Energy Released by fuel combustion}}$$

$$\eta_{Boiler} = \frac{\dot{m}_s (h_1 - h_4)}{\dot{m}_f \cdot CV}$$

$\eta_{Boiler} \approx$ 92 to 93%.

Cycle efficiency (Rankine) :-

$$\eta_{cycle} = \frac{W_{net}}{Q_s} = \frac{h_1 - h_2}{h_1 - h_4}$$

$\eta_{cycle} \approx$ 40% to 45%

Mechanical efficiency :-

$$\eta_{mech} = \frac{\text{Brake power Output}}{\text{Net cycle output}}$$

$$\boxed{\eta_{mech} = \frac{B.P}{\dot{m}_s (h_1 - h_2)}} \qquad \eta_{mech} \approx 95\% \text{ to } 96\%$$

Generator efficiency :-

$$\eta_{gen} = \frac{\text{Electrical power output of Generator}}{\text{Brake power output}}$$

$$\boxed{\eta_{gen} = \frac{G.P}{B.P}} \qquad \eta_{gen} \approx 92\% \text{ to } 94\%$$

Auxiliary efficiency :-

$$\boxed{\eta_{Aux} = \frac{\text{Net power}}{\text{Generator power}} = \frac{N.P}{G.P}} \qquad \eta_{aux} \approx 95\%$$

$$\boxed{\eta_0 = \eta_{boiler} \times \eta_{cycle} \times \eta_{mech} \times \eta_{gen} \times \eta_{aux}}$$

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for CFWH :-

$E_{in} = E_{out}$

$$Y \cdot h_{10} + (1-y) h_4 = y \cdot h_6 + (1-y) h_5$$

$$y = 0.176 \text{ kg/kg of steam}$$

for OFWH :-

$$z \cdot h_{12} + (1-y-z) h_2 = (1-y) h_3$$

$$z = 0.1306 \text{ kg/kg of steam}$$

$$w_T = (h_9 - h_{10}) + (1-y)(h_{11} - h_{12}) + (1-y-z)(h_{12} - h_{13})$$

$$w_T = 1443.8 \text{ KJ/kg}$$

$$w_p = (1-y-z) w_{p1} + (1-y) w_{p2} + y \cdot w_{p3}$$

$$w_p = 5.909 \text{ KJ/kg}$$

$$Q_s = (h_9 - h_8) + (1-y)(h_{11} - h_{10})$$

$$Q_s = 2923.5 \text{ KJ/kg}$$

$$\eta = \frac{w_T - w_p}{Q_s} = 49.2\%$$

P-h diagram for above question