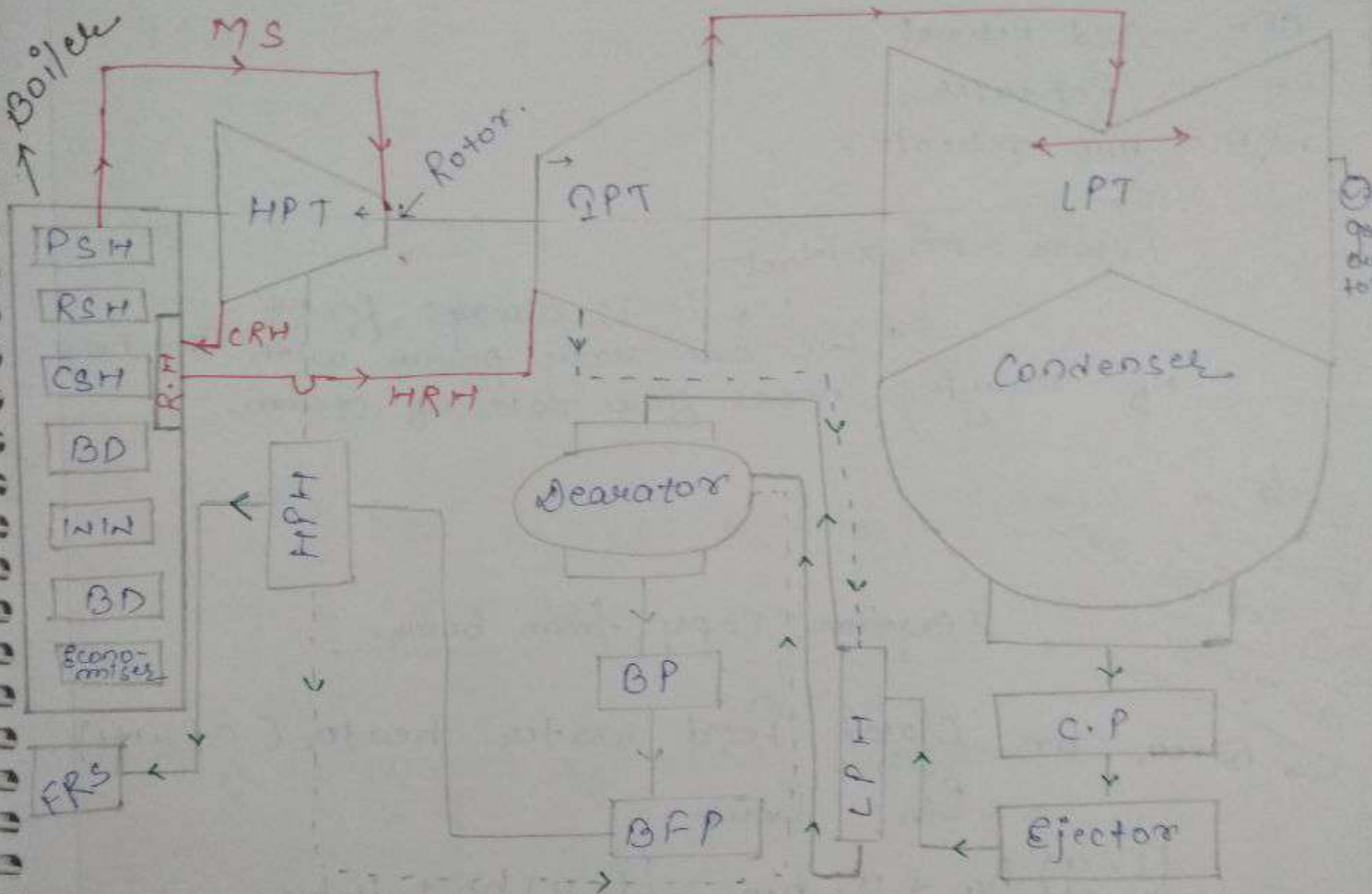
THERMAL POWER PLANT

Lecture - 12

· Steam or Water cycle :-



HPT → High pressure turbine
IPT → Intermediate pressure turbine
LPT → Low pressure turbine
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 Risers or Radiant Evaporato
CSH : Convective Superheater
RSH : Radiant Superheater
PSH : Pendant Superheater.
MS : Main Steam
CRH : Cold Reheat
RH : Reheater
HRH : Hot reheat.

Power = $\dot{m}_s \times W_{net}$

↳ ↳ it is always fixed
We can vary power with the help of varying mass flow rate of steam.

8.34.
P.NO-32.
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→ Diagram, Copy from book.

→ Given, for Closed feed water heater (CFWH)

$\dot{E}_{in} = \dot{E}_{out}$

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

$(1-y)\ 643.92 + y \cdot 3155.0 = (1-y)\ 1087.5 + y \cdot 1087.4$

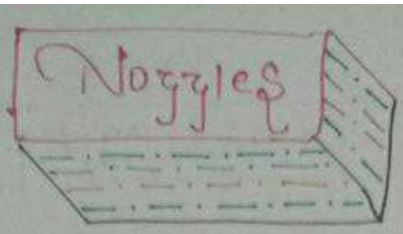
$\therefore$ **$y = 0.176$ kg/kg of steam** Ans.

for OPWH.

$\dot{E}_{in} = \dot{E}_{out}$

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

Nozzles



Speed of Sound, $C = \sqrt{\gamma RT}$

Speed of Water > Speed of air

Steel > Water > Air, as fluid getting incompressible, Speed of Sound increases.

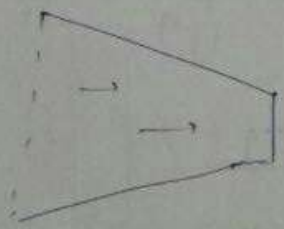
R = Characteristic gas constant = $\frac{R_u}{\text{Molecular Weight}}$

$\therefore C_{Hydrogen} > C_{Helium}$

$C_{Oxygen} > C_{Nitrogen}$.

As the

- Mach No = $\frac{\text{Actual velocity}}{\text{Sonic velocity}}$, $\boxed{M = \frac{V}{C}}$



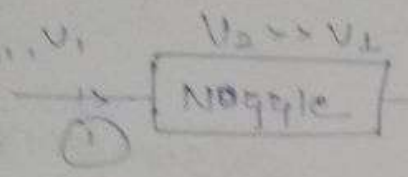
$$\frac{dA}{A} = \frac{dV}{V}(M^2 - 1)$$

- If fluid is compressible, it may be Nozzle or diffuser depends upon sonic velocity.
- If fluid is incompressible ie water it is always nozzle. (Converging passage always acts as nozzle whereas diverging passage always works as diffuser).

$$\boxed{\frac{dA}{A} = -\frac{dV}{V}}$$

→ For compressible fluid, $\dot{m} = \rho A V$ = constant.

$$\frac{d\rho}{\rho} + \frac{dA}{A} + \frac{dV}{V} = 0 \quad \therefore \boxed{\frac{dA}{A} = -\frac{dV}{V}}$$



By SFEE,

$$h_1 + \frac{V_1^2}{2} = h_2 + \frac{V_2^2}{2}$$

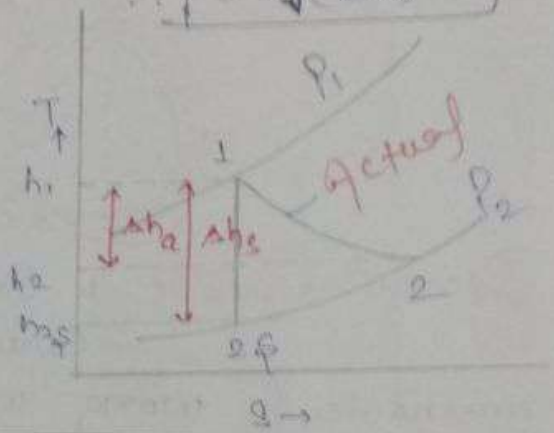
(if $V_1 \approx 0$), $h_1 - h_2 = \frac{V_2^2}{2}$

$$\therefore V_2 = \sqrt{2(h_1 - h_2)} \quad \therefore \boxed{V \propto \sqrt{(\Delta h)}}$$

Nozzle Efficiency :-

$$\eta = \frac{\text{Actual Enthalpy drop}}{\text{Isentropic enthalpy drop}}$$

$$\boxed{\eta = \frac{h_1 - h_2}{h_1 - h_{2s}}}$$



$$\boxed{\dot{m} = \rho A V = \frac{A \cdot V}{v \uparrow}}$$

In actual working, there is always friction while flow takes place through the nozzle. Friction is mainly due to surface of nozzle and also between fluid layer. Nozzle efficiency is defined as the ratio of actual enthalpy drop to isentropic enthalpy drop possible in the nozzle.

$$\Rightarrow \boxed{\eta = \frac{(\Delta h)_a}{(\Delta h)_s}}$$

In terms of velocity.

$$\boxed{\eta_N = \frac{V_2^2 - V_1^2}{V_{2s}^2 - V_1^2}}$$

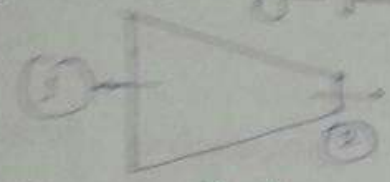
if $V_1 << V_2$

$$\boxed{\eta_N = \frac{V_2^2}{V_{2s}^2}}$$ where $V_{2s} > V_2$

1. Subsonic ($M < 1$)

$(M^2 - 1)$: -ve

a) Converging :→



$M_1 = 0.4$ M ↑ $M_2 = 0.45$

dA : -ve

$\therefore \frac{dA}{A} = \frac{dv}{v}(M^2 - 1)$

$-ve = \frac{dv}{v}(-ve)$

$\therefore$ dv : +ve

It will act as nozzle.

V ↑, P ↓, ρ ↓, T ↓

b) Diverging :→←

$M_1 = 0.2$ $M_2 = 0.45$

dA : +ve

$\therefore$ dv : -ve

V ↓, P ↑, ρ ↑, T ↑

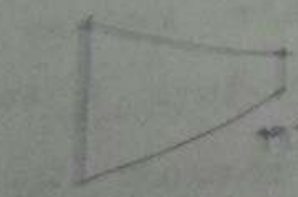
M ↓

For Subsonic Compressible flow, Converging passage acts as nozzle and diverging passage acts as diffuser.

2. Supersonic :→ $(M > 1)$

$M^2 - 1$: +ve

a) Converging :→



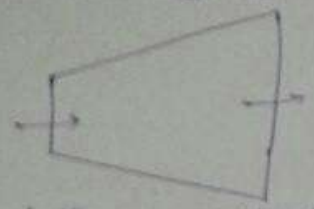
$M = 1.4$ $M = 1$

$(dA = -ve)$ $\therefore dv = +ve$

V ↓, P ↑, ρ ↑, T ↑

M ↓

b) Diverging :→ $dA = +ve$ $\therefore \boxed{dV = -ve}$



$M = 1.5$ $M = 2.4$

$V \downarrow, P \uparrow, \rho \uparrow, T \uparrow$

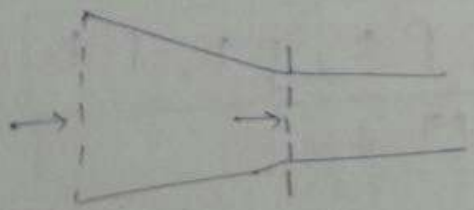
$M \uparrow$

· For Supersonic Compressible flows. Converging passage act as diffuser and diverging passage acts as nozzle.

c. Sonic ($M = 1$) :→

$$(M^2 - 1) = 0.$$

$$\therefore \frac{dA}{A} = \frac{dV}{V}(M^2 - 1) \quad \therefore \boxed{dA = 0}$$



→ To obtain Supersonic Speed, we need Convergent-Divergent section.

→ Throat - Area where does not change.

→ At throat, Mach no = 1, mass flow rate does not change at Mach no : 1.

· If $\boxed{M = 1}$, ($dA = 0$) and these Conditions Corresponds to min. Cross-section area of nozzle known as Throat. Nozzles are designed in such a manner that Sonic Conditions exits at throat. At this point, mass passing through nozzle is max. and nozzle is called choked nozzle.