IES MASTER

Civil Engineering

Toppers Handwritten Notes

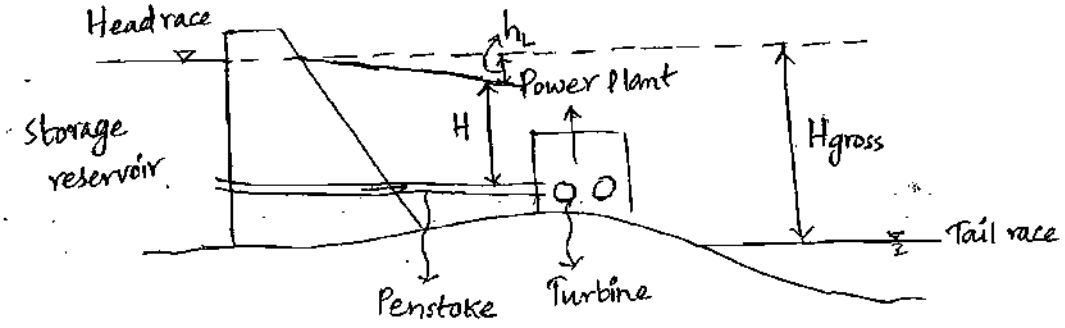
HYDRAULIC MACHINES

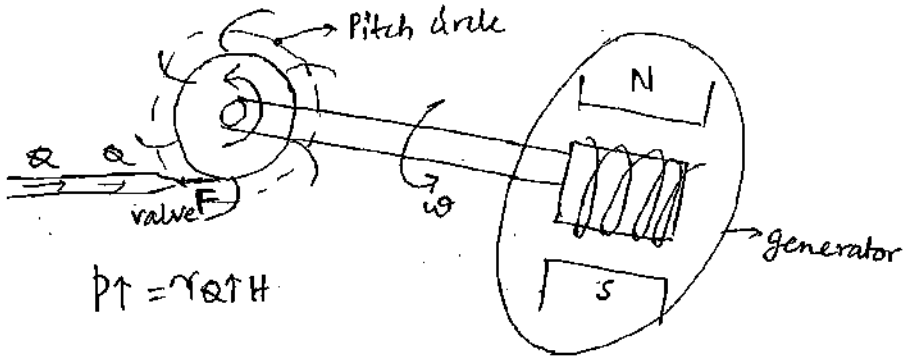
- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

Hydraulic Machines

→ Hydroelectric Plant ;

→ Hydroelectric plants are used for power generation. The essential component of Hydroelectric plant are as follows;





→ Storage Reservoir ;

→ water available from the catchment area is stored in the reservoir so that it can meet the requirement of Powerplant throughout the year.

→ The storage reservoir can be natural (or) Artificial.

Natural ⟶ lakes in the mountain

Artificial ⟶ Dams & Reservoir

→ Waterways ;

→ It is the passes through which water is carries from the reservoir to the Power-house. It consist of tunnel, Canal, Foreway, Surge tank, Penstock etc.

→ Foreway ; (check the name)

→ It is the enlarged section of a canal spreadout to accommodate the required width of intake, its function is to store the water rejected by the plant when the load is required and to meet instantaneous increased demand due to sudden increase in load.

→ It also helps in absorbing the sudden pressure rise due to closing of valves on account of load reduction, and it acts as large settling basin for the sediment particles.

→ Foreway is provided at the junction of Power canal and the intake structure.

→ Surge tank ;

→ It is the small reservoir fitted at some opening made in a long opening to receive the rejected flow when pipe is suddenly closed.

→ It helps in absorbing the high pressure rise due to water hammer effect and provides for absorbing and providing the discharge to the turbine.

→ Surge tank is provided on a long Penstock.

→ In case of short Penstock, thickness of Pipe is increased.

→ Penstock ;

→ Penstocks are pipe of large diameter carrying water under pressure from the storage to the turbine.

→ Tail race ;

→ It is the waterway to conduct the water discharge from the Turbine to a suitable point where it can be safely disposed off or stored to be pumped back into the original reservoir.

→ Head Race (write from Text book)

→ Classification of Power Plants;

1) Classification based on the head under which the Power Plant works;

i) High head plant → H > 250m

ii) Medium head Plant → 30-250m

iii) Low head Plant → 2m-30m

2) Classification based on Power Produced;

i) Mega hydal project → > 500MW

ii) Large hydal Project → 25-500 MW

iii) Small hydal Project

a) Small → 2-25 MW

b) Mini → 101 KW - 2MW

c) Micro → < 100 KW

d) Pico → < 5 KW.

3) classification on the basis of function;

i) Runoff River Plant;

→ Low storage of water is done and whatever water is available in the river is used to produce the power.

→ The Firm Power is computed from 95% dependable discharge.

→ If runoff river plant is to meet the Peak demand, we use a barrage to create Pondage, and hence due to availability of water during the peak period we can meet the Peak demand

→ Runoff River Plant without Pondage → Base load Plant

→ Run off River Plant with Pondage → As a Peak load Plant

Note:-

→ Pondage factor; It is defined as the ratio of Total stream flow hour per week to the no. of hours the Plant is operational in the week.

→ Pondage factor helps in deciding the Pondage Volume needed.

ii) Storage Plant;

→ In the storage Plant we construct dam across the river to create the storage.

→ The storage plant is generally called "Concentrated fall hydroelectric development" if the powerhouse is located near the dam.

→ if water is carried to the Power house through Canal or Tunnel it is called "Divided fall development".

→ Storage Plant can very easily meet the fluctuation of Power demand.

iii) Pump storage Plant;

→ It takes care of Peak load of the Plant. In this case water from the Tail race is pumped back to the reservoir during off-peak hours by using other source of energy.

→ The Turbine itself is used as Pump by reversing its direction of flow.

→ This Plant is generally used when there is shortage of water.

4) Classification on the basis of Load Capacity;

i) Base load Plant → It supplies constant Power

ii) Peak load Plant → It supplies power during peak loads only.

5) Classification based on the Source of energy;

i) River Power Plant

ii) Tidal Power Plant. → It taps the energy of tides, Power is produced both during the rising phase & retreating phase by reversing the direction of turbine.

→ Other terms & definitions ;

i) Load factor ;

$$= \frac{\text{Avg. load in a Period}}{\text{Peak load in that Period}}$$

ii) Plant use factor (or) Capacity factor (or) utilisation factor ;

→ It is the ratio of Power actually produced to the Power that the powerhouse is capable of producing [Installed Capacity]

iii) Firm Power ;

→ It is the Net power which is continuously available from the Plant.

→ 95% dependable power is generally called " Firm Power"

iv) Secondary Power ;

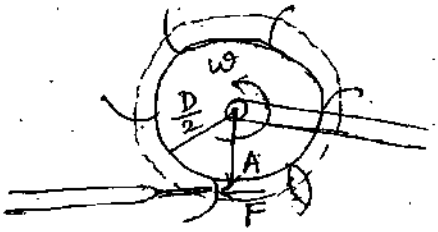
→ Excess Power available over Firm Power.

⇒ Turbines ←

→ Turbines are Hydraulic machines which converts the Hydraulic energy into mechanical energy

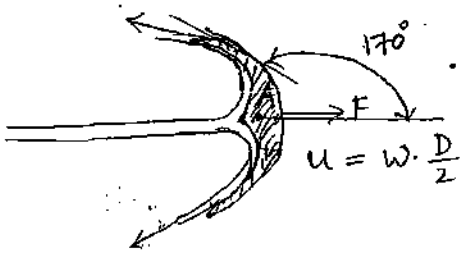
→ Mechanical energy inturn is converted to electrical energy by using generator

Impulse Turbine



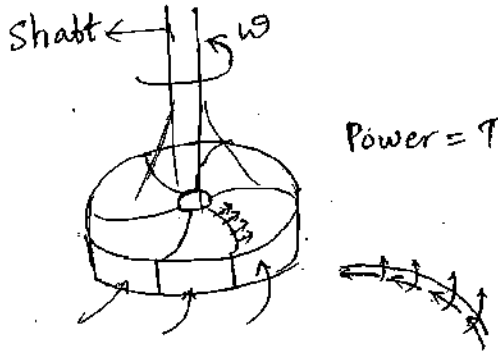
Power Force velocity

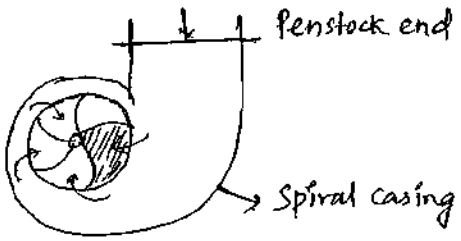
$P = F.u$



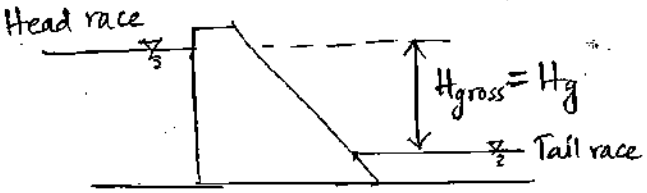
$u = \omega \cdot \frac{D}{2}$

Reaction Turbine





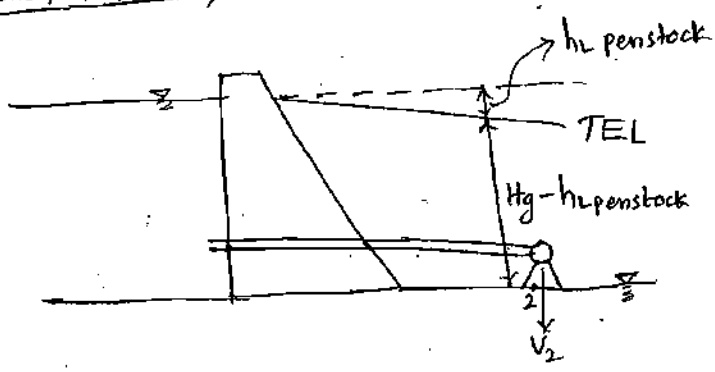
→ Gross & Net head of Turbine ;



→ Difference b/w the elevation of Head race and Tail race is called "Gross head".

→ Net Head ;

→ Reaction Turbine ;



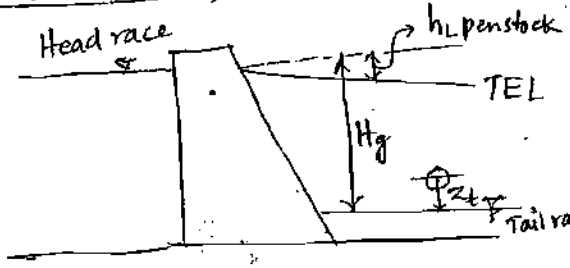
$$H = H_g - h_{L\,penstock} - \frac{V_2^2}{2g}$$

Net head

K.E converted by water exerting the draft tube

→ $H = H_g - h_{L\,penstock} - \frac{V_2^2}{2g} = h_{L\,turbine} + h_{L\,draft\,tube}$ + Head extracted by the Turbine

→ Impulse Turbine ;



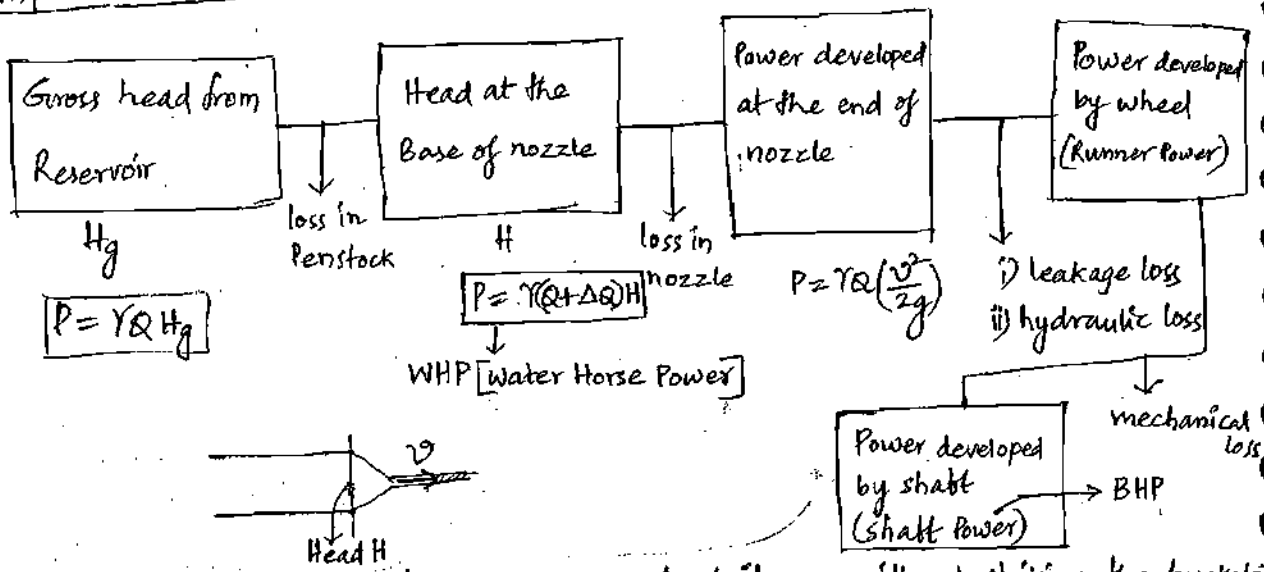
$$H = H_g - h_{L\,penstock} - Z_t$$

Net head

Z_t = elevation of turbine above the tail race.

→ Losses & efficiencies In Turbine ;

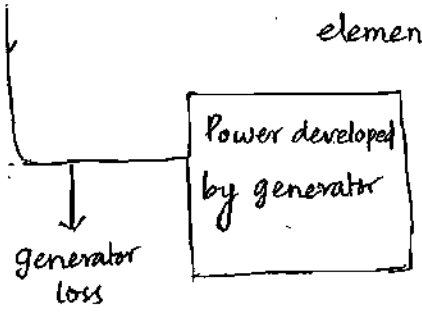
→ Impulse Turbine ;



⇒ leakage loss → Accounts for water going to tail race without striking the bucket.

⇒ hydraulic loss → Includes Impact loss, frictional loss, eddy losses while water is moving over the bucket and energy carried by the outgoing water.

⇒ Mechanical loss → Includes bearing friction and the air friction of the rotating element [windage loss]



Note :

→ Shaft Power is the Power developed by the turbine.

→ Nozzle is considered to be the integral part of turbine.