Page No.
Date:

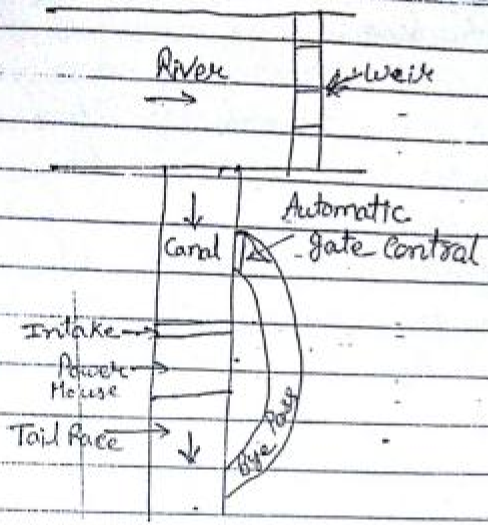
Section - B
Unit - III

☒ Classification Of Hydropower Plants:-

Various Plants Components Of Hydroelectric:
(i) Reservoir (ii) Forebay (iii) Intake structure
(iv) Surge tank (v) Penstocks (vi) Power house
(vii) Turbines and governors (viii) Generators
(ix) Transformers (x) Transmission lines

1) Reservoir:- This is created in hydropower plants to store water and release it for power generation. The reservoir is made by construction of Dams across the river. Power tunnel is constructed to convey water to turbines.

2) Forebay:- A forebay is an enlarged body of water just in front of the intake. It is constructed by enlarging. The main function of the forebay is to store, temporarily, the water rejected by the plant when the load is reduced and to meet the instantaneous increased demand when the load is instantaneous increased. Thus, the forebay absorb the short interval variations of intake of water into the turbines in accordance with the fluctuating loads.



3) <u>Intake Structure</u>:- The water is conveyed from the forebay to the penstocks through the intake structure. Following are the accessories of intake structure:

⇒ Trash rack: It prevents the debris ~~from~~ from getting into the penstock.

⇒ Rakes to clear the trash rack

⇒ Ice removal equipment, if necessary

⇒ Penstock closing gates with hoists

4) <u>Penstocks</u>:- Water ~~from~~ from the storage reservoir is conveyed through penstocks or canals to the power house. Penstocks are the pipes of large diameter, usually made of steel in various forms, reinforced concrete or wood. Stave, which carry water under pressure from the storage reservoir to the turbines. Penstocks may be subjected to water hammer pressure due to fluctuation in the load. Short length penstocks are designed to

Date

take this extra pressure. However, in the case of long penstocks, surge tank is provided to reduce hammer.

5) Surge Tank:- When the load on the turbine is reduced, the governor automatically closes the inlate gates partially, to reduce the inflow to the turbines. This retards the water flowing in the penstocks, leading to water hammer in the penstocks. The excessive inertia pressure so caused may burst the penstocks. A surge tank may be provided to reduce the water hammer pressures. The functions of a surge tank are as follows:

(i) The surge tank furnishes a free reservoir surface very near to the discharge end of the penstock to dampen the water hammer pressure.

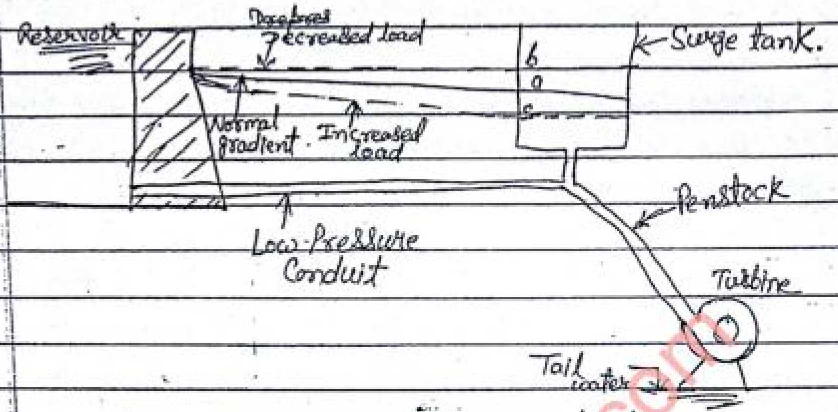
(ii) It temporarily stores water when the load is reduced until much time that the velocity has fallen to the steady value.

(iii) It temporarily supplies more ~~than~~ water when the load is increased until such time that the velocity has increased to a fresh steady value.

(iv) It calms down effectively and rapidly the surging in the water level.

An elementary surge tank consists of a cylindrical open-top storage reservoir connected by a vertical branch pipe to the penstock at a point as close to the turbine as possible. These are almost always built high enough so that the water cannot overflow.

even with a full-load change.



6) Turbines:- These are the machines which convert hydraulic energy into mechanical energy. The mechanical energy developed by a turbine is used in running an electric generator which is directly coupled to the shaft of the turbine. The generator develops electric power which is also sometimes known as hydro-electric power. A water turbine consists of a wheel called runner which is provided with specially designed blades or buckets. The water possessing large hydraulic energy when strikes the runner cause it to rotate. These may be classified as under two heads:

(i) Impulse or Velocity Turbine
(ii) Reaction or pressure Turbine

(I) Impulse Turbine:- In this, all available potential energy or head is converted into kinetic energy or velocity head by passing it through a contracting nozzle or by guide vanes before it strikes

Page No.
Date

the buckets of the turbine.

Characteristics:-

(i) The wheel passages are not completely filled

(ii) The water acting on the wheel vanes is under atmospheric pressure.

(iii) The water is supplied at a few points at the periphery of the wheel.

(iv) Energy applied to the wheel is wholly kinetic

(II) Reaction Turbine:- In this, only a part of the available potential energy is converted into velocity head, at the enterance to the runner, and the balance that forms a substantial portion remains as a pressure head. The pressure at the inlet to the turbine is much higher than the pressure at the outlet.

Characteristics:-

(i) The wheel passages are completely filled with water

(ii) The water acting on the wheel vanes is under pressure greater than atmospheric.

(iii) The water enters all around the periphery of the wheel.

(iv) Energy in the form of both pressures and kinet is utilized by the wheel.

Types:-

(i) Tangential flow turbine

(ii) Radial flow turbine

(iii) Axial flow turbine.

(iv) Mixed flow turbine

The Power House:– A power house of a hydel scheme serves as a protective covering for the hydraulic and electrical equipment. The power house is the conspicuous and vital part of an hydroelectric development. The following items of equipment should be provided for in the layout of power house:

1) Turbine Hydraulic Equipment
(i) Turbines (ii) Gates or gate valves
(iii) Relief valves for penstock setting
(iv) Governors (v) Flow measurement equipment

2) Electrical Equipment
(i) ~~Gover~~ Generators: Air ducts
(ii) Exciters (iii) Transformers: pump and cooling system connections, runs and platforms
(iv) Switching Equipment:
Low tension buses, switch board panels, switch board equipment and instruments, oil switches, reactors
(v) High tension system:
Buses, oil circuit breakers, Lightening arrestors, outgoing connections
(vi) Auxiliaries:
Storage batteries, station lighting.

3) Miscellaneous Equipment:
(i) Crane (ii) Shop (iii) Office rooms
(iv) Lavatory etc.

Date: __ | __ | __

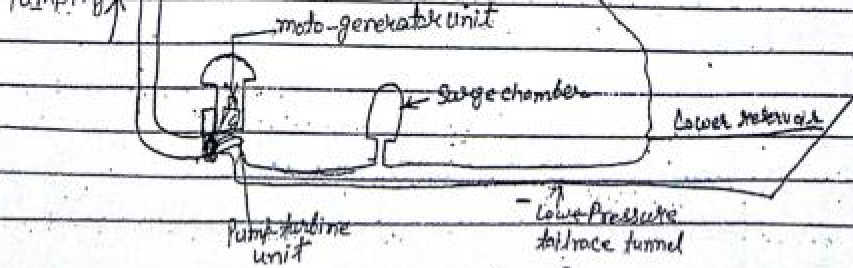
8) Tail Race:- The water from the power house is conveyed back to the river after generation of power through a tail race. The tail race may be a canal or a tunnel depending upon the location and geography of the area.

Classification And Basis :-

1) Based On Hydraulic Features

(i) Conventional Hydro-plans: Use normally available hydraulic energy of the flow of the river. Such as diversion plant, Storage plant

(ii) Pumped Storage Plants: Use the concept of recycling the same water. Normally used with areas with a shortage of water. It generates energy for peak load and at off-peak periods water is pumped back for future use. It is an economical addition to a system which increases the load factor of other systems and also provides additional capacity to meet the peak load. The upper reservoir supply water to power house



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to generate power. During non-operation of power house, water from lower reservoir is pumped back to the upper reservoir by reversible turbines.

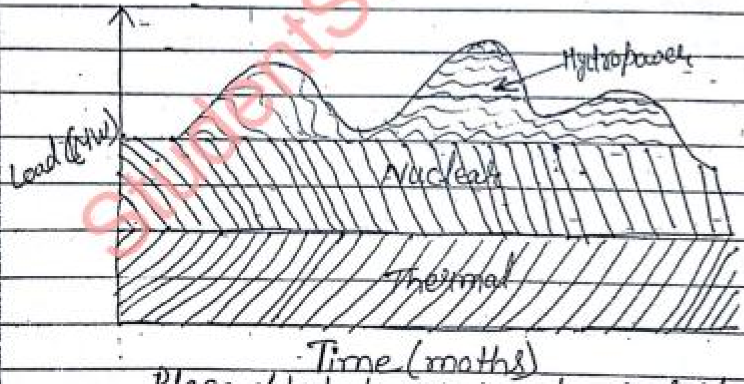
(iii) Unconventional Hydro-plants:

(a) Tidal power Plant: Use it's the tidal energy of the sea water. Very few have been constructed due to structural complication

(b) Wave Power Plant: Waves of sea are used to generate power by making use of kinetic energy of waves.

(C) Depression Power Plant: Hydropower generated by diverting an ample source of water in the natural depression and water level in the depression is controlled by evaporation.

2) Based Of Operation:



Place of hydropower in a power system

Based on actual operation in meeting the demand, one can have:

- Isolated plant - operating independently
- Interconnected to grids

This is a grid system, a power station may be distinguished as a base load plant or peak load plant. Hydropower plants are best suited as peak load plants, because hydropower plants can start relatively quickly and can thus accept load quickly.

3) Based On Plant Capacity:

It changes with time as technology improves. Thus,

Present day Classification	According to Mossonyi
Micro hydropower < 5MW	Midget Plant upto 10KW
Medium Plant 5 to 100 MW	Low Capacity > 1000 KW
High Capacity 100 to 1000 MW	High Capacity > 10000 KW
Super Plant above 1000 MW	Medium Capacity > 10000 KW

4) Based On Head

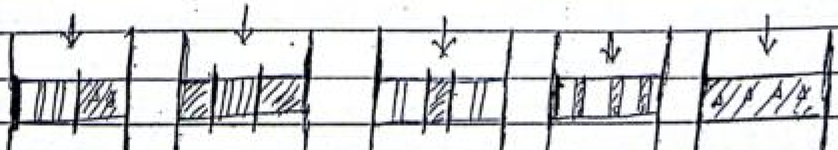
The most popular & convenient classification is the one, based on head on turbine. On this basis:

(i) Low head plants < 15 m
(ii) Medium head plants 15-20 m
(iii) high head plants 50-250 m
(iv) Very high head plants > 250 m

5) Based On Construction Features (Layout)

(i) Run-off-river plants (low to medium head plants)

These plants are further classified as



(a) Block power Plant (b) Twin block plant (c) Island Plant (d) Pier head Plant (e)

(a) The power house constructed at the one end of barrage.

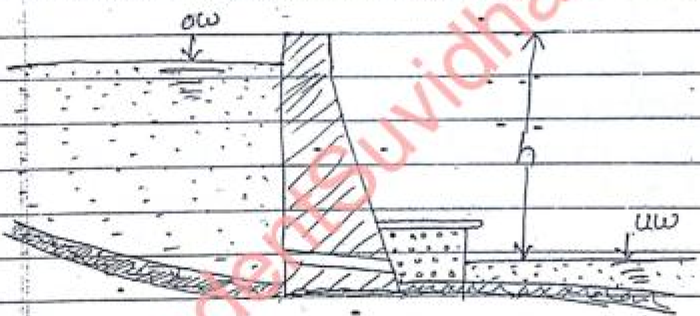
(b) The power house are constructed at the end of the weir.

(c) The plant is installed at the centre of the weirs

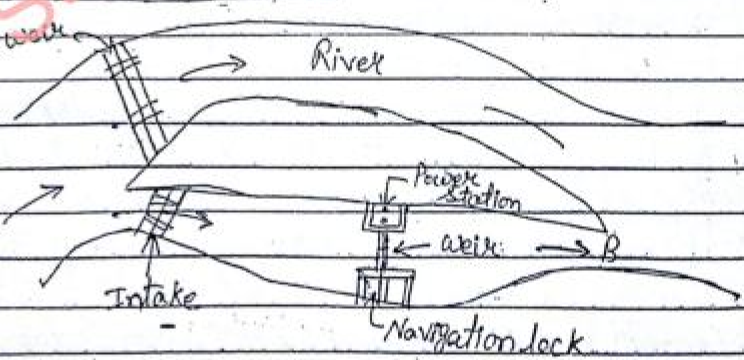
(d) The power house is constructed inside the pier cavity

(ii) Valley Dam Plants (Medium to High Head Plants):

In this type of hydropower plant the power is generated Constructed right at the centre of the garage of river to generate power by making use of head available upstream of power house due to reservoir to store water.



(iii) Diversion Canal Plant:



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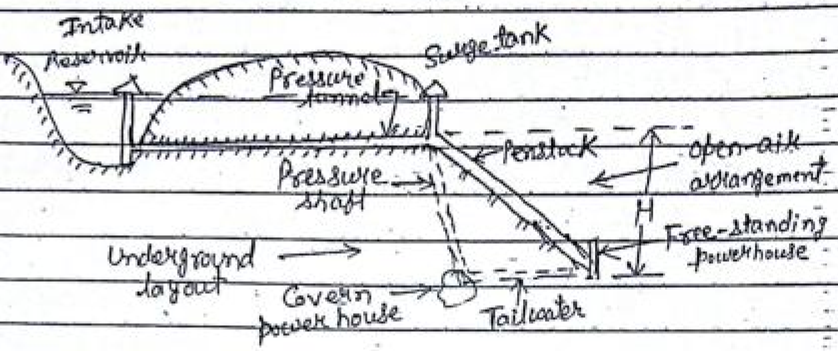
(iv) High Head Diversion Plant:



(V) Pumped Storage Plant Arrangement

6) Runoff-River Plants (Low to Medium Head Plants)

- The normal flow of the river is not disturbed
- There is no significant storage
- A weir or barrage is built across a river and the low head created is used to generate power. It also acts as a controlled spilling device.
- The power house is normally in the main course of the river.
- Preferred in perennial rivers with moderate to high discharge, flat slope, little sediment and stable reach of a river.

Water enters the power house through an intake structure incorporation or all of the following:

1) Entrance flume separated by piers and walls for each machine unit.
2) Turbine chamber: Scroll case with turbine
3) Concrete or steel draft tube
4) Power house building

Additional structures are
- deflector or skimmer walls
- forebay
- Service bridge
- river training walls
- sediment trap and flushing sluices, where necessary

7) Valley Dam Plants (Medium to High Head Plants)

- The dominant feature is the dam which creates the requires storage and necessary head for the power house.
- Power house is located at the toe of the dam
- Water flows through the penstock embedded in the dam and enters the power house.
- Sometimes the power house is not immediately at the toe of the dam but at some distance. This arrangement is more expensive and is used only when it offers advantages such as extra head due to advantageous topographical conditions.

Important Components of a valley dam plant:

(i) The dam with its appurtence structures like spillway, energy dissipation arrangements etc.
(ii) The intake with racks, stop logs, gates and ancillaries.
(iii) The penstock conveying water to the turbine with inlet valve and ancharage.
(iv) The main power house with its components.

Date

3) Diversion Canal Plant:

- The distinguishing feature is the presence of power canal that diverts the water from the main stream to channel.
- The power house is provided at suitable location along the stretch of the canal.
- The water after flowing through the turbine is brought back to the old stream.
- Diversion canal plants are generally low head or medium head plants.
- They don't have storage.
- Pondage requirement is met through a pool called forebay located just U/S of the power house.

Ways of developing head:

(i) The flatter slopes of power canal and the absence of meander, by reducing length, helps in providing head.

(ii) If the river has a natural fall, diverting the water from U/S side of the fall and locating the power house at the D/S side of the fall provide the required head.

(iii) In inter-basin diversion, water may be diverted from a higher level river to a lower river through a diversion ~~cannot~~ canal to the power house located at the lower river.

Main structures of diversion canal plant:

1) Diversion weir with its appurtenant structures
2) Diversion canal intake with its ancillary works is needed in some sediment laden streams.
3) Bridges and culverts of the canal.
4) Forebay and its appurtenant structures.

Date : | |

9) **High Head Diversion Plants:**

High head is developed by:

(i) diverting the river water through a systems of canals and tunnels to a point on another river which is at much lower level. The main feature here is complicated conveyance system and relatively high head compared to the diversion type.

There may be two situation concerning storage situation:

(a) A diversion weir to creat pondage (and no storage). Here like run-off plant the power production is governed by the natural flow in the river.

(b) Storage may be provided on the main river at the point of diversion.

Main Components of high head diversion plants:

(i) Storage or diversion weir with appurtenant structures

(ii) The Canal/tunnel

(iii) The head race either open cut or tunnel.

(iv) Forebay/surge tank

(v) Penstock

(vi) Power house

(vii) The tail race

10) **Pumped Storage Plant:** "Diagram drawn before"

Pumped storage plant is suitable where:

- The natural annual run-off is insufficient to justify a conventional hydroelectric installation.
- It is possible to have reservoir at head and tail water locations.

Date

This kind of plant generates energy for peak load, & at off peak period water pumped back for future use. During off peak periods excess power available from some other plants in the system is used in pumping back water from the lower reservoir.

Various arrangements are possible for higher and lower reservoirs:

(i) Both reservoirs in a single river

(ii) Two reservoirs on two separate river close to each other and flowing at different elevations.

(iii) Higher reservoir on artificially constructed pool and the lower reservoir on natural river.

(iv) The lower reservoir in a natural lake while the higher is artificial.

Another way of classifying is as pure pumped storage scheme and mixed plant scheme.

The most important basis of pumped storage plant is the relative arrangements of turbines and pumps.

four units - pump, motor, generator, turbine.

three units - pump, generator, turbine

two units - generator, turbine > reversible pump-turbine installation

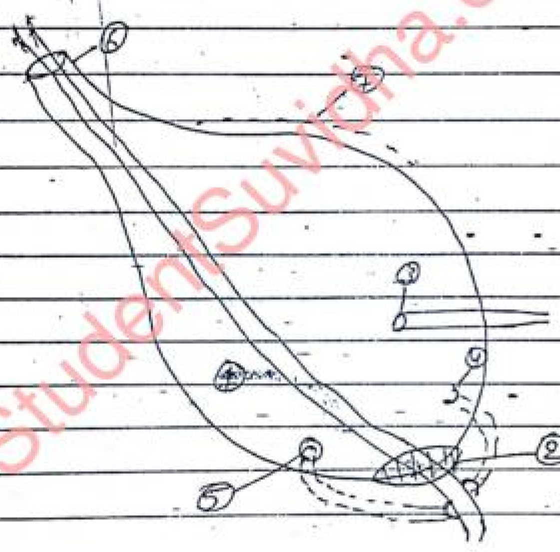
11) Storage and Pondage :-

Storage is provided to balance seasonal fluctuation by building reservoir dams. Pondage is provided through balancing reservoir or forebay for short term fluctuations (daily ~~or~~ or hourly).

(i) Reservoir (storage) capacity: It is determined by means of mass curve procedure of computing the necessary capacity corresponding to a given inflow and demand pattern. Reservoir capacity has to be adjusted to account for the dead storage, evaporation losses and carry over storage.

Appurtenant Structure: Intake and spillway structure

1) Storage 2) Dam 3) Service intake
4) Bottom outlet 5) Spillway
6) Diversion 7) Service load



(ii) Dead Storage:-

This is a storage capacity of the reservoir provided to accomodate the deposition of silt in the reservoir. It is expected that the dead storage space will eventually fill up with sediment at which time one says the dam has served its full purpose. The life of a reservoir is dependent on the silting capacity of the reservoir.

(iii) Evaporation Loss:- Provision should be made for evaporation since it is an important loss item actual evaporation rate depends upon location and meterological factors. In arid and semi-arid regions at least 2 to 2.5 m of depth should be added as a rule of thumb.

(iv) Carry Over Storage:- Sometimes it may be required to carryover some of the live storage to the next year as a safety measure. This carry over storage is determined by analyzing the storage requirement for a sequence of two or three consecutive dry years.

Pondage Capacity:-

Pondage is provided to cater for short term fluctuations:

- For run-off river plants the pondage is provided by the main weir on its side.
- For diversion canal plants, the pondage is provided at the end of the canal in the form of force bay reservoir. Reason for short term fluctuations are:

(i) Sudden increase or decrease in load on the turbine. The pondage would provide the extra water when needed and retain excess water when not needed.

Date

The load and thus the water demand may be steady but the supply may undergo a change. Branches in the supply canal may lead to this.