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Thermal power plant

Thermal power plants converts heat energy to electrical energy [coal, fossils].

Coal is burnt in a boiler, which converts water to steam. Steam is then fed to turbine, which produces mechanical energy which is fed to alternator.

Main equipments of a Thermal power plant consist of boiler, steam turbine and alternator.

To achieve efficient conversion of heat energy to electrical energy auxillary equipments are used. Auxillary equipments used in thermal power plant are many that they overshadow the main parts.

Main and Auxillary parts -

1- Coal handling plant
2- Pulverising plant
3- Draft fans
4- Boiler
5- Ash handling plant
6- Turbine
7- Condensor
8- Cooling tower and ponds
9- Feed water heater
10 Economiser
11 Superheater and reheater
12 Air preheater
13. Alternator with exciter
14 Protection and control equipment
15. Instrumentation

Thermal power plant comprises of four ckt -

1- Coal and ash ckt
2- Air and gas ckt
3- Feedwater and steam flow ckt
4- Cooling water ckt

→ Coal handling plant :-

function of coal handling plant is to automatic feeding of coal to boiler furnace. A thermal power plant burns enormous amount of coal, a 200 mw power plant requir 2000 tons of coal daily. In every plant there is enough storage to store 15 days coal.

→ Pulverising plant :-

In modern thermal power plant, a coal is pulverised i.e - ground to dust like size and carried in a stream of hot air.

"Pulverisation is means of exposing large surface area to the action of oxygen and continuously help in combustion."

Advantages -

1- The rate of combustion can be controlled and changed acc. to need.
2- The percentage of excess air required is low.
3- Wide variety of even low grade coal can be used.
4- Boiler can be started from cold conditions very easily.
5- The pulverising equipment is outside the furnace, hence it can be repaired without cooling down unit.

6- System is completely free from slinker and slagging trouble.

Disadvantages :-

1. Investment cost of plant is increased.
2. Auxillary power consumption is increased.
3. Building space required is more.
4. Skilled operators are required.

→ Draft system :-

Combustion in boiler continuously requires supply of sufficient air and removal of exhaust gasses.

Circulation of air is caused by the difference in pressure known as draft.

Draft is the pressure diff. between the atmosphere and inside the boiler.

Q - Types.

① Natural → It is provided by chimney.

It serves two purpose - ① - To produce a draft so as air can flow into the boiler and products of combustion are discharged to atmosphere.

② - to deliver product of combustion and ash to high altitude, as to reduce pollution.

② Mechanical -

Modern large plants have a very huge boilers hence normal chimney cannot provide enough draft.
In these, the movement of air is due to the action of fan.
~~For these~~
They have 2 types -

① Forced draft system → Fan is installed near boiler
② Induced " " → " " " near chimney.

→ Boiler :-

Boiler is a closed vessel which is used to convert water to steam under pressure.

Boilers are designed to absorb max. amount of heat released in the process of combustion.

Heat is transfered to boiler by all 3 means.
→ Conduction
→ Convection
→ Radiation

Two types -

① Fire tube boiler →

In these types of boiler product of combustion passes through the pipe, and tube is surrounded by water.

→ Water tube boiler-

In this boiler, water flows inside the tube whereas hot gasses flow outside the tube.

→ Super heater -

Function of superheater is to increase the temp of steam above its saturation point.

Resulting steam is called superheated steam

↓

contains more heat than saturated steam at same pressure.

The function of super heater is to remove the last traces of moisture from the saturated steam leaving boiler.

Advantages of superheated steam

- Provide more energy to the turbine thus increase output
- Lesser erosion to turbine blades.
- Can be transmitted to long distance with little heat loss.
- Improve efficiency.

→ 2 types → convection
→ radiant

→ Steam turbine :-

The steam turbine is a prime mover in which potential energy of steam is transformed into Kinetic energy, and later to mechanical to drive generator.

It uses the principle that the steam when passing through a small opening attains a high velocity. Velocity attained depends on the initial and final heat content of steam.

Types :-

① Impulse
② Reaction

→ Impulse :- High speed

In Impulse turbine, steam is expanded in turbine nozzle and attains a velocity. The steam jet impinges of blades fixed on the rotor.

Complete expansion takes place in nozzle.

→ Reaction :- Low speed:

In reaction turbine only partial expansion takes place in the nozzle and further expansion takes place as steam flows over the rotor blades.

Classification -

- Acc. to no. of pressure stages -
  1- Single stage turbine
  2- Multi stage Impulse and reaction turbine.

- Acc. to direction of steam flow -
  1- Axial turbine
  2- Radial turbine.

- Acc. to no. of cylinder
  1- Single cylinder turbine
  2- Double cylinder turbine
  3- Three cylinder turbine.
  4- Four cylinder turbine.

- Acc. to steam condition at inlet to turbine.
  1- Low pressure turbine
  2- Medium " "
  3- High " "
  4- very high " "
  5- Turbine of super critical pressure.

→ Ash handling plant :-

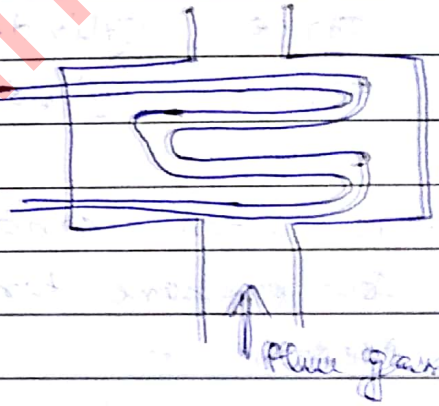
Coal contains a considerable amount of ash. It varies from 5% to 40%. Ash handling plant is a arrangement of conveyers to dump ash from power plant.

→ Condensor -

The condensor does the job of condensing the steam exhausted from turbine. Thus, it helps in maintaining low pressure at the exhaust. It improves plant efficiency.

→ Economisers -

Flue gasses coming out of the boilers carry lot of heat. An economisers extracts a part of this heat from flue gasses and uses it for heating feed water. It uses results in saving coal consumption and increase efficiency. But investment is increased.



→ Air- preheater -

After the flue gases leaves the economiser, some further heat can be extracted from them and used to heat the incoming air for combustion. Cooling of flue gases by 20°C increases efficiency by 1%.

→ Deaerators :-

They are the device used to remove oxygen and other gasses from the feed water to boilers.

→ Cooling towers and ponds

Cooling towers need a large amount of water to condense the steam. Roughly 1 kg of steam needs 100 kg of water for condenser. water is fed into the plant by means of pumps, after passing through the condensor water is fed back to the river.

It is necessary to establish correct input and outfall. If they are too close recirculation can take place, reducing efficiency of plant, and if they to far operating cost will increase.

"A large source of water is generally not available near thermal plant hence cooling towers are used which cool, warm water from condenser and reuse it".

~~Functions~~ - Working / Functioning.

- Water is divided into small quantities, mainly in size of drops.
- These drops falls from the height of 5-10 m to bottom of tower.
- water from the base of tower is fed to the condenser, this process is Cycle.
- Some water (2 to 5%) is evaporated and fed by the tank.

→ Main consideration in site selection :-

⇝ Availbility of raw material :-

Steam power plant requires coal as their fuel, hence plant should be located nearest to coalfield so, as to reduce transportation charges.

⇝ Nature of land :-

The type of land to be selected should have good bearing capacity as it has to bear dead load of plant and force made by machines.

⇝ Cost of land :-

Cost of land should be reasonable.

⇝ Availbility of water :-

An ample supply of water should be availble for condenser cooling water.

⇝ Transport facilities :-

Transport should be easily availble for transportation of fuel.

⇝ Availbility of Labours
⇝ Size of the plant
⇝ Ash disposal facilities.

→ Layout →

Main parts -

→ Coal handling plant
→ pulverising plant
→ Draft fans
→ Boiler
→ Ash handling plant
→ Turbine
→ Condensor
→ Superheater
→ Economisers.
→ Alternator
→ Cooling tower
→ Feed water heater.
→ Protection equip.

Four circuits

Coal and ash circuit
Air and gas ckt
Feed water and steam flow ckt
Cooling water ckt.

→ Coal and ash ckt :-

Coal arrives at the storage yard and after necessary handling passes on to the furnaces through the fuel feeding device. After combustion it is carried out by Ash handling plant.

→ Air and gas ckt :-

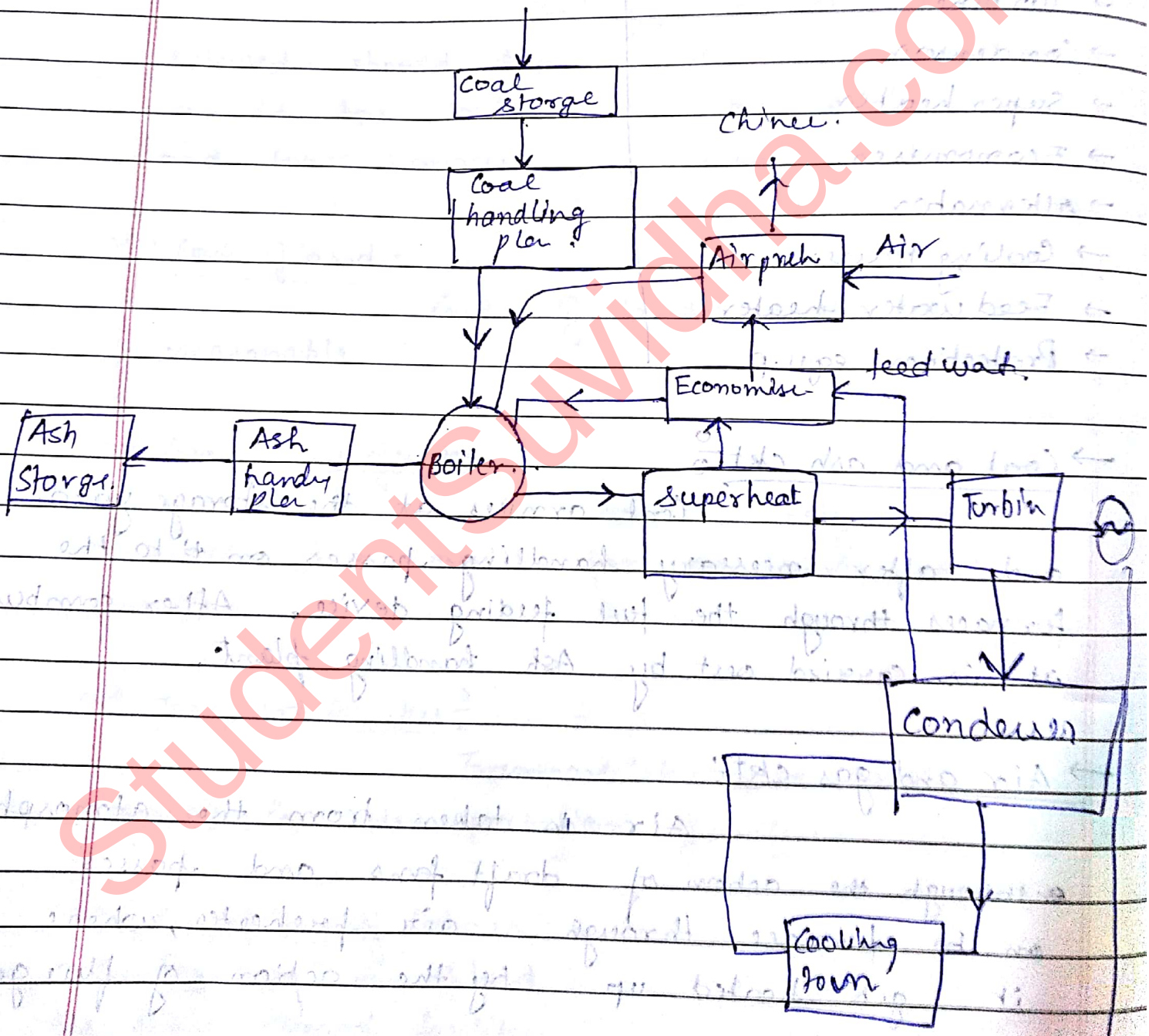
Air is taken from the atmosphere through the action of draft fans and passes on to furnace through air preheater, where it gets heated up by the action of flue gases.

→ feed water and steam flow ckt :-

water and condensed steam leaving the condensor is first headed in a close feed water heater.

→ Cooling water ckt -

The cooling water is supplied to condensor helps in maintaining a low pressure in it.



→ Advantage and disadvantage of steam power plant

Advantage

1- They can respond to rapidly changing loads with difficulty.
2- They can be located very easily near load centres.
3- They can work under 25% of Overload continuously.
4- Fuel is cheaper.
5- less space as compared to other plant.

Disadvantage

1- Maintainence and operating cost are high.
2- Large time req. for putting in to action.
3- Very large quantity of water req.
4- Difficulty is coal handling.
5- less life span when compared to hydro plant.

Hydro-electric plant

Hydro-electric plants harness water power for generation of electric energy. when water drops from a height its energy is able to rotate the turbine, which are coupled with alternator.

→ Advantages.

1- The useful life of Hydro plant is around 50 Yrs as compared to thermal which is only 25-30
2- No fuel required, hence operating cost is low
3- More robust
4- Maintanence cost is very low.
5- efficiency does not decrease with age.

→ Disadvantages -

1- Due to high civil eng. work, capital cost per kW is high.
2- Since it is dependent on water, generation is affected in dry years.
3- More time for construction.
4- Affect large area, due to their site selection measures.

→ Site selection -

1. Water Availbility :

Since all the designs of hydro-plant are made by keeping in mind the availbilty of water in that area, hence they should be made near the water abundant areas.

2- Water storage -

During a year, there are variations in water availbility, hence storage is necessary.

3- Water pollution -

polluted water may cause excessive corrosion and damage to internal machine parts.

4. Sedimentation -

The capacity of reservoir is reduced due to deposition of silt, also it may cause damage to turbine blades.

5- Access to site :

Construction of hydro plant requires man-power and machines. Hence, it should be made appropriate site.

→ classification -

① Acc. to xtent of water flow storage.

a- Run off river plant without pondage -

These plants are located such that they use water as it comes. It does not have any pondage or storage to store water. They have very less capacity, hence during heavy flows water is wasted.

b- Run off river plant with pondage -

These plants have storage for water to takeover hour to hour fluctuations in load at station. Pondage increases the firm capacity provided flood should not raise the tail race.

c- Reservoir plants -

Most of the plants across the world are of this type. When water is stored in a reservoir behind dam, it is possible to to control it very effectively.

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(2) - Acc. to Load -

a- Base load plants -

They fed the base load of the system. Thus they supply almost constant load throughout and operate on a high rate factor. Reservoir and with pondage plant are used as Base load plant

b- Peak load plants -

They are meant to supply peak load of system. With pondage and Reservoir plant are used as Peak load plants. They have large seasonal storage. Operate at low load factor.

(3) Acc. to Head -

a- Low head plants -

These plants usually consist of a dam across river. The plant is located near river/dam hence no surge tank is required. They operate at head of 30 m or less. Francis and Kaplan turbine are used.

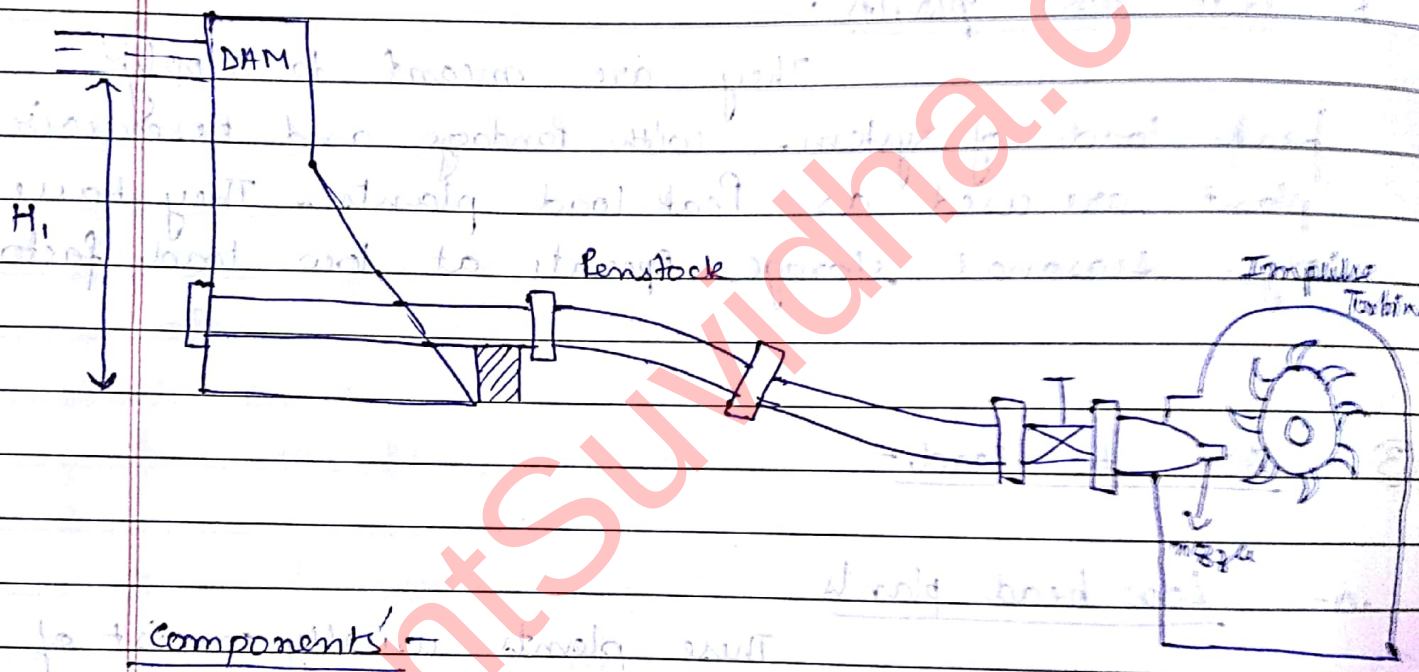
b- Medium head plant -

These plants operate under heads vary from 30m - 100m. Francis turbine is the main primemover. Forebay before the penstock acts as a surge tank.

c- High head.

These work under head of 100 m and above. Pelton wheel is common prime mover.

→ Layout and description



Components -

① Reservoir -

- It is the basic requirement of a hydro-plant
- Its purpose is to store water which is utilised later for moving prime-mover

② DAM :-

- function of DAM is to provide artificial head and storage.
- It is the most expensive and imp. part of hydro plant
- they are classified as-

  ① Masonary dam
  ② Earth dam.

③ Trash Rack -

Its main purpose is to stop the entry of debris which can damage the turbine.

④ Fore bay -

It acts as a regulating water reservoir to meet the hourly load fluctions.

⑤ Surge tank :-

Surge tank is a seperate water storage provided along with Dam in order to keep the flow of water regulated ~~in order to~~ in case of fluctuation of load.

A Reduction in load on alternator causes closing of governes which increase pressure in turbine, called water hanner.

→ Penstock -

It carries water from storage to turbine.

→ Spillway -

It is a arrangement to discharge excess water during floods to stop damage of dam.

→ Turbines

① Pelton turbine (Impulse type).

These are extensively used for high head installations. The runner consists of a circular disc in which two lobe elipsoidal bucket are installed evenly on periphery.

Each bucket has a splitter which divides the jet into two equal streams.

The Nozzle directs the flow on wheel. It also governs the quantity of flow with help of spear value.

In simple arrangement there is single jet feeding water to turbine but for large discharge there are turbine having upto 6 jets.

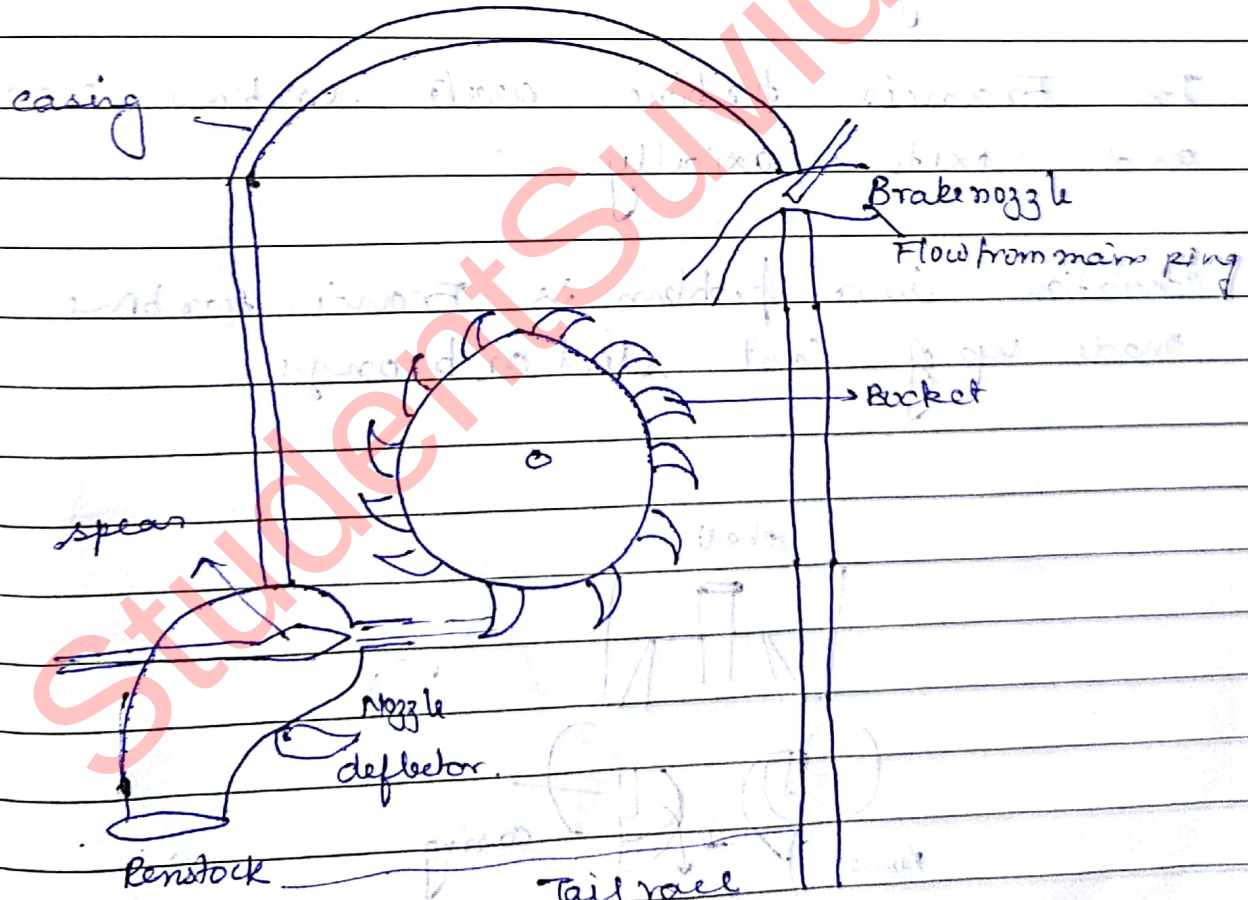
The erosion of pelton turbine occurs at

① on buckets due to erosive effect of flow
② on the nozzle due to cavitation effect.

To protect bucket from wear & tear chrome alloy steal or stainless steel is used.

In India max jet turbine is of 5 jet. (Kundah I (360m head)).

Worlds larget pelton is a 6 jet turbine (840m he in Brazil.



(2) Francis turbine (Reaction type)

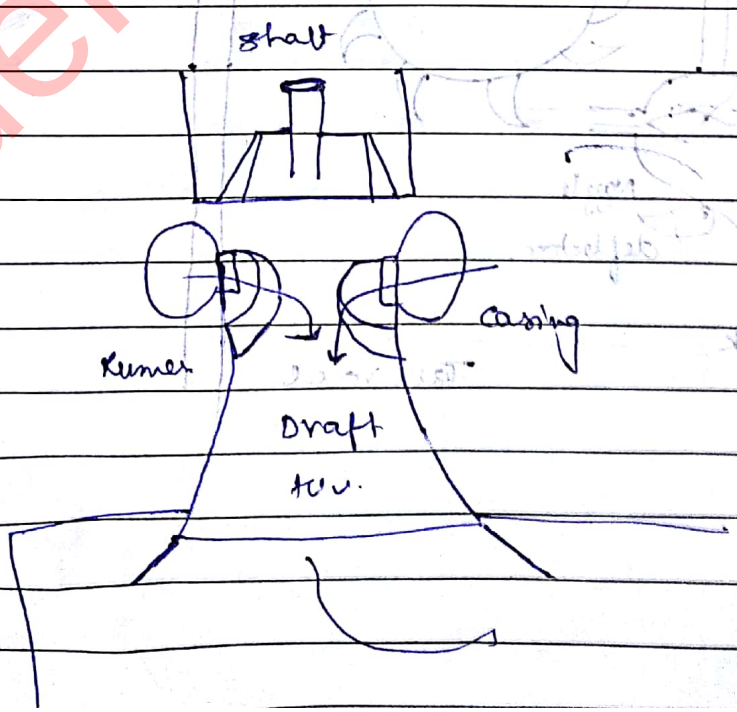
In francis turbine, the pressure of water at the inlet is more than that of outlet. Thus the water in the turbine must flow in a closed conduit.

In francis turbine, the runner is always submersed in water, after doing its work water is discharged to tail race.

Francis turbine work under medium heads. and velocity remains constant.

In Francis turbine, water enters radially and exits axially.

Cavitation is a problem is Francis turbine. made up of cast steel or brongs



(3) Kaplan turbine

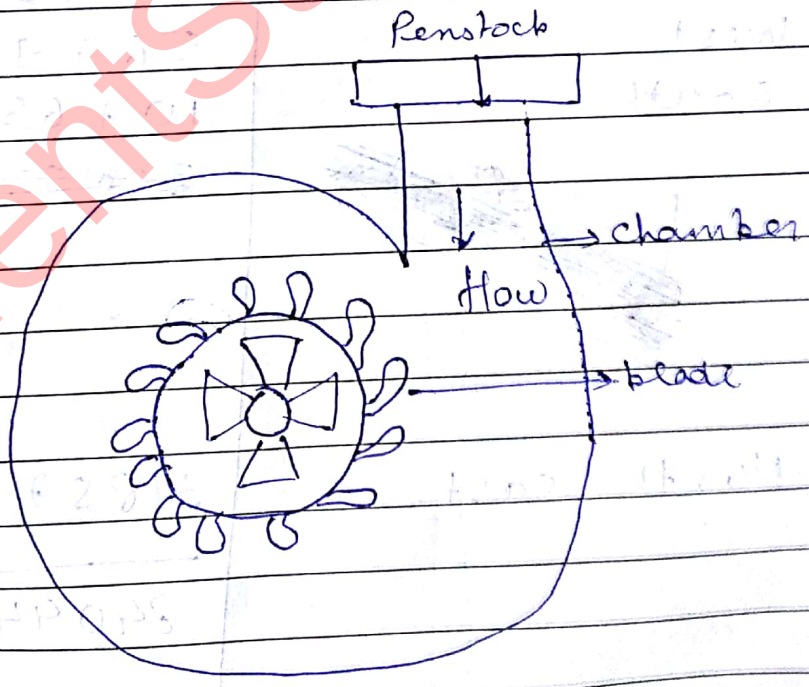
Kaplan turbine is a reaction turbine suitable for low heads (30m). It has adjustable blades. Their speed vary from (300 - 1000).

It is an axial flow device providing large flow area.

All parts of Kaplan turbine except runner are similar to Francis turbine.

It has 3 to 6 blades.

Capable of reverse operation



Hydro potential

1- Hydro-power is a renewable source of energy.

2- In India scope of water power development is tremendous.
First plant was made in 1897 with a capacity of 200 kW.

~~State~~ Region	MW Capacity
~~Andhra Pradesh~~	
North	30155
East	5590
West	5679
South	10763
~~3485~~	
North east.	31857
	84044