Site Selection for Hydroelectric Power Plant: The Site Selection for Hydroelectric Power Plant includes several structures like dam, conduits, intakes, surge tank, power house and many others. It requires several investigations and study to determine the most economical solution. The following factors must be considered while on site selection for a hydroelectric power plant.

- Water availability
- Water storage
- Water head
- Accessibility of the site
- Distance from load center
- Environment Aspects

Water Availability

The most important aspect for a hydel power plant is the water availability at the site because all designs are based on it. Therefore the run-off data for the proposed site should be available. It may not be possible to have run-off data but data as rainfall over the catchment area is always available.

From the data available, an estimate should be made about, average quantity of water available, minimum and maximum quantity of water available throughout the year can be determined. The details of availability of water is necessary:

- To set up peak load plants such as steam, diesel and gas turbine plants.
- To decide the capacity of hydel electric plant.
- To provide spillways (or) gate relief during flood period.

Water storage

There is a wide variation in rainfall over the year, so it is required to store water for continuous generation of power. By using a mass curve, the storage capacity can be calculated. The expenditure on the project depends upon maximum storage.

There are two types of storage.

- The storage is constructed to provide water for one year. In this case storage is full at the beginning of the year and becomes empty by the end of year. So there is no shortage of water throughout the year.
- The storage is constructed to provide water in sufficient quantities even during the worst dry periods.

Water head

The available water head depends upon the topological conditions. To generate the required quantity of power, it is necessary to provide a large quantity of water at a sufficient head. An increase in head, for a given output reduces the quantity of water to be supplied to the turbines. Hence water is supplied to the turbine at high potential.

Accessibility of the site

The Site Selection for Hydroelectric Power Plant should be easily accessible in order to use the electrical power generated. Because once the electricity is produced it must be delivered where it is needed (homes, schools, office) etc., and power must be transmitted over some distance to its users near the plant site. The site should have transportation facilities of rail and road.

Distance from load center

It is of supreme importance that the power plant must be set up near the load center. If distance between the load center is less from the power plant, then cost of erection is reduced and maintenance of transmission line will be easier.

Environment Aspects

The land selected should be efficient and economical for the purpose of selection. The projects should be designed on the basis of best available information to enhance the local environment, and be in the best public interest.

The Site Selection for Hydroelectric Power Plant should fulfill the following requirements.

- To assure a safe, productive, healthy and culturally pleasing environment.
- To preserve important cultural, historic and natural aspects of the site.
- To avoid health hazards and unintended consequences.
- The land selected for the site should be cheap and rocky.

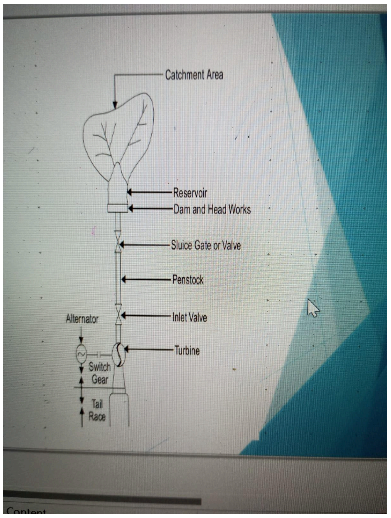
Following factors should be considered while selecting the site for hydro-power plant :

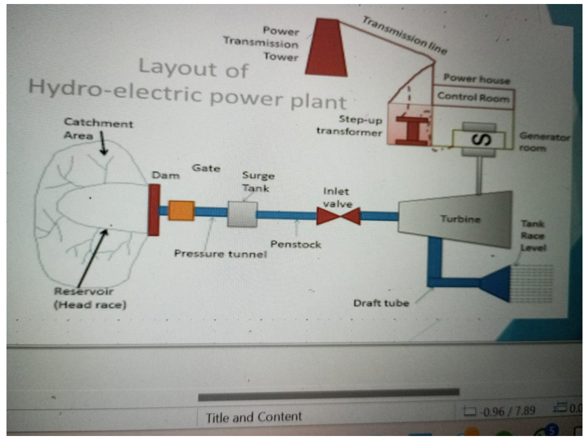
1. Availability of water: Large quantity of water should be available throughout the year at the proposed site.
2. A requirement of head flow availability and storage capacity.
3. The character of the foundation, particularly for the dams.
4. The land should be cheap and rocky.
5. The topography of the surface at the proposed location.
6. Accessibility of the site i.e. the site should have transportation facilities like road and rail.

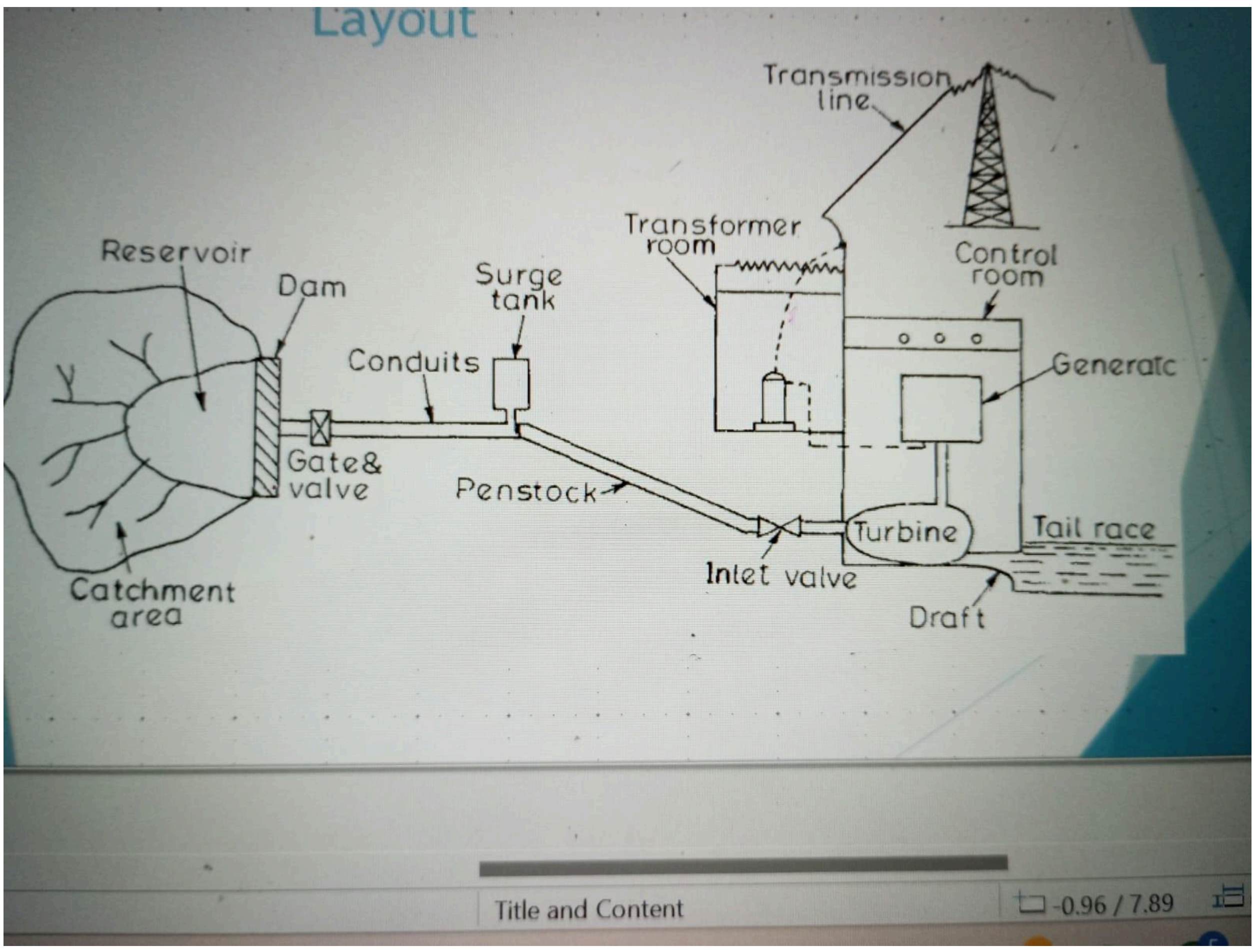
7. Nearness to the load center.
8. Availability of the materials for the construction.
9. Arrangement and type of dam, intakes, conduits, surge tank and powerhouse.
10. Cost of project and period required for completion.
11. Impacts of water pollution.

Hydropower Plant Layout

A simple layout of the hydropower plant as shown in fig. 2.3. It consists of the catchment area, reservoir, dam, slice gate or valve, surge tank, penstock, inlet valve, turbine, draft tube, powerhouse equipment, tailrace, etc.







The collected water from the reservoir is supplied from the dam through slice gate, penstock, inlet valve to the turbine. The turbine converts the potential energy of the water into mechanical energy to run the generator. The generator produces electric power. After doing the work water flows into the tailrace through draft tube.

Components for Hydro Power Plant Layout:

Following are the essential components of the hydro-power plant:

1. Catchment area
2. Reservoir
3. Dam
4. Spillways
5. Penstock
6. Surge tanks
7. Prime movers
8. Draft tubes
9. Powerhouse and equipment.

1 Catchment Area

The whole area behind the dam draining into a stream or river across which the dam has been built at a suitable place is called the catchment area.

2 Reservoir: It is the area where the water is stored and utilized for power generation. A reservoir may be natural or artificial.A natural reservoir is a lake in high mountains. An artificial tank is built by erecting a dam across the river.

3 Dam

A dam is a barrier built across the river to store the water for power generation. Dams are built of concrete or stone masonry, earth, or rockfill. The dam stores the water on one side and on the other side, it is having a powerhouse to generate the power.

4 Spillways

It is a safety valve for a dam. It is provided to discharge the excess water from the dam to safeguard the dam against floods.

5 Penstock

It is a pipe connected between the surge tank and prime mover, usually, these are of steel-reinforced concrete pipes.

6 Surge Tank

There is a sudden increase in pressure in the penstock due to the sudden decrease in the rate of water flow to the turbine when the gates admitting water to the turbines are suddenly closed owing to the action of the governor.

This happens when the load on the generator decreases. This sudden rise of pressure in the penstock above normal due to reduced load on the generator is known as the “water hammer”.

A surge tank is a small reservoir employed between the dam and the powerhouse nearer to the powerhouse to reduce the pressure swings in the penstock by allowing the excess water to enter into the surge tank during low load periods and the stored water can be supplied to the penstock during high load periods.

7 Prime Mover

These are the turbines used to convert the kinetic energy of the water into mechanical energy to produce electric energy.

8 Draft Tube

It is a diverging discharge passage connected to the tailrace. It supports the runner in utilizing the remaining kinetic energy of the water at the discharge end of the runner.

9 PowerHouse

A powerhouse consists of two main parts, a substructure to support the hydraulic and electric equipment such as turbines, generators, valves, pumps, governors, etc., and a superstructure to house and protects these types of equipment.

Types of Hydro Power Plan

Different types of hydro power plants can be classified as follows:

1. According to the availability of head
    1. High head power plants
    2. Medium head power plants
    3. Low head power plants.
2. According to the nature of the load

    1. Base load plants
    2. Peak load plants.
3. According to the availability of water
    1. Runoff river plant without pondage
    2. Runoff river plant with pondage
    3. Storage type plants
    4. Pump storage plants
    5. Mini and micro-hydel plants.

Advantages of Hydro Power Plant

The following are the advantages of a hydro-electric power plant:

1. Low operating cost compared to a thermal power plant.
2. The cost of generation is unaffected by the load factor.
3. No fuel charges.
4. The high useful life of about 100 – 125 years.
5. Low maintenance cost compared to the thermal power plant
6. Highly reliable.
7. It can be started quickly and synchronize the plant.
8. There is no problem with fuel and ash handling.
9. No nuisance badha of smoke exhaust gases and soots. kalikh
10. No health hazards due to air pollution.
11. It has no standby losses.
12. The machines used in hydel plants are robust and have no problem with high temperatures and pressure.
13. The efficiency of the hydel plant does not change with age.
14. The number of operations required is considerably small.
15. It can serve the purpose of flood control and stored water can be used for drinking and irrigation work.
16. Less labour is required to operate the plant.

Disadvantages of Hydro Power Plant

Following are the disadvantages of a hydro-electric power plant:

1. High capital cost.
2. Power generation only dependent on the quantity of water availability.
3. It takes a considerably long time for the construction

4. Site of the hydro-electric power station is always away from the load centre, therefore transmission cost becomes high.
5. Sometimes isolated sites are difficult to access.

Different Types of Turbine used in Hydropower Plant

The turbines are used to convert the kinetic energy of water into mechanical energy. According to the available water head and flow or volume of water, the hydropower turbine is selected. The hydropower turbines are classified into two types;

- Impulse turbine
- Reaction turbine

Impulse Turbine:

As the name suggests, this turbine works on the principle of impulse. It uses the head of water and converts the pressure of water into kinetic energy with the help of nozzles.

In some plants, one or more nozzles are constructed near the runner. This will increase the velocity of the water. And this high-velocity water impinges on the turbine. The turbine has a number of buckets fixed on the outer periphery of the wheel.

The bucket is used to change the direction of jet flow if required. The momentum of water is used to convert kinetic energy into mechanical energy.

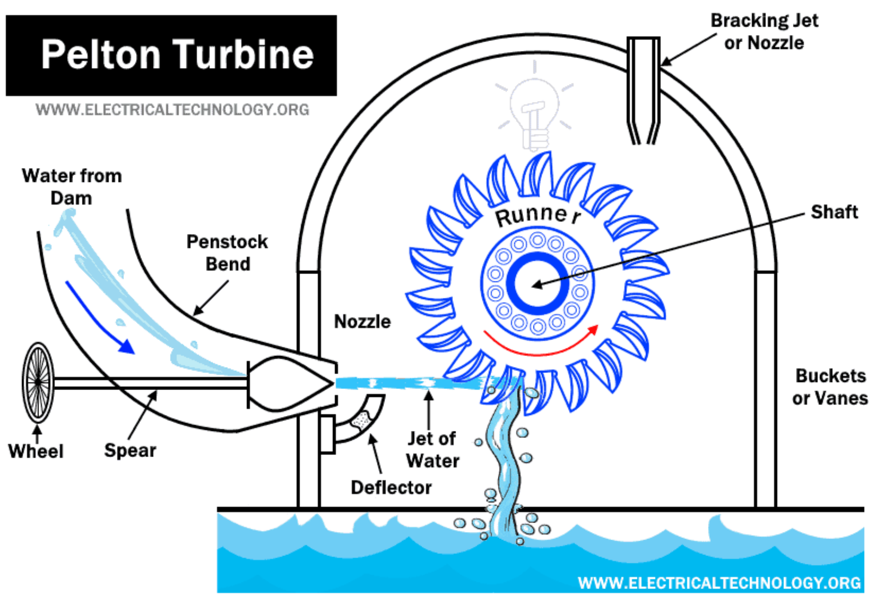
The pressure of water remains constant at atmospheric while passes through the runner. An example of impulse turbine is Pelton turbine, cross-flow turbine;

Pelton Turbine

In a Pelton turbine, the blades are spoon-shaped and the water is allowed to strike via a nozzle to the blade of a turbine. The blade of the Pelton turbine is also known as a bucket. Sometimes, the Pelton turbine is also known as the Pelton wheel.

In some cases, instead of one nozzle, a set of nozzles are used to split into a number of streams. These streams flow along the inner curve of the blade and pass in the opposite direction. This creates an impulse on the blade of the turbine and generates high torque by which the turbine starts rotating.

Generally, Pelton turbines are used in a hydroelectric power plant where the high head and low flow should consider. The plants which have available water head more than 985 feet and have a reservoir of water uses the Pelton wheel.



Cross-flow Turbine

The shape of the cross-flow turbine is similar to the drum and water wheel. This turbine is also known as the Ossberger turbine. The water strikes the rotor of the turbine. For the first time, pressured water transfers impulse force inside the drum, and water leaves the turbine rotor at ambient pressure.

After that, the cross-flow turbine changes the water pressure and converts it into mechanical energy. This will be led to reduce the pressure of water and increase the efficiency of the turbine and produce high torque that rotates the turbine and produce mechanical energy.

Reaction Turbine

In a reaction turbine, first, the pressure energy of water is converted into kinetic energy before supplied to the runner. So, entered water has partially pressure energy and partially kinetic energy. After that, both energies are reduced simultaneously while passing over the runner.

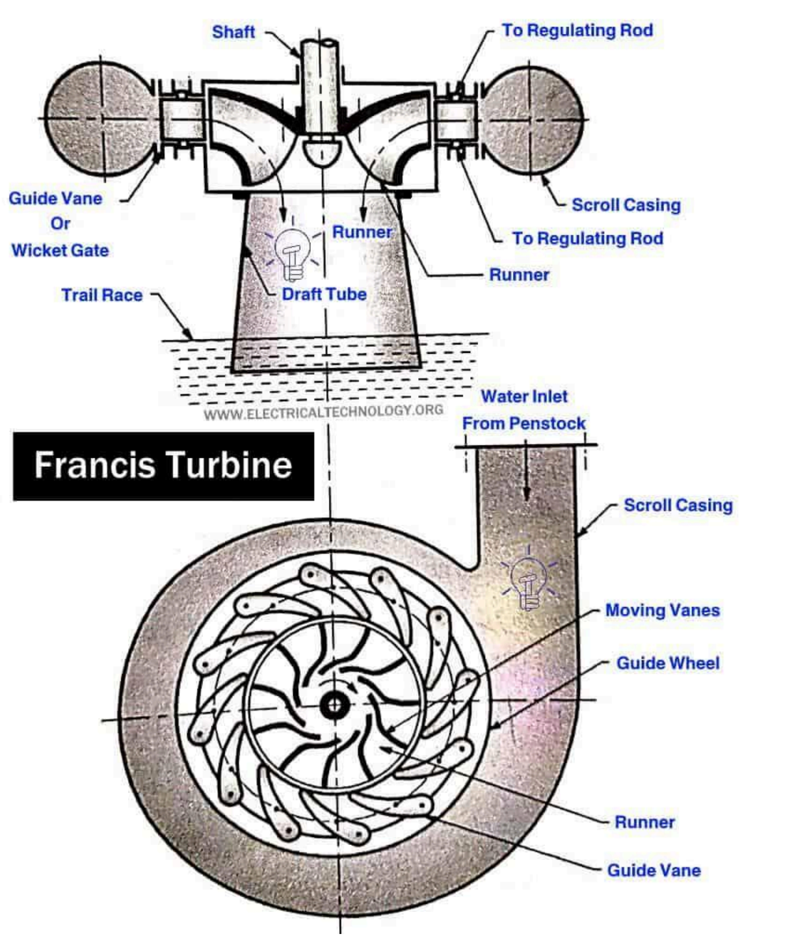
Hence, this turbine works on the principle of impulse reaction. The runner of this turbine is under pressure (above atmospheric pressure). Therefore, the blade of this turbine is filled with water in all conditions.

Examples of reaction turbines are Francis, Kaplan, and Propeller turbines.

Francis Turbine

Francis turbine is the most popular turbine compared to all other types of turbine used in the hydroelectric power plant as it has high efficiency and wide range of water head. This turbine is useful in the plant which has available water head between 130 to 2000 feet.

A Francis turbine can work on both orientations; vertical as well as horizontal. The rapid water strikes the turbine and flows towards the center of the turbine. It leaves the turbine axially parallel to the rotation axis once the water has flown through the turbine.



Propeller Turbine

The propeller turbines are used in low-head plants. This type of turbine has a fixed or adjustable propeller. The diameter of the propeller is large which results in slow rotational speed.

A propeller turbine looks like a large propeller of ships and submarines. The turbine has adjustable guide vanes. The water flow of the turbine is controlled by the vanes. To transfer the energy of water, the vanes move the water into a runner.

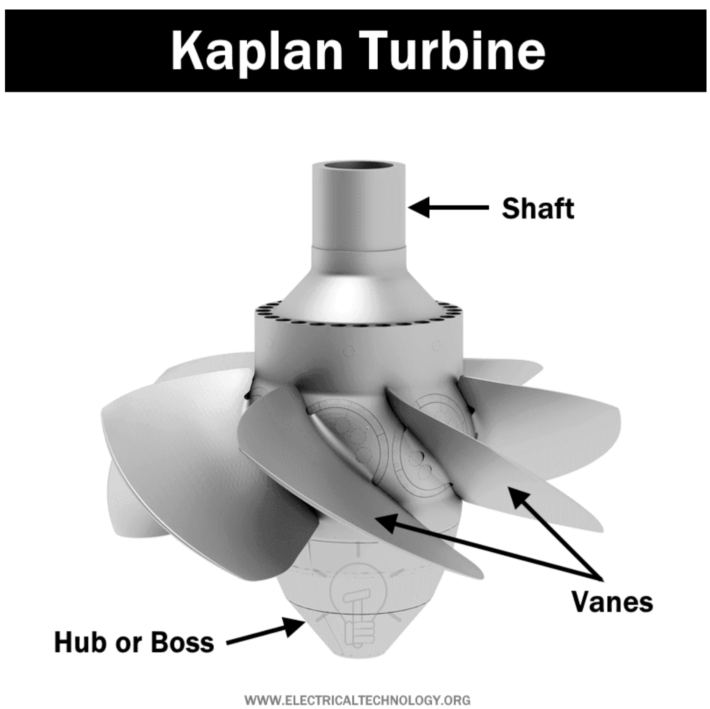
The Kaplan turbine is also a type of propeller turbine. There are many other types of turbine-like; bulb turbine, tube turbine, straflo turbine, etc. But out of these turbines, the Kaplan turbine is widely used in hydroelectric power plants.

Kaplan Turbine

Kaplan turbine is a propeller-type turbine. It has adjustable blades. It was introduced by Australian professor Viktor Kaplan in 1913. The Kaplan turbine is an evolution version of the Francis turbine.

A Kaplan turbine can work with low-head power plants. This is not possible in the case of the Francis turbine. The Kaplan turbine works efficiently with the water head ranges between 33 to 230 feet and the output of the plant between 5 to 200 MW.

The runner diameter lies between 2 to 11 meters. The Kaplan turbines are widely used in high-head and low-head hydroelectric plants.



Governing of Water Turbines:

In order to have electrical output of constant frequency it is necessary to maintain speed of the alternator driven by the turbine constant. This is achieved by controlling the flow of water entering the turbine by the automatic adjustment of guide vanes in case of reaction turbines and of the nozzle needle in the case of impulse turbines. Such an operation of speed regulation is called the governing, and it is attained automatically by means of a governor. In case of impulse turbine the governor also operates the auxiliary relief valves or jet deflectors.

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For the regulation of water below the penstock connection, at the time of decrease in load on the impulse turbines, the governor reduces the water flow from the power nozzle and the surplus water is diverted with the help of auxiliary relief nozzles. In the case of multi-nozzle turbines, a deflector plate deflects some water from the runner buckets by swinging into the water jet from each nozzle. With the movement of deflector plate out of the path of water jets, the needles slowly reduces the flow of water so as to keep the output of the turbine constant at the level of new load.In the case of Francis turbine, there are pressure regulators for discharging the water from the casing to the tailrace at the time of drop in load. The regulators close as fast as the guide vanes open and vice versa.

The governor should be quite sensitive to variations in the shaft speed and should be rapid in action but not so rapid as to cause water hammer in the penstock. The governing systems for the modern hydraulic turbines have a regulating time of 3-5 seconds.

Simplified arrangement of a water turbine governor is illustrated in Fig. 2.22. The principal elements of the governor are:

1. The speed-responsive element—usually flyball mechanism or speed (centrifugal) governor.

2. Control valve or relay valve to supply fluid under pressure to the power cylinder (servomotor) in order to actuate the turbine control mechanism. The use of control valve and servomotor is to amplify the small force created by the flyballs.

3. The restoring mechanism or follow-up linkage to hold the servomotor in required fixed position when the turbine output and load demand are equalised.

4. The fluid pressure supply required for the action of servomotor.

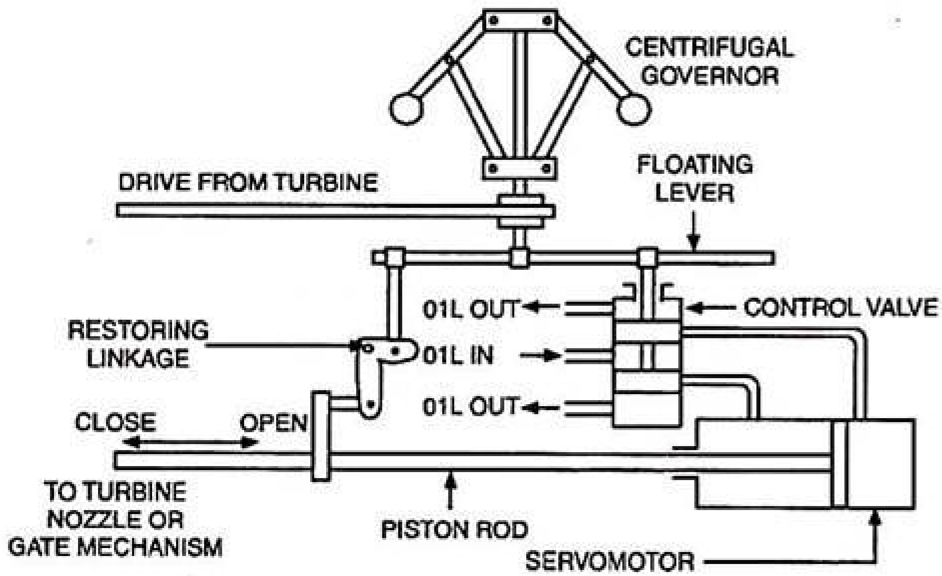


Fig. 2.22. ***Governing of Water Turbines***

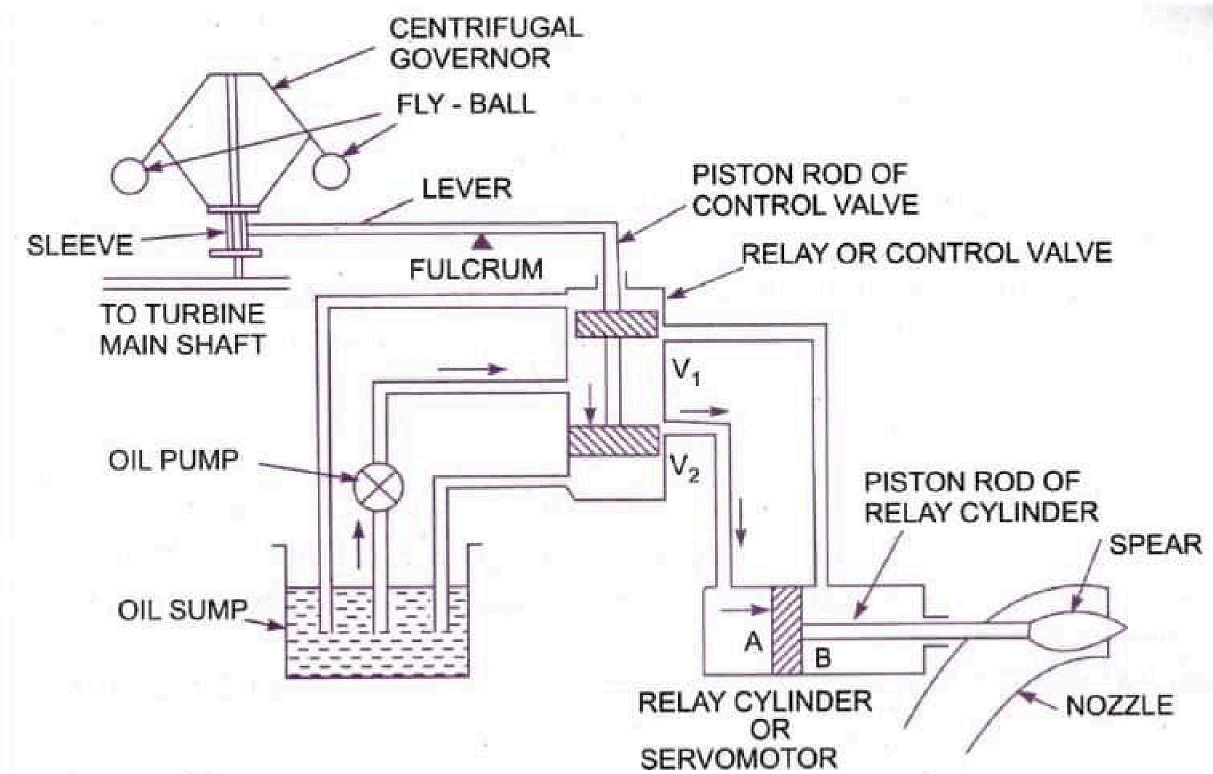
The flyballs may be belt driven, as shown in Fig. 2.22 or driven by a small electric motor fed from a separate generator operated in synchronism with the turbine. When the load on the turbine decreases, the speed of the turbine increases, consequently, the flyballs also rotate at high speed and move outwards. The floating lever gets lifted up, control valve is displaced upwards from its central or dead beat position, the upper port is uncovered and the oil flows from a pressure tank through the port into the right hand end of the servomotor cylinder.

The piston moves to the left and closes the nozzle with the help of a spear in the case of Pelton wheels and adjusts the guide vanes in the case of reaction turbines. In case of increase of load on the generator, the speed of the turbine will decrease and the reverse action would take place. The restoring or follow up linkage resets the relay; pilot or control valve after the servomotor piston has adjusted the water control mechanism.

In case of Pelton wheel a combined spear and deflector regulation is employed in order to avoid water hammer in the penstock. In case of decrease of load on turbine, the deflector, which is usually a plate connected to the servomotor by means of levers, is brought in between the nozzle and buckets, thereby, diverting water away from the runner and directing into the tailrace. In the mean time, the spear has been adjusted to the new position of equilibrium and the deflector plate is moved out of the path of water nozzle.

Working of Governing Of Impulse turbine (Pelton Wheel):

- When the load on the generator decreases, the speed of the generator increases. Hence the speed of the turbine also increases beyond the normal speed.
- The centrifugal governor which is connected to the turbine main shaft will be rotating at an increased speed and hence centrifugal force on the fly ball increases and it moves upward. The sleeve of the governor will also move upward.
- As the sleeve moves upward, a horizontal lever turns about the fulcrum, and the piston rod of the control valve moves downward. This closes the valve V1 and opens the valve V2 as shown in Fig.



Governing of Pelton wheel (Spear regulation)

Governing of Pelton wheel – (Impulse turbine)

- The oil pumped from the oil pump to the control valve under pressure will flow through the valve V2 to the servomotor and will exert force on the face A of the piston of the relay cylinder.
- Piston along with piston rod and spear will move towards the right. This will decrease the area of flow of water at the outlet of the nozzle and it will reduce the rate of flow to the turbine which consequently reduces the speed of the turbine.
- Meanwhile, the bell crank lever moves downward, the jet deflector will operate and divert the whole or part of the jet away from the buckets.
- As soon as speed becomes normal, the fly balls, sleeves, lever and piston rod come to its normal position.

rence Between Impulse and Reaction Turbine

S.no	Impulse Turbine	Reaction Turbine
1.	In an impulse turbine, the steam flows through the nozzle and strike on the moving blades.	In the reaction turbine, first, the steam flows through the guide mechanism and then flows through the moving blades.
2.	Steam strikes on the buckets with kinetic energy.	The steam glides over the moving blades with both pressure and kinetic energy.
3.	During the flow of steam through moving blades, its pressure remains constant.	During the flow of steam through moving blades its pressure reduces.
4.	The steam may or may not be admitted to the whole circumference.	The steam must be admitted over the whole circumference.
5.	The blades of impulse turbine are symmetrical.	The blades of reaction turbine are not symmetrical.
6.	While gliding over the blades the relative velocity of steam remains constant.	In reaction turbine, while gliding over the blades the relative velocity of steam increases.
7.	For the same power developed, the number of stages required is less.	For the same power developed, the number of stages required is more.
8.	The direction of steam flow is radial to the direction of turbine wheel.	The direction of steam flow is radial and axial to the turbine wheel.
9.	It requires less maintenance work.	It requires more maintenance work.
10.	It is suitable for low discharge.	It is suitable for medium and high discharge.
11.	Pelton Wheel is the example of impulse turbine.	Francis turbine, Kaplan turbine etc. are the examples of reaction

		turbine.