HYDRO ELECTRIC POWER PLANTS

In hydro electric power plants Kinetic Energy of water is converted into mechanical energy by a turbine and then electrical energy by a generator.

CLASSIFICATION

1. Classification according to the availability of load
   a. Low head power plant
   b. Medium head power plant
   b. High head power plant

   Classification according to the nature ofload
   c. Base load plant   b. Peak load plant

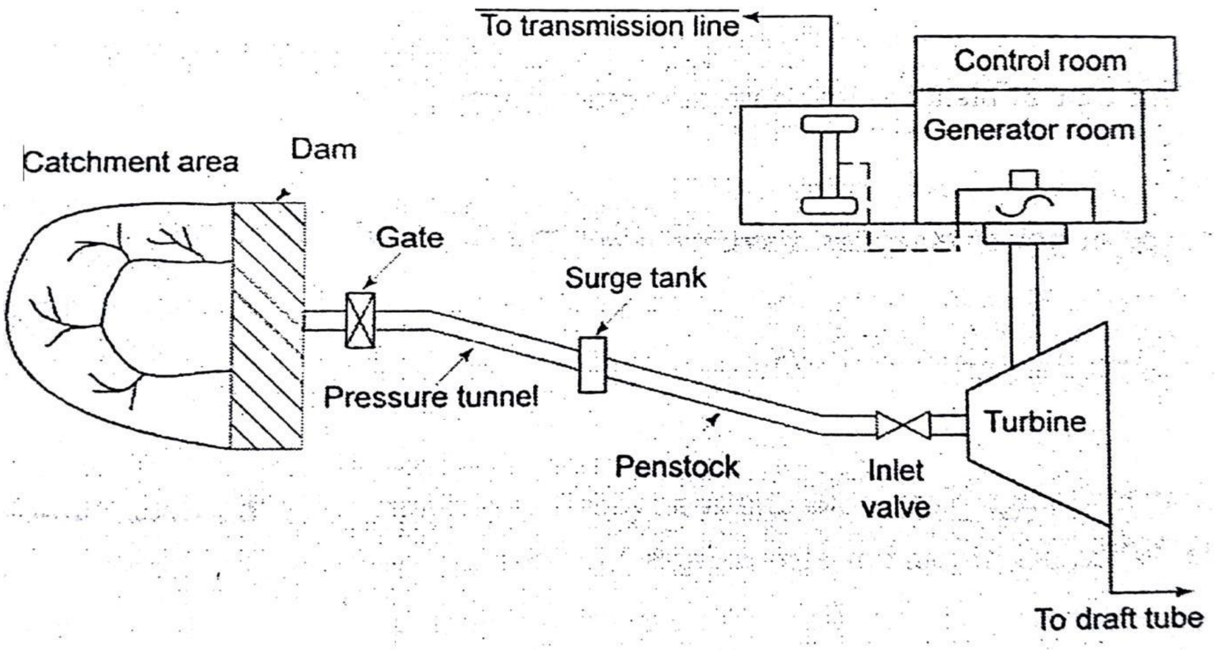
2. Classification according to the quantity of water available
   a. Run-off river plant without pondage
   b. Run-off river plant with pondage
   c. Pumped storage plant

3. Classification based on the power developed by the plant

Large hydro	More than 100 MW
Medium hydro	15-100 MW
Small hydro	1-14 MW
Mini hydro	Above 100kW but below 1 MW
Micro hydro	From 5 kW upto 100 kW
Pico hydro	From few hundred watts upto 5 kW

<u>**LAYOUT OF HYDRO ELECTRIC POWER PLANT**</u>

Fig. shows the typical layout of a hydroelectric power plant and its basic components.



Layout of hydroelectric power plant

The different parts of a hydroelectric power plant are

(1) Dam

Dams are structures built over rivers to stop the water flow and form a reservoir. The reservoir stores the water flowing down the river. This water is diverted to turbines in power stations. The dams collect water during the rainy season and stores it, thus allowing for a steady flow through the turbines throughout the year. Dams are also used for controlling floods and irrigation. The dams should be water-tight and should be able to withstand the pressure exerted by the water on it. There are different types of dams such as arch dams, gravity dams and buttress dams. The height of water in the dam is called *head race*.

(2) Spillway

A spillway as the name suggests could be called as a way for spilling of water from dams. It is used to provide for the release of flood water from a dam. It is used to prevent over toping of the dams which could result in damage or failure of dams. Spillways could be controlled type or uncontrolled type. The uncontrolled types start releasing water upon water rising above a particular level. But in case of the controlled type, regulation of flow is possible.

(3) Penstock and Tunnel

Penstocks are pipes which carry water from the reservoir to the turbines inside power station. They are usually made of steel and are equipped with gate systems.Water under high pressure flows through the penstock. A tunnel serves the same purpose as a penstock. It is used when an obstruction is present between the dam and power station such as a mountain.

(4) Surge Tank

Surge tanks are tanks connected to the water conductor system. It serves the purpose of reducing water hammering in pipes which can cause damage to pipes. The sudden surges of water in penstock is taken by the surge tank, and when the water requirements increase, it supplies the collected water thereby regulating water flow and pressure inside the penstock.

(5) Power Station

Power station contains a turbine coupled to a generator (see the cross section of a power house on the left). The water brought to the power station rotates the vanes of the turbine producing torque and rotation of turbine shaft. This rotational torque is transferred to the generator and is converted into electricity. The used water is released through the *tail race*. The difference between head race and tail race is called gross head and by subtracting the frictional losses we get the net head available to the turbine for generation of electricity.

Advantages

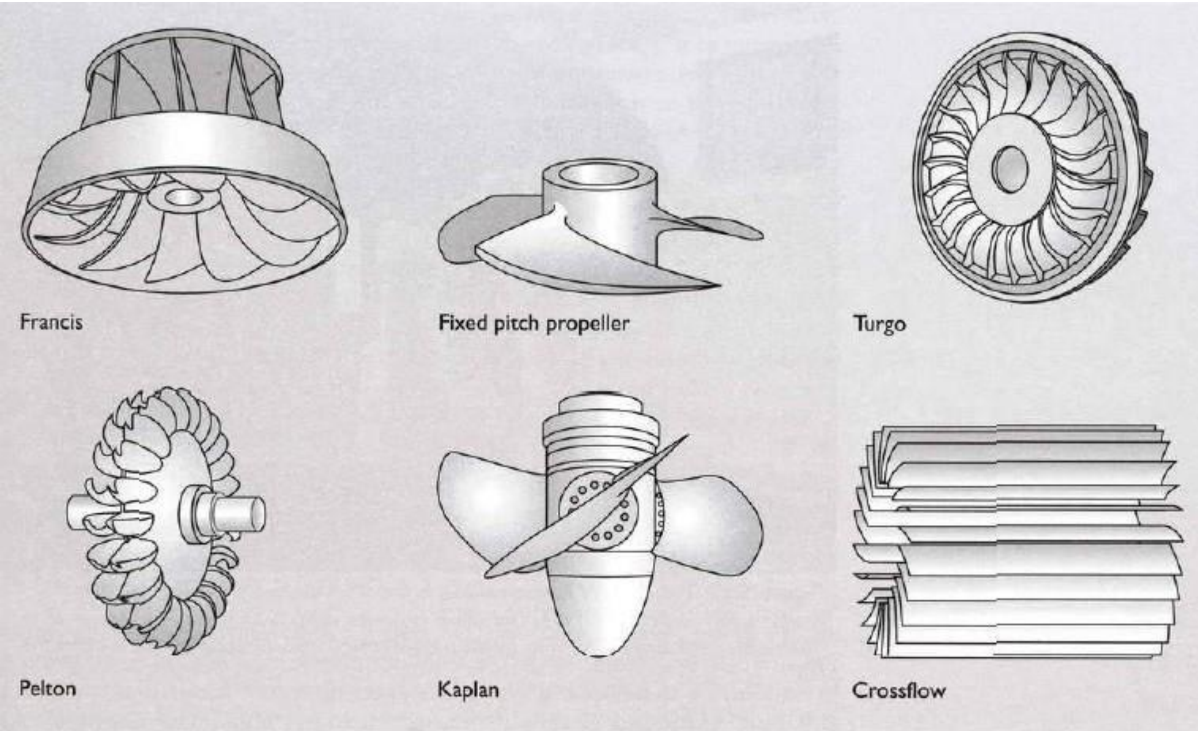
- No fuel is required as potential energy is stored water is used for electricity generation
- Neat and clean source of energy
- Very small running charges - as water is available free of cost
- Comparatively less maintenance is required and has longer life
- Serves other purposes too, such as irrigation

Disadvantages

- Very high capital cost due to construction of dam
- High cost of transmission – as hydro plants are located in hilly areas which are quite away from the consumers

WATER TURBINE

There are two main categories of hydro turbines: impulse and reaction, as described above. The type of hydropower turbine selected for a project is based on the height of standing water—referred to as "head"—and the flow, or volume of water, at the site. The most common type of impulse turbine is Pelton turbine. There are also Turgo turbine, Cross-flow turbine (also known as the Bánki-Michell turbine, or Ossberger turbine), Jonval turbine, Reverse overshot water-wheel,Screw turbine.On the other side,the most common reaction turbine is Francis turbine but there are also Kaplan turbine,Tyson turbine,Gorlov helical turbine.



1. PELTON TURBINE

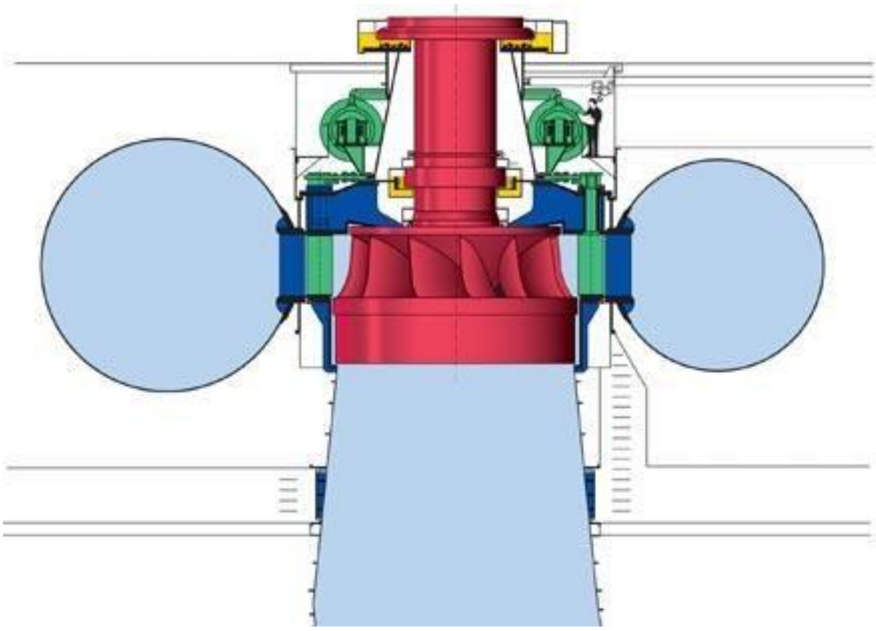
Pelton turbine or wheel is an impulsive turbine used mainly for high head hydroelectric schemes. The Pelton wheel is among the most efficient types of water turbines. The fluid power is converted into kinetic energy in the nozzles. The total pressure drop occurs in the nozzle. The resulting jet of water is directed tangentially at buckets on the wheel producing impulsive force on them.

Nozzles direct forceful, high-speed streams of water against a rotary series of spoon-shaped buckets, also known as impulse blades, which are mounted around the circumferential rim of a drive wheel. As the water jet impinges upon the contoured bucket-blades, the direction of water velocity is changed to follow the contours of the bucket. Water impulse energy exerts torque on the bucket and wheel system, spinning the wheel, the water stream itself does a "u-turn" and exits at the outer sides of the bucket, decelerated to a low velocity. In the process, the water jet's momentum is transferred to the wheel and thence to a turbine. Thus, "impulse" energy does work on the turbine. For maximum power and efficiency, the wheel and turbine system is designed such that the water jet velocity is twice the velocity of the rotating buckets. A very small percentage of the water jet's original kinetic energy will remain in the water, which causes the bucket to be emptied at the same rate it is filled and thereby allows the high-pressure input flow to continue uninterrupted and without waste of energy. Typically two buckets are mounted side-by-side on the wheel, which permits splitting the water jet into two equal streams. This balances the side-load forces on the wheel and helps to ensure smooth, efficient transfer of momentum of the fluid jet of water to the turbine wheel.

Pelton wheels are the preferred turbine for hydro-power, when the available water source has relatively high hydraulic head at low flow rates, where the Pelton wheel is most efficient. Thus, more power can be extracted from a water source with high-pressure and low-flow than from a source with low-pressure and high-flow, even when the two flows theoretically contain the same power. Also a comparable amount of pipe material is required for each of the two sources, one requiring a long thin pipe, and the other a short wide pipe. Pelton wheels are made in all sizes. There exist multi-ton Pelton wheels mounted on vertical oil pad bearings in hydroelectric plants. The largest units can be up to 200 megawatts. The smallest Pelton wheels are only a few inches across, and can be used to tap power from mountain streams having flows of a few gallons per minute. Some of these systems use household plumbing fixtures for water delivery. These small units are recommended for use with 30 feet (9.1 m) or more of head, in order to generate significant power levels. Depending on water flow and design, Pelton wheels operate best with heads from 49–5,905 feet (14.9–1,799.8 m), although there is no theoretical limit.

2. FRANCIS TURBINE

The Francis turbine is a reaction turbine where water changes pressure as it moves through the turbine, transferring its energy. A watertight casement is needed to contain the water flow. Generally such turbines are suitable for sites such as dams where they are located between the high pressure water source and the low pressure water exit. Francis turbines are the most common water turbine in use today. They operate in a water head from 40 to 600 m (130 to 2,000 ft) and are primarily used for electrical power production.



Water flows from the penstock into the spiral casing. In the spiral casing the water is distributed around the complete periphery. The water is then guided by the stay vanes and guide vanes in the correct angle towards the runner. The guide vanes are adjustable and can change the angle depending on the inlet and outlet conditions of the turbine, they are controlled by a governor servo motor. The runner transfers the energy from the pressure and velocity in the water to a rotational momentum. The water exits through a draft tube that extracts the remaining energy in the water. The torque produced in the runner is transferred to a power producing generator through a shaft.

Francis turbines may be designed for a wide range of heads and flows. This, along with their high efficiency, has made them the most widely used turbine in the world. Francis type units cover a head range from 40 to 600 m (130 to 2,000 ft), and their connected generator output power varies from just a few kilowatts up to 800 MW. Large Francis turbines are individually designed for each site to operate with the given water supply and water head at the highest possible efficiency, typically over 90%. In addition to electrical production, they may also be used for pumped storage, where a reservoir is filled by the turbine (acting as a pump) driven by the generator acting as a large electrical motor during periods of low power demand, and then reversed and used to generate power during peak demand. These pump storage reservoirs, etc. act as large energy storage sources to store "excess" electrical energy in the form of water in elevated reservoirs. This is one of only a few ways that temporary excess electrical capacity can be stored for later utilization.

3. KAPLAN TURBINES

The Kaplan turbine has adjustable blades and was developed on the basic platform (design principles) of the Francis turbine by the Viktor Kaplan in 1913. The main advantage of Kaplan turbines is its ability to work in low head sites which was not possible with Francis turbines. Kaplan turbines are widely used in high-flow, low-head power production. The Kaplan turbine is an inward flow reaction turbine, which means that the working fluid changes pressure as it moves through the turbine and gives up its energy. The design combines radial and axial features. The inlet is a scroll-shaped tube that wraps around the turbine’s wicket gate. Water is directed tangentially through the wicket gate and spirals onto a propeller shaped runner, causing it to spin.

The outlet is a specially shaped draft tube that helps decelerate the water and recover kinetic energy. The turbine does not need to be at the lowest point of water flow, as long as the draft tube remains full of water. A higher turbine location, however, increases the suction that is imparted on the turbine blades by the draft tube that may lead to cavitations due to the pressure drop. Typically the efficiencies achieved for Kaplan turbine are over 90%, mainly due to the variable geometry of wicket gate and turbine blades. This efficiency however maybe lower for very low head applications. Since the propeller blades are rotated by high- pressure hydraulic oil, a critical design element of Kaplan turbine is to maintain a positive seal to prevent leakage of oil into the waterway. Kaplan turbines are widely used throughout the world for electrical power production. They are especially suited for the low head hydro and high flow conditions – mostly in canal based hydro power sites.