ASSIGNMENT 4

RENEWABLE ENERGY SYSTEMS

BY

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23EE025

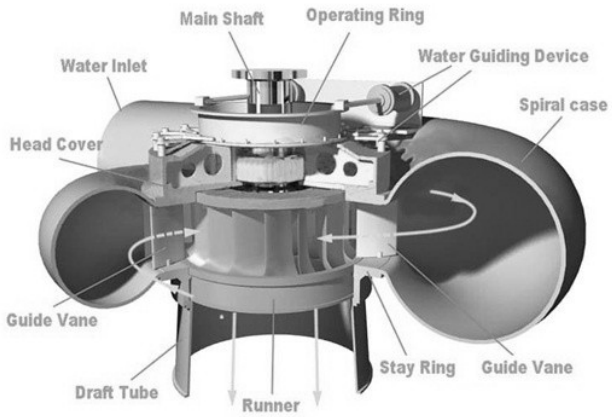
Classification Of Water Turbines

Water Turbine

A rotating machine that is used to change the energies of water like kinetic & potential into mechanical work is known as a water turbine. These are used mostly in the dams for the generation of electric power using the potential energy of the fluid. Modern water turbines operating efficiency is higher than 90%. The **Water turbine diagram** is shown below.

Construction

The most frequently used Francis water turbine is shown below. This can be designed with different components like the main shaft, operating ring, water guiding device, spiral case, guide vane, stay ring, runner, draft tube, headcover & fluid inlet. The **construction of the water turbine** is shown below.



This is a combination of both reaction & impulse turbine, where the blades in this turbine turn with both impulse & reaction water supply force so that it generates electricity very efficiently. In hydropower stations, this type is most frequently used for electricity production within hydropower stations.

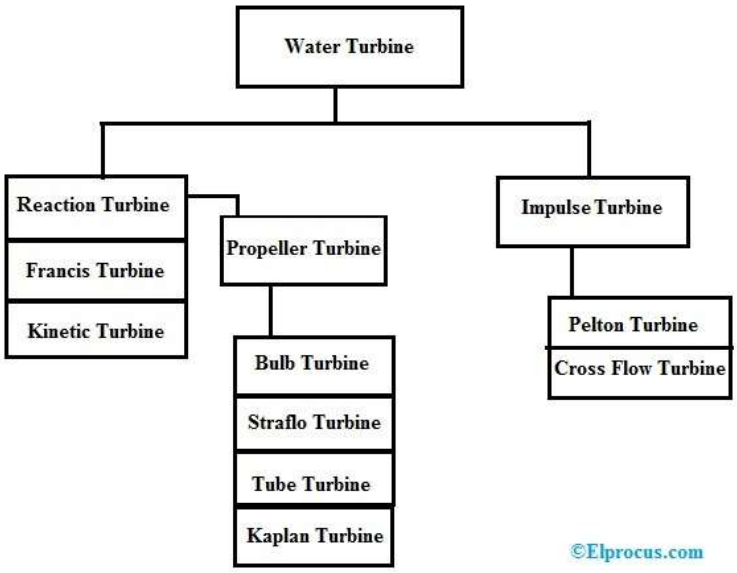
There are two turbines flow patterns based on working like radial flow & axial flow. An American civil engineer like James B. Francis came up with an idea by combining both turbines like impulse & reaction where water supplies radically into the turbine & axially exits.

Water Turbine Working Principle

Turbines are fundamentally work based on Isaac Newton's third law because this law states that for each action there is also an equivalent and reverse reaction. Generally, Turbines are fixed in position so once water supplies throughout it then there is a drop within force at the backside of every blade that pushes the turbine to revolve. For water or air, the working principle is similar, the medium will move faster, the pressure is greater & the turbine spins will be faster.

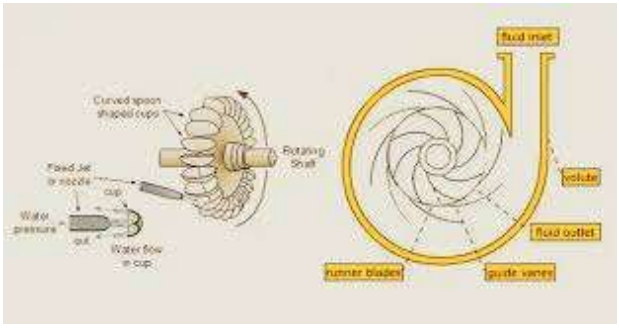
Water Turbine Types

The working of the turbine mainly depends on different factors like height of “head”, water flow, deepness to set the turbine, efficiency, cost, etc. There are two main types of hydropower turbines: reaction and impulse.



Reaction Turbine

This turbine generates power once both the forces are combined like moving water and pressure. A runner is directly located within the water stream so that water flows on the turbine blades instead of hitting every blade separately. Generally, these turbines are mostly used in the United States due to their lower head & higher water flow. The most frequently used reaction turbines are Francis & Propeller. Kinetic turbines are also reaction turbines.



Propeller Turbine

Generally, a propeller turbine includes a runner with a minimum of 3 to a maximum of 6 blades. This is an inward flow reaction type turbine with a propeller-shaped runner, used in submarines & ships. This runner can be designed with either adjustable or fixed blades. In this turbine, the flow of water can be changed through wicket gates or variable guide vanes which move the water into the runner for transferring its energy toward the blades. Generally, this turbine is used in hydraulic sites through high flow rates.

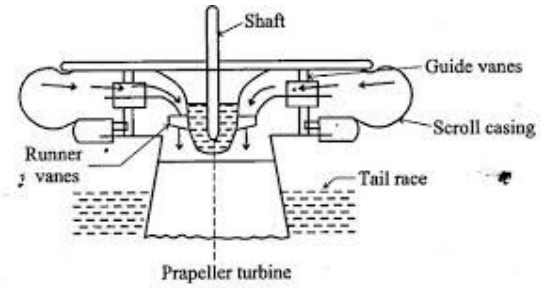
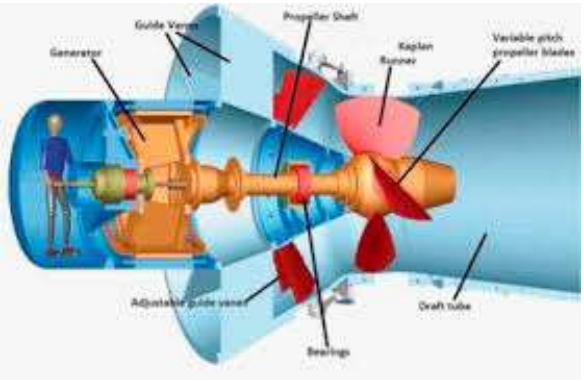


Figure 5.22 Propeller turbine

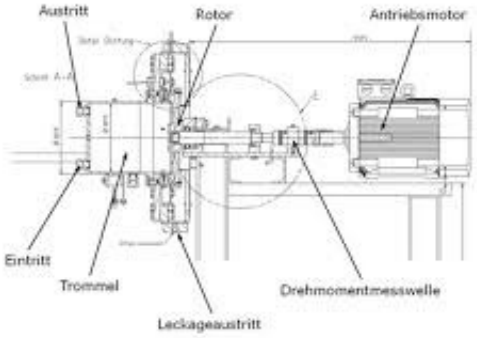
Bulb Turbine

This is a reaction turbine, used for very low heads. As the name suggests, the components of this turbine and the generator are located in a bulb. This turbine includes different blades based on the water flow and head. As compared to the Kaplan turbine, this turbine includes higher flow capacity & full-load efficiency. The construction cost of this turbine is low.



Straflo

These are axial turbines where the generator is placed at the outside of the water channel and is connected to the edge of the runner. These turbines reduce the requirement of the bulb by placing the generator outside of the water channel.



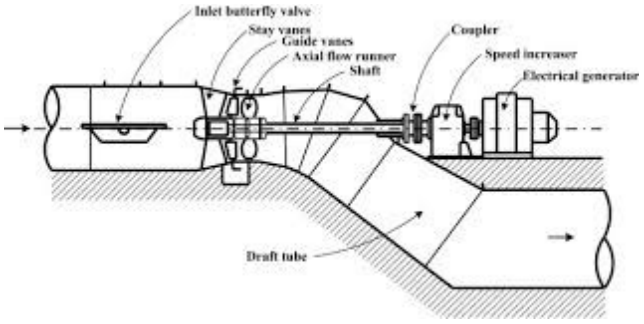
Tube Turbine

The power range of this turbine ranges from 20 kW to 700 kW where the generator

and the turbine are located on a similar shaft including common seals & bearings. The configuration of a tube turbine generator is used where there is a penstock feeding water toward the plant.

Generally, a closing device is a butterfly valve where is opened normally through a hydraulic power pack & blocked through dead weight. A flexible connection is necessary between the turbine and valve to allow fitting & elimination of the unit.

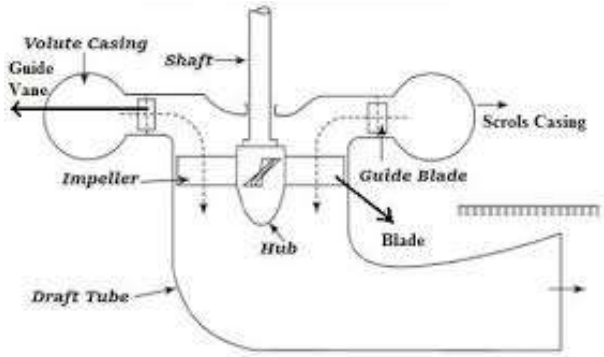
Here, the power plant design can be simplified by selecting an installation angle among horizontal & vertical. The requirement of space for this turbine unit is small & no separate installation beds are necessary.



Kaplan Turbine

The propeller-type is a Kaplan turbine that includes adjustable blades. This turbine was developed by an Austrian professor namely "Viktor Kaplan" in the year 1913. He combined the propeller blades with wicket gates which are automatically adjusted to get efficiency on a wide range of water flow & levels.

These turbines are at present used widely worldwide in low-head & high-flow power production. The head of this turbine mainly ranges from 33 to 230 ft whereas its output mainly ranges from 5 to 200 MW.

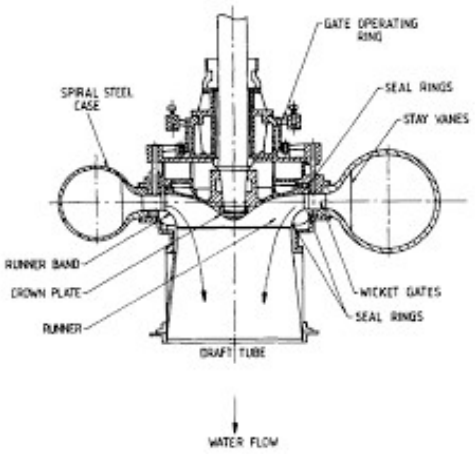


Francis Turbine

The first modern hydropower turbine is the Francis turbine, invented by an Engineer namely 'James Francis' in the year 1849. This turbine includes a runner through fixed blades

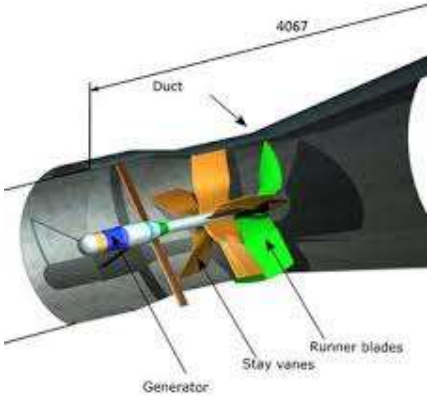
where the flow of water around the runner can cause the blades to rotate. The components used beside the runner are a draft tube, scroll case & wicket gates.

These turbines are mainly used in medium to high head situations and used for low heads also. This turbine performs very well in both the orientations like vertical & horizontal.



Kinetic Turbine

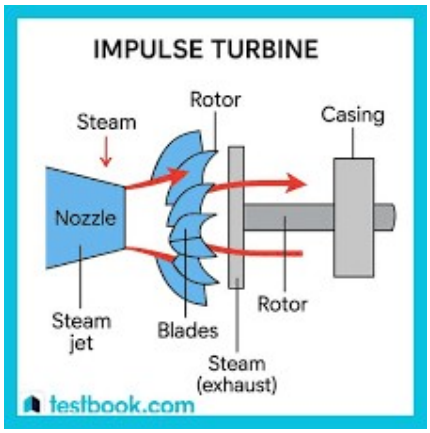
These turbines are also known as free-flow turbines, used for generating electricity from the KE (kinetic energy) within the water flow instead of the potential energy (PE) from the head of the turbine. These turbines work in tidal waters, rivers, man-made channels & ocean currents because kinetic systems naturally use water streams and they do not need water diversion throughout riverbeds, pipes, and man-made channels. Kinetic systems do not need large civil works as they can utilize existing structures like tailraces, channels & bridges.



Impulse Turbine

Generally, this type of turbine uses the speed of the water for rotating the runner & releases atmospheric force. A water stream strikes every bucket on the runner. The water flows out the base of the turbine after striking the runner without suction on the base of the turbine.

Generally, an impulse turbine is used for low flow and high speed-based applications. The impulse turbines are classified into two types like Pelton & crossflow.



Pelton Turbine

Pelton turbine was invented in the year 1870 by American inventor namely “Lester Allan Pelton”. Generally, these turbines are used for extremely high heads & low flows. Draft tubes are not required for an impulse turbine because the runner should be located above the maximum tailwater to permit operation at atmospheric pressure.

This turbine includes a minimum of one or several free jets which discharges water into an aerated gap & intrudes on the runner buckets.

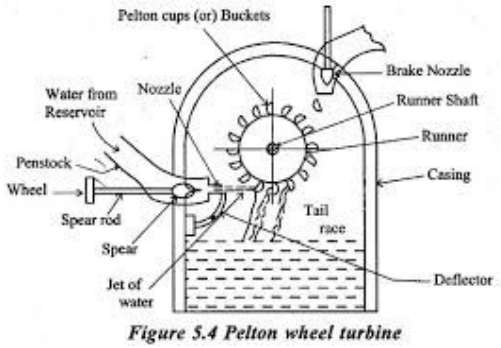
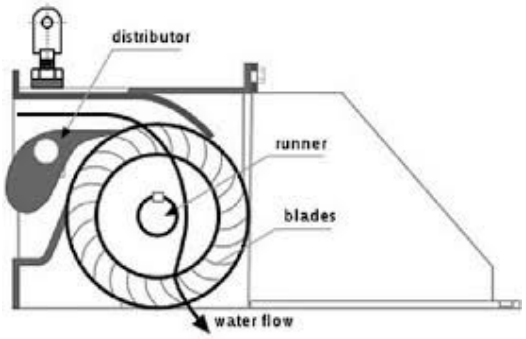


Figure 5.4 Pelton wheel turbine

Cross-Flow Turbine

The cross-flow turbine was invented by an Austrian engineer namely “Anthony Michelle” in the year 1900. Later, some improvisations on this design have done by a Hungarian engineer like Donát Bánki & a German engineer like Fritz Ossberger. This turbine is available in drum shape with a rectangular-shaped nozzle directed next to bent vanes on a cylindrically model runner. It looks like a squirrel cage blower.

This turbine allows the flow of water throughout the blades two times. For the first time, water supplies from the external side of the blades to the inside. After that, the water supplies from the inside back out.
At the beginning of the turbine, a guide vane directs the flow of water into a restricted part of the runner. This turbine was designed to hold a huge water supply & lower heads than the Pelton turbine can handle.



Advantages

The **advantages of a water turbine** include the following.

- These are Renewable.
- Emission Free.
- Consistent.
- Changeable.
- It can create small lakes.
- Lands can be developed very fast.
- Hydropower gives several benefits like irrigation support, flood control & clean drinking water.
- Hydropower is inexpensive.
- It provides inexpensive electricity & strength eventually as compared to other energy sources.

The **disadvantages of a water turbine** include the following.

- Effects on fishes in the water
- Plant locations are limited
- The initial cost is high
- Methane & carbon emissions
- Flood Risk

Applications

The **applications of a water turbine** include the following.

- These are widely used for industries to electrical grids
- These turbines are mostly used for generating electric power.

- These turbines are available in dams for generating electric power using the potential energy of water.
- The most widely used Francis turbine is used within hydro-power plants for producing electricity.
- A mixed-flow type turbine is used in irrigation for pumping water from the ground.
- It is a very efficient type of turbine as compared to others.