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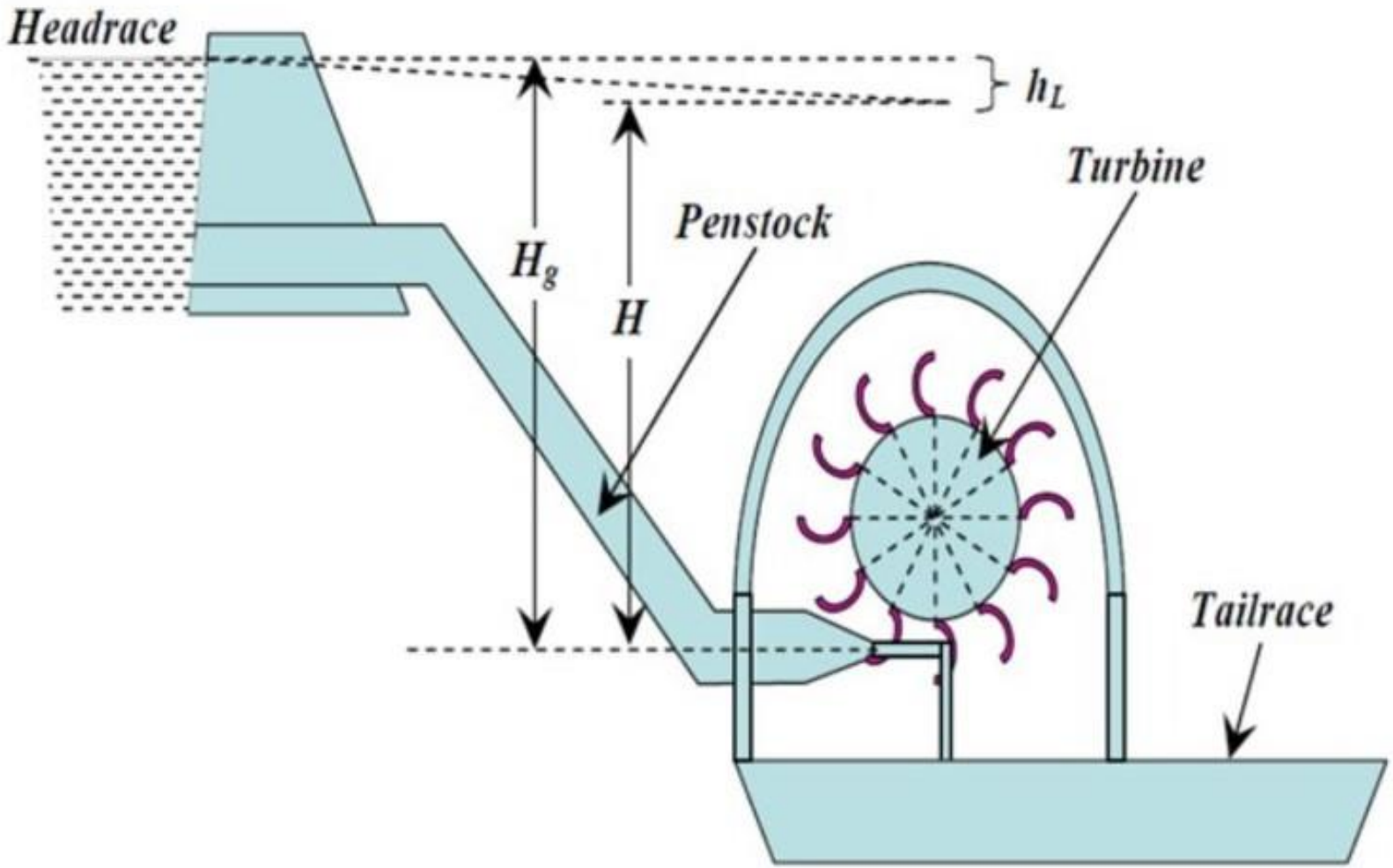
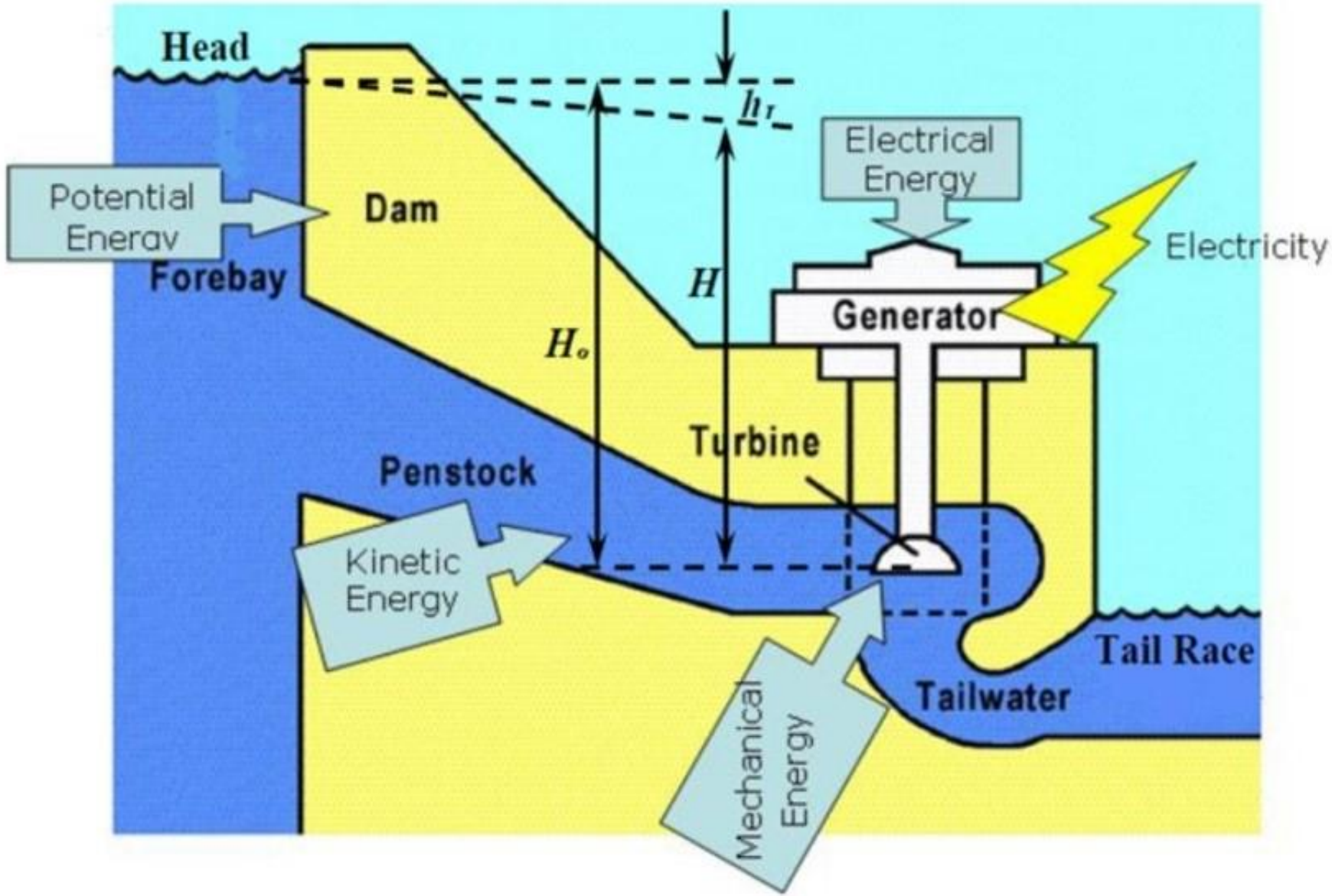
Intoduction

- Water under pressure contains energy.
- Turbines convert the energy in water into rotating mechanical energy.
- Impulse turbines convert the kinetic energy of a jet of water to mechanical energy.
- Reaction turbines convert potential energy in pressurized water to mechanical energy.

- The device which converts hydraulic energy into mechanical energy or vice versa is known as ***Hydraulic Machines.***
- The hydraulic machines which convert hydraulic energy into mechanical energy are known as ***Turbines and that convert mechanical energy into hydraulic energy is*** known as ***Pumps.***

General layout of Hydraulic Plant




Head
h_f
Electrical Energy
Potential Energy
Dam
Forebay
H
Electricity
Generator
H_o
Turbine
Penstock
Kinetic Energy
Tail Race
Tailwater
Mechanical Energy

- A ***Dam constructed across a river or a channel to store water. The*** reservoir is also known as ***Headrace.***
- Pipes of large diameter called ***Penstocks which carry water under*** pressure from storage reservoir to the turbines. These pipes are usually made of steel or reinforced concrete.
- ***Turbines having different types of vanes or buckets or blades*** mounted on a wheel called runner.
- ***Tailrace which is a channel carrying water away from the turbine*** after the water has worked on the turbines. The water surface in the tailrace is also referred to as tailrace.

Important Terms:

- ***Gross Head (Hg): It is the vertical difference between headrace and*** tailrace.
- ***Net Head:(H): Net head or effective head is the actual head available*** at the inlet of the to work on the turbine.
- $H = H_g - h_L$
- Where h_L ***is the total head loss during the transit of water from the*** headrace to tailrace which is mainly head loss due to friction, and is given by

$$h_f = \frac{4 f L V^2}{2 g d}$$

- Where *f is the coefficient of friction of penstock depending on the* type of material of penstock
- *L is the total length of penstock*
- *V is the mean flow velocity of water through the penstock*
- *D is the diameter of penstock and*
- *g is the acceleration due to gravity*

- A hydraulic machine is a device in which mechanical energy is transferred from the liquid flowing through the machine to its operating member (runner, piston and others) or from the operating member of the machine to the liquid flowing through it.
- Hydraulic machines in which, the operating member receives energy from the liquid flowing through it and the inlet energy of the liquid is greater than the outlet energy of the liquid are referred as hydraulic turbines.

- Hydraulic machines in which energy is transmitted from the working member to the flowing liquid and the energy of the liquid at the outlet of the hydraulic machine is less than the outlet energy are referred to as pumps.
- It is well known from *Newton's Law that to change momentum fluid, a force is* required. Similarly, when momentum of fluid is changed, a force is generated. This principle is made use in hydraulic turbine.

What is a TURBINE???

- A turbine is a rotary mechanical device that extracts energy from a fast moving flow of water, steam, gas, air, or other fluid and converts it into useful work.

- A turbine is a turbo-machine with at least one moving part called a rotor assembly, which is a shaft or drum with blades attached.

- Moving fluid acts on the blades so that they move and impart rotational energy to the rotor.

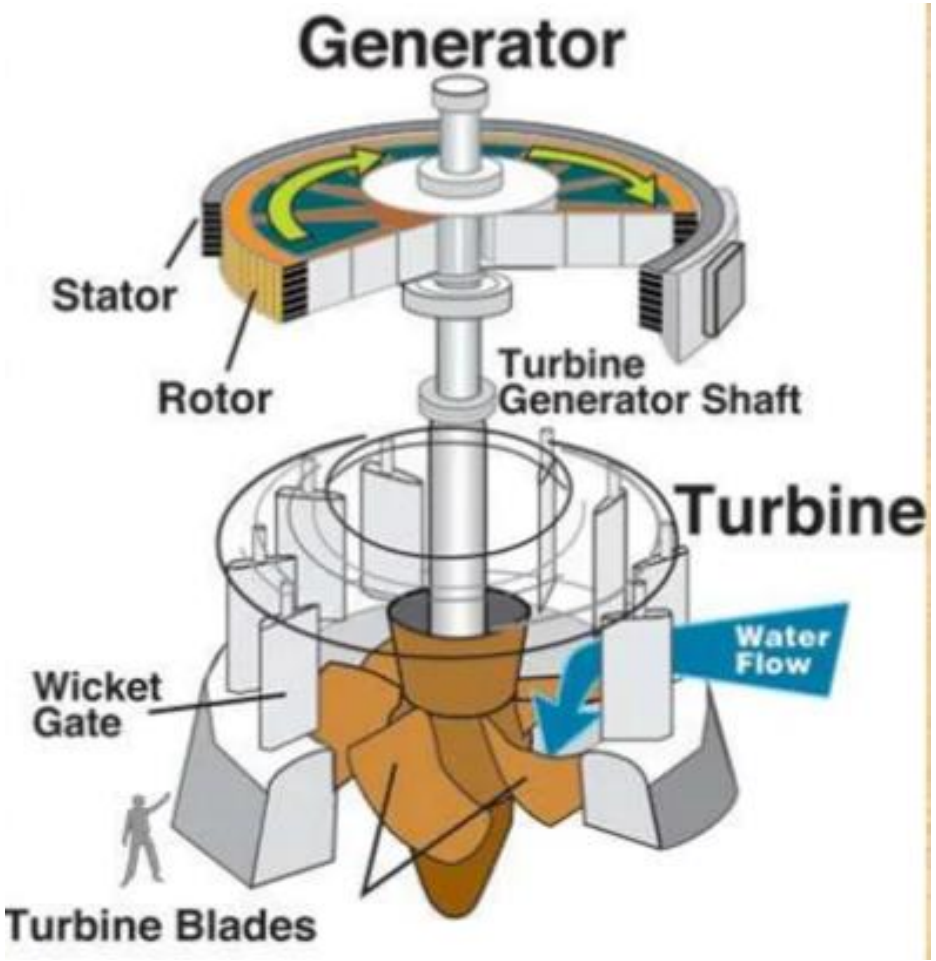
- In a turbine, blades or buckets are provided on a wheel and directed against water to alter the momentum of water. As the momentum is changed with the water passing through the wheel, the resulting force turns the shaft of the wheel performing work and generating power.
- A *hydraulic turbine uses potential energy and kinetic energy of and converts it into* usable *mechanical energy. The mechanical energy made available at the turbine shaft* is used to run an electric power generator which is directly coupled to the turbine shaft

- The electric power which is obtained from the hydraulic energy is known as Hydroelectric energy. Hydraulic turbines belong to the category of *roto- dynamic machinery.*
- The hydraulic turbines are classified according to type of energy available at the inlet of turbine, direction of flow through vanes, head at the inlet of the turbines and specific speed of the turbines.

Working Principle

- When any fluid strikes the blade of the turbine, the blades are displaced which produces rotational energy.

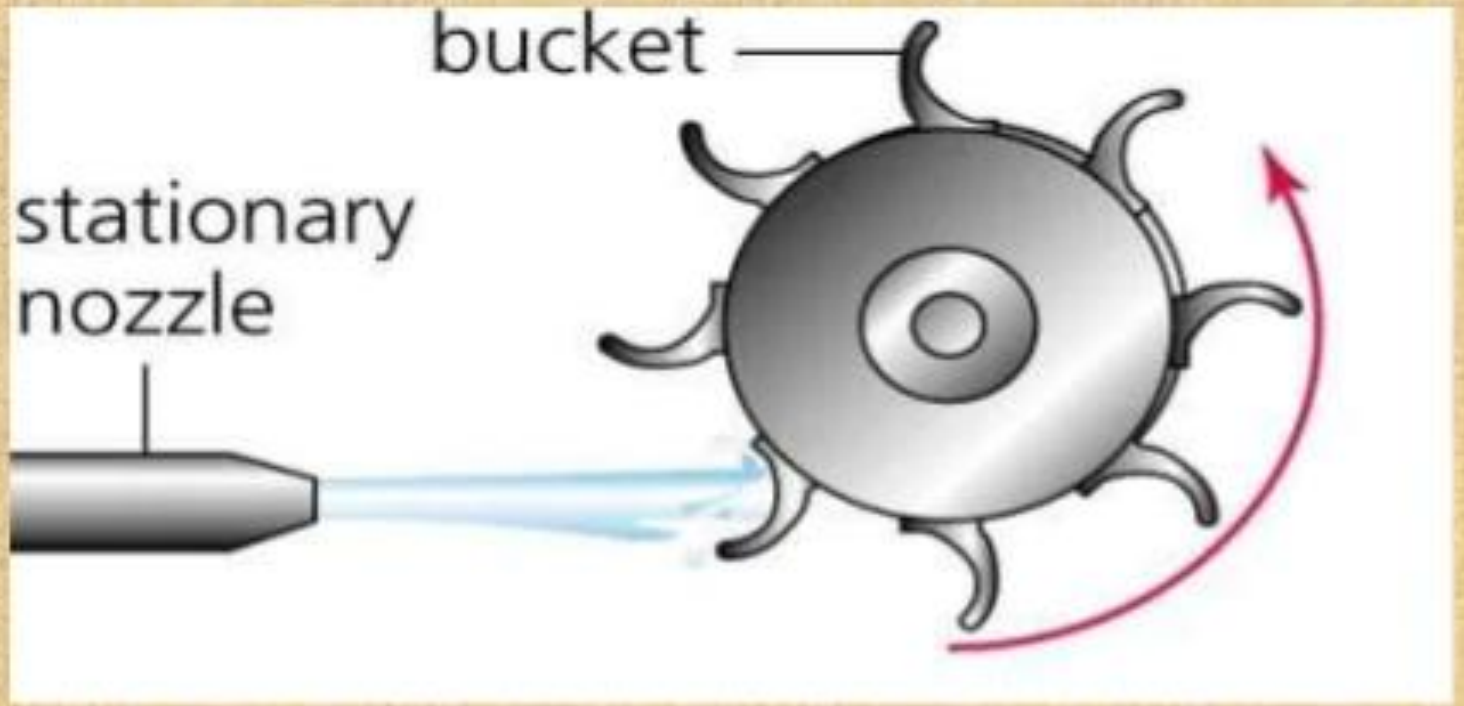
- When the turbine shaft is directly coupled with generator mechanical energy to convert into electrical energy.



According to the type of energy at inlet:

- ***Impulse turbine:***
- In the impulse turbine, the total head of the incoming fluid is converted in to a large velocity head at the exit of the supply nozzle. That is the entire available energy of the water is converted in to kinetic energy.
- Although there are various types of impulse turbine designs, perhaps the easiest to understand is the ***Pelton wheel turbine*** . *It*is most efficient when operated with a large head and lower flow rate.

- In an impulse turbine, the fluid is forced to hit the turbine at high speed.

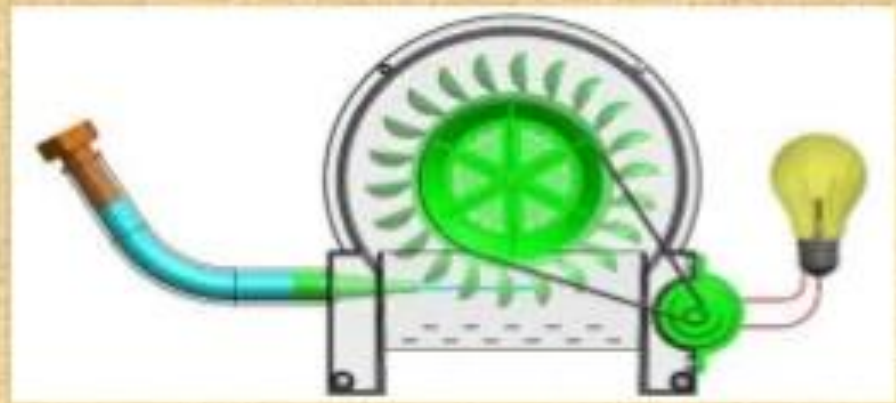


Types of Impulse Turbines:

I. Pelton Turbine

II. Cross-flow Turbine

Pelton Wheel



Cross-flow Turbine

- As with a water wheel, the water is admitted at the turbine's edge. After passing the runner, it leaves on the opposite side.
- Going through the runner twice provides additional efficiency.
- The cross-flow turbine is a low-speed machine that is well suited for locations with a low head but high flow.

Hydropower Turbine

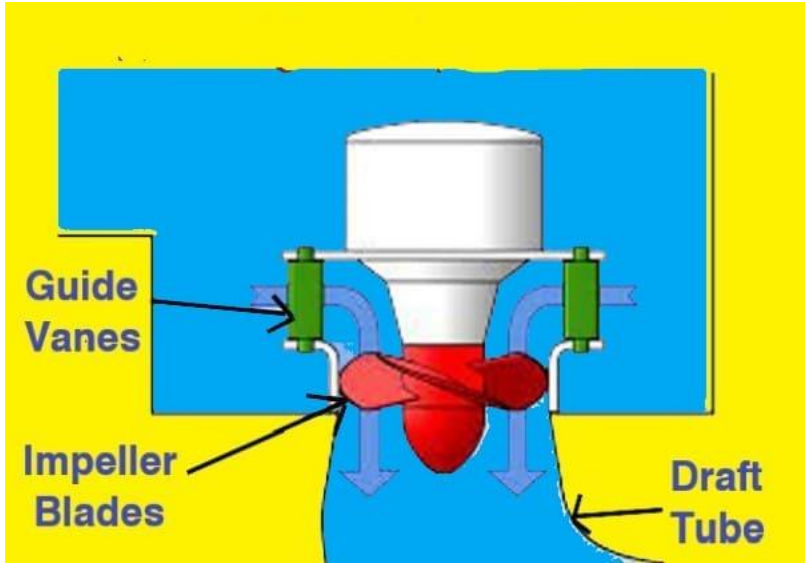
- A **Hydropower turbine** (also known as water turbine) is a rotary machine that converts KE and PE of water into mechanical work.
- There are two main types of hydropower turbines:
  a) Reaction turbine
  b) Impulse turbine
- The type of hydropower turbine selected for a project is based on the head and the flow of water, or volume of water over time, at the site.
- Other deciding factors include how deep the turbine must be set, turbine efficiency, and cost.

Reaction Turbine

- A reaction turbine generates power from the combined forces of pressure and moving water.
- Reaction turbines are generally used for sites with lower head and higher flows.
- The reaction turbines can be classified into the following three types, depending upon the direction of flow of water through the wheel:
  1) Radial flow turbine
  2) Axial flow turbine
  3) Mixed flow turbine

Reaction Turbine

- **Working principle:**
  - A reaction turbine works on the Newton's third law.
  - In a reaction turbine, the reaction force is produced by the moving fluid over the impeller blades.
  - The reaction force generated by the impeller blade causes the impeller to rotate



Radial Flow turbine

- Radial Flow turbine: In such turbines, the flow of water is radial (i.e., along with the radius of the wheel).

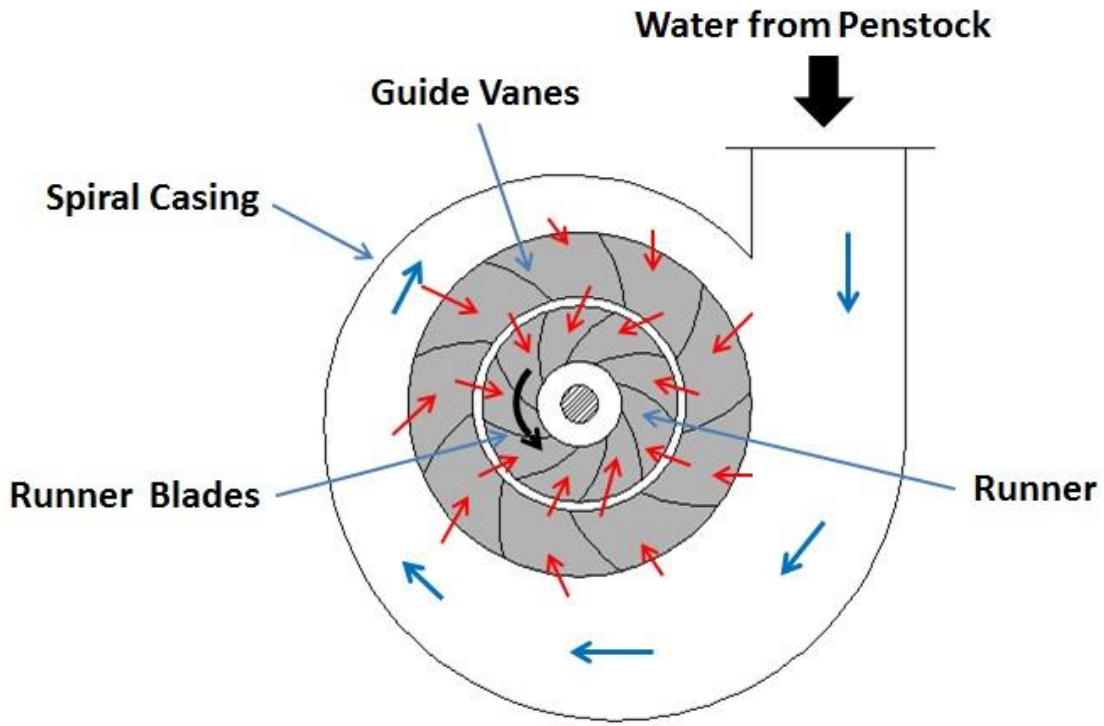


Image source: https://1.bp.blogspot.com/-HBH5mP1iqmg/XRjPkXI4JGI/AAAAAAAAKMc/9_G1vTU4eQAq3IwrX80R-q9Pf_jeXUSUwCLcBGAs/s1600/4.jpg

Radial Flow Turbine

The radial flow turbines may be further sub-division into the following two classes:

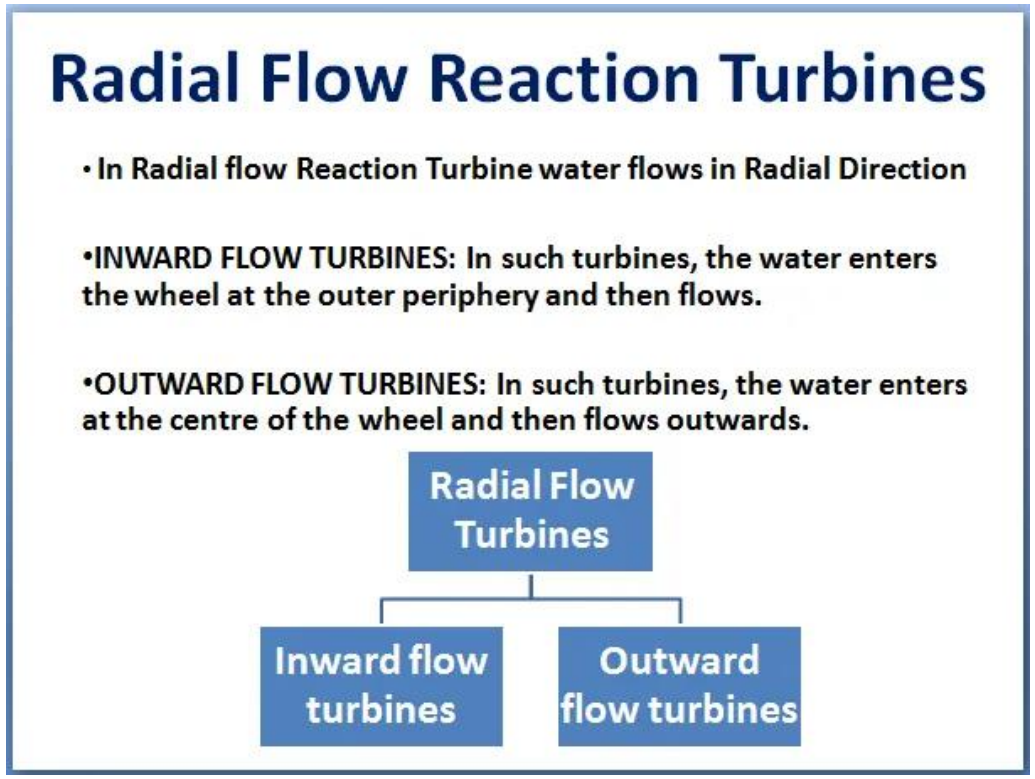


Image Source : https://www.theengineerspost.com/types-of-reaction-turbine/

Radial Flow turbine

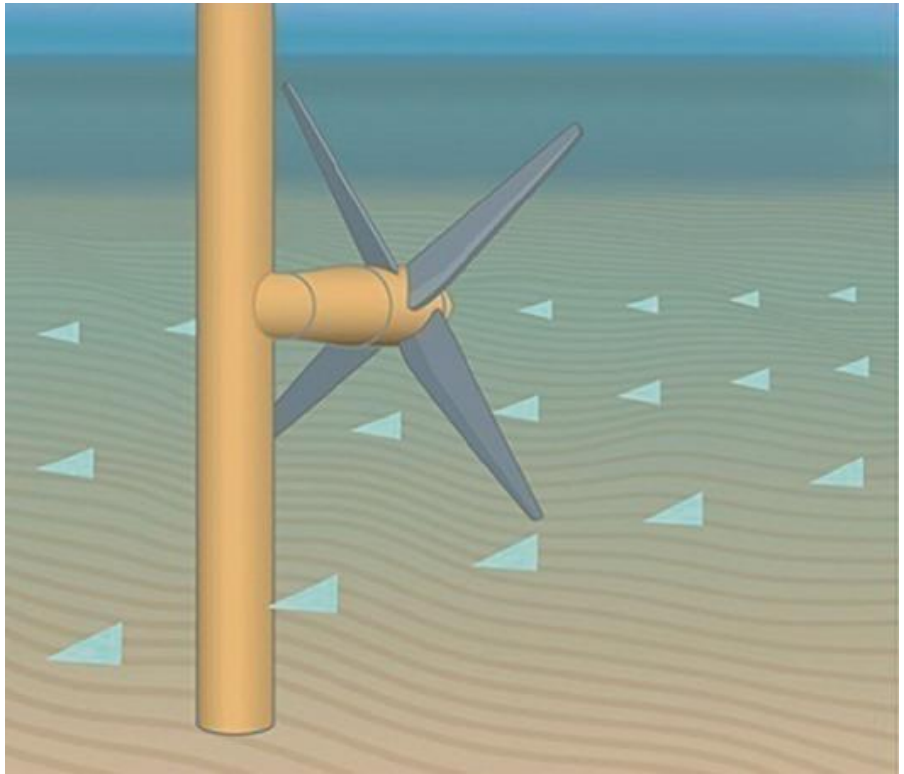
- **Inward Flow Turbines**
  - In such turbines, the water enters the wheel at the outer periphery and then flows inwards(i.e. towards the centre of the wheel).
  - Here the runner is surrounded by a guide mechanism.
  - In this turbine, the outer diameter of the runner is the inlet and the inner diameter is the outlet.

Radial Flow turbine

- **Outward Flow Turbines**
  - In such turbines, the water enters at the centre of the wheel and then flows outwards (i.e., towards the outer periphery of the wheel).
  - Here guide mechanism is surrounded by the runner.
  - In this turbine, the inner diameter of the runner is the inlet and outer diameter is an outlet.

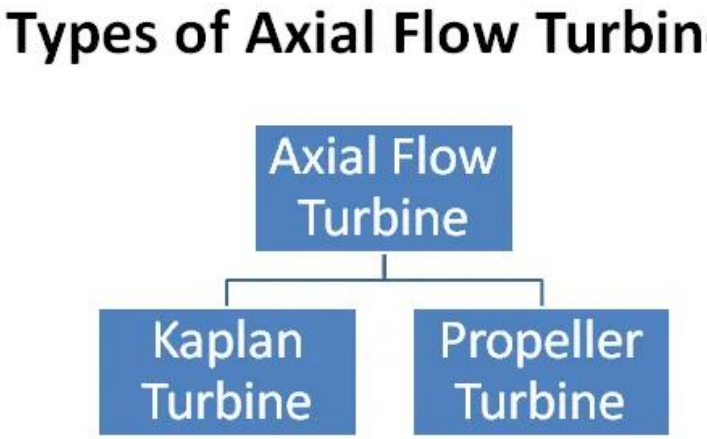
Axial Flow Turbines

- In Axial flow turbines, the water flows parallel to the axial of the wheel. Such turbines are also called parallel flow turbines.



Axial Flow Turbines

- **Types of Reaction Turbine in Axial Flow Turbine:**
  1. Kaplan turbine
  2. Propeller turbines

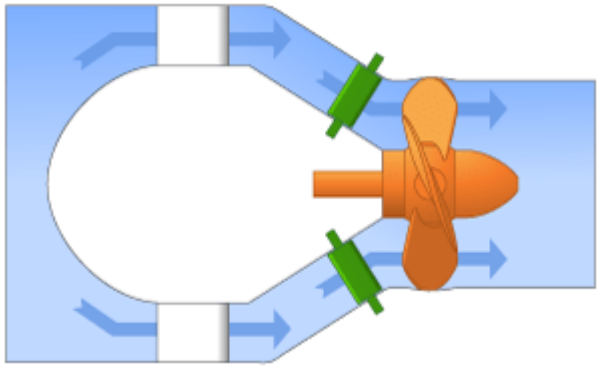


Axial Flow Turbines

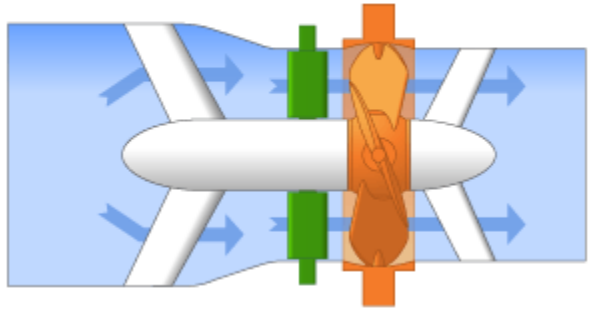
- **Propeller Turbine:**
  - A propeller turbine generally has a runner with three to six blades
  - The water is in constant contact with all of these blades.
  - Propeller turbines only install at the place where the load and height are constant.

Axial Flow Turbines

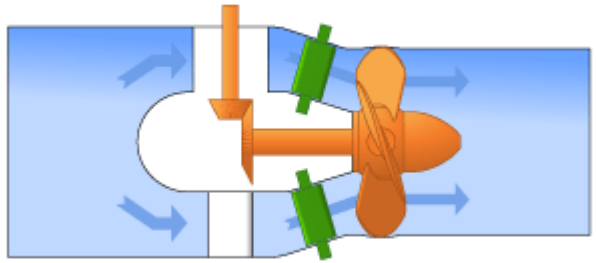
- There are several different types of propeller turbines:



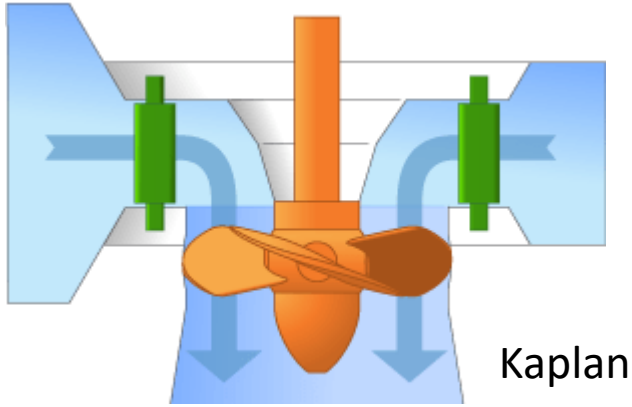
Bulb Turbine



Starflo Turbine



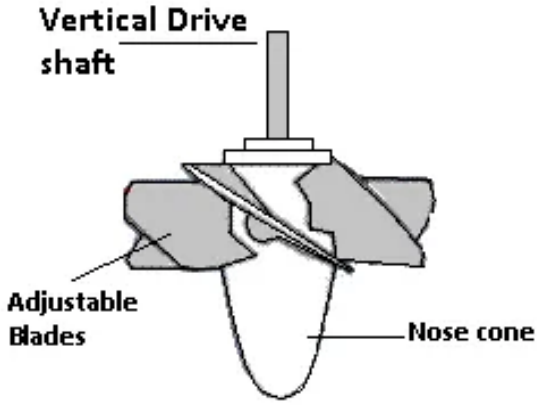
Tubular gear Turbine



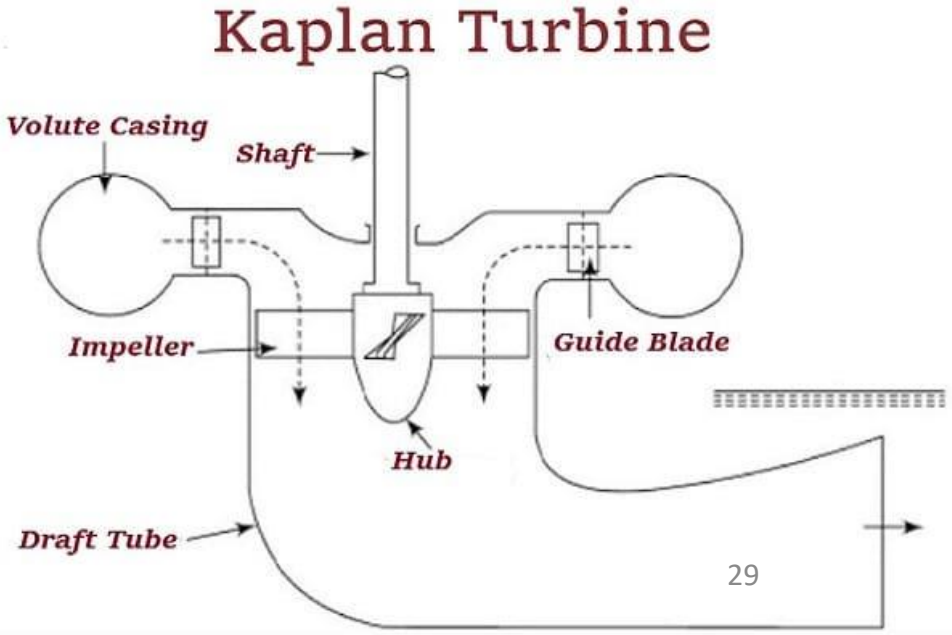
Kaplan Turbine

Axial Flow Turbines

- The **Kaplan turbine** is a propeller-type water turbine which has adjustable blades.
- It allowed efficient power production in low head applications
- Kaplan turbine is now widely used throughout the **world in high-flow, low-head power production.**

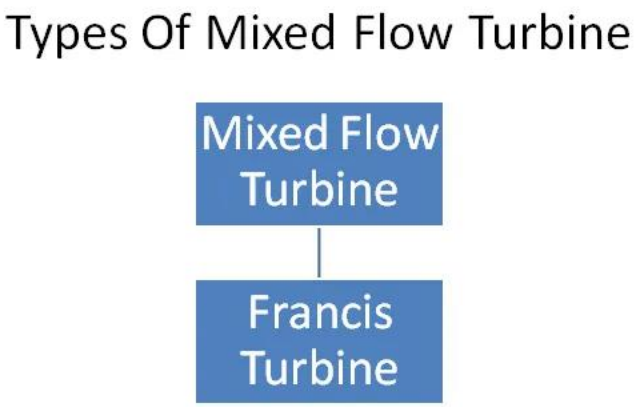


Kaplan Turbine



Mixed Flow Turbines

- These are the latest type of turbines, in which the flow is partly radial and partly axial.
- Francis turbine is a good example of Mixed flow turbine.
- It is an inward flow reaction turbine that combines radial and axial flow concepts.



Mixed Flow Turbines

- **Francis Turbine :**
  - They operate in a head range of ten meters to several hundred meters and are primarily used for electrical power production and their output varies from a few kilowatts to 1000 megawatt.
  - In this turbine the working fluid changes pressure as it moves through the turbine, giving up its energy.
  - This types of turbines are located in between the high-pressure water source and the low-pressure water exit.

According to the direction of flow through runner

- **Tangential flow turbines:**

  In this type of turbines, the water strikes the runner in the direction of tangent to the wheel. Example : Pelton wheel turbine.

- **Radial flow turbines:**

  In this type of turbines, the water strikes in the radial direction. It is further classified as

- **Inward flow turbine:** The flow is inward from periphery to the centre (centripetal type).

Example : Old Francis turbine

- **Outward flow turbine :** The flow is outward from the centre to periphery (centrifugal type).

Example : Fourneyron turbine

- **Axial flow turbine:**

  The flow of water is in the direction parallel to the axis of the shaft.

  Example : Kaplan turbine and propeller turbine.

- **Mixed flow turbine:**

  The water enters the runner in the radial direction and leaves in axial direction.

  Example : Modern Francis turbine.

According to the head at inlet of the turbine

- **High head turbine:**

  In this type, the net head varies from 150m to 2000m or even more and these turbines require a small quantity of water.

  Example: Pelton wheel turbine.

- **Medium head turbine:**

  The net head varies from 30m to 150m, and also these turbines require moderate quantity of water.

  Example : Francis turbine

- **Low head turbine:**

  The net head is less than 30m and also these turbines require large quantity of water.

  Example : Kaplan turbines.

According to the specific speed of the turbine

- The specific speed of a turbine is defined as , the speed of a geometrically similar turbine that would develop unit power when working under a unit head (1m head).
- **Low specific turbine:**

  The specific speed is less than 50 (varying from 10 to 35 for single jet and up to 50 for double jet)

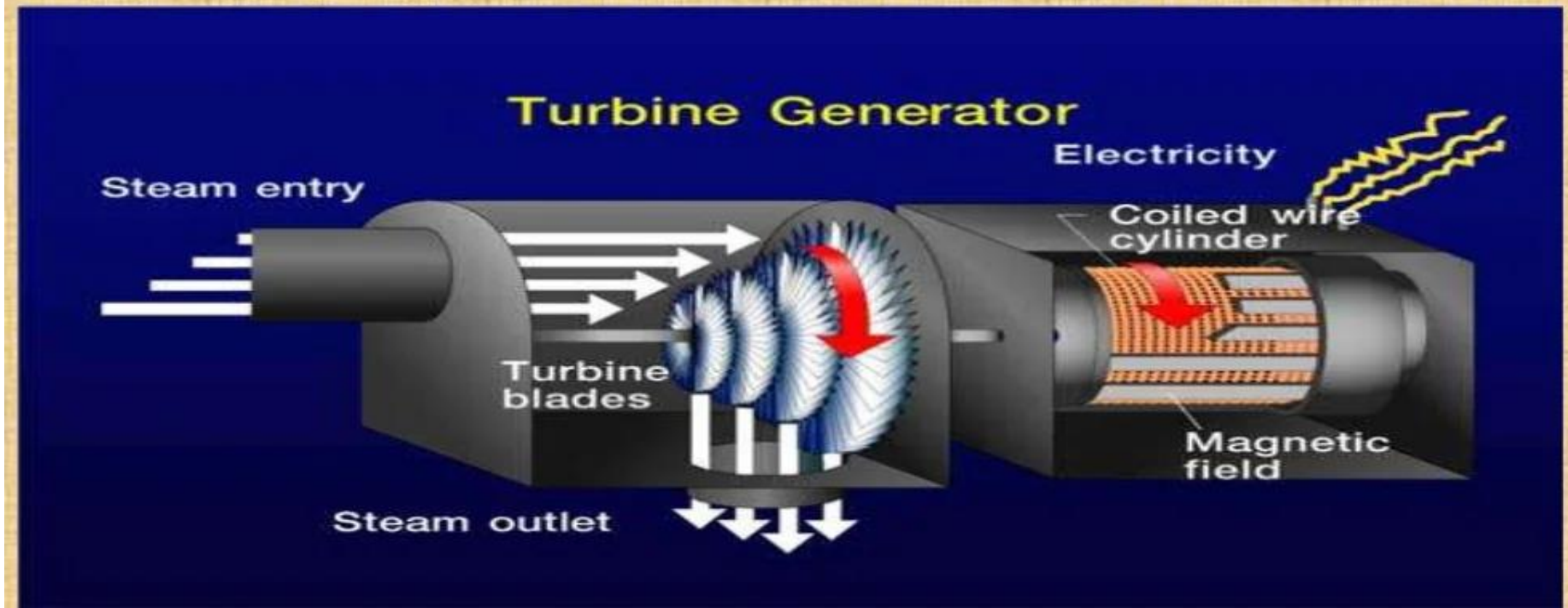
  Example : Pelton wheel turbine
- **Medium specific turbine:** The specific speed varies from 50 to 250.

  Example : Francis turbine
- **High specific turbine:** The specific speed is more than 250.

  Example : Kaplan turbine

Steam Turbine

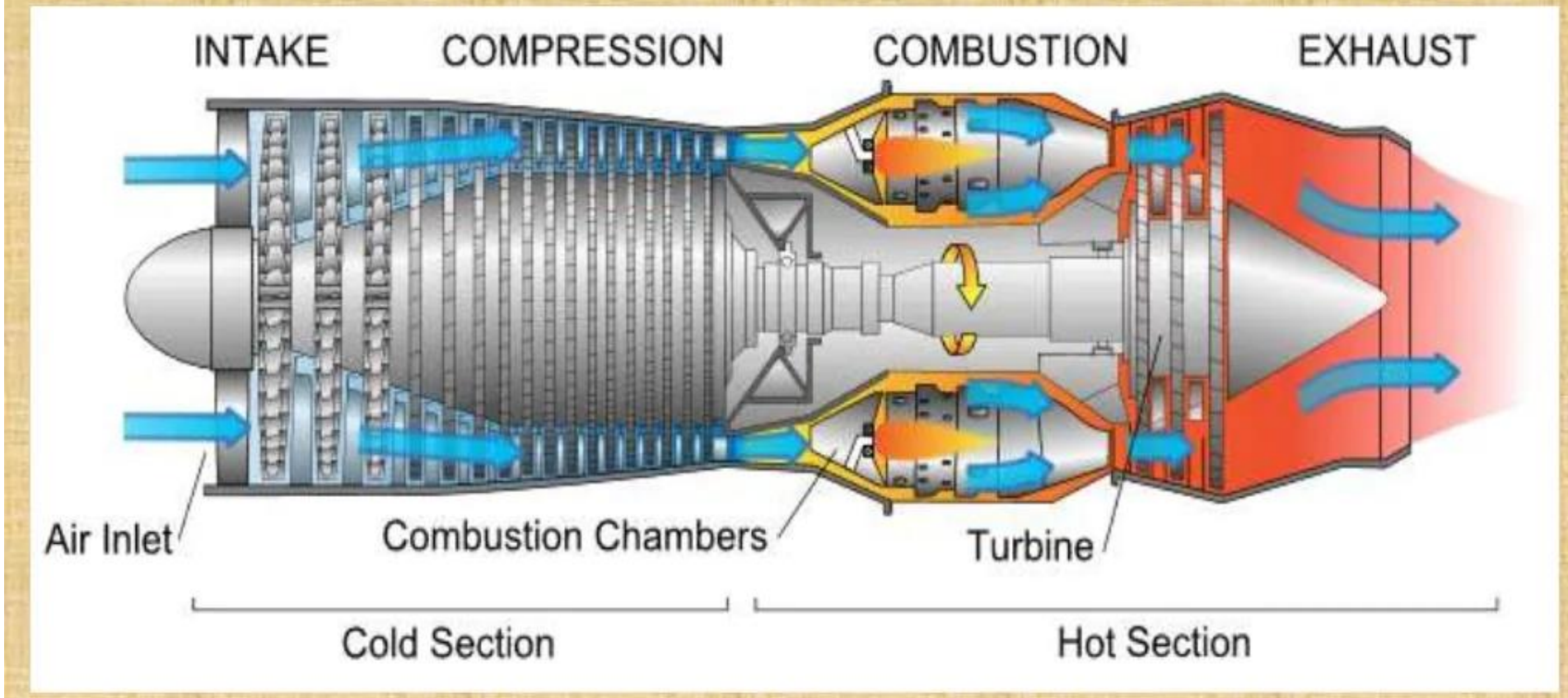
- A steam turbine is a device that extracts thermal energy from pressurized steam and uses it to do mechanical work on a rotating output shaft.
- Steam turbines are used for the generation of electricity in thermal power plants, such as plants using coal fuel oil or nuclear fuel.



Gas turbine

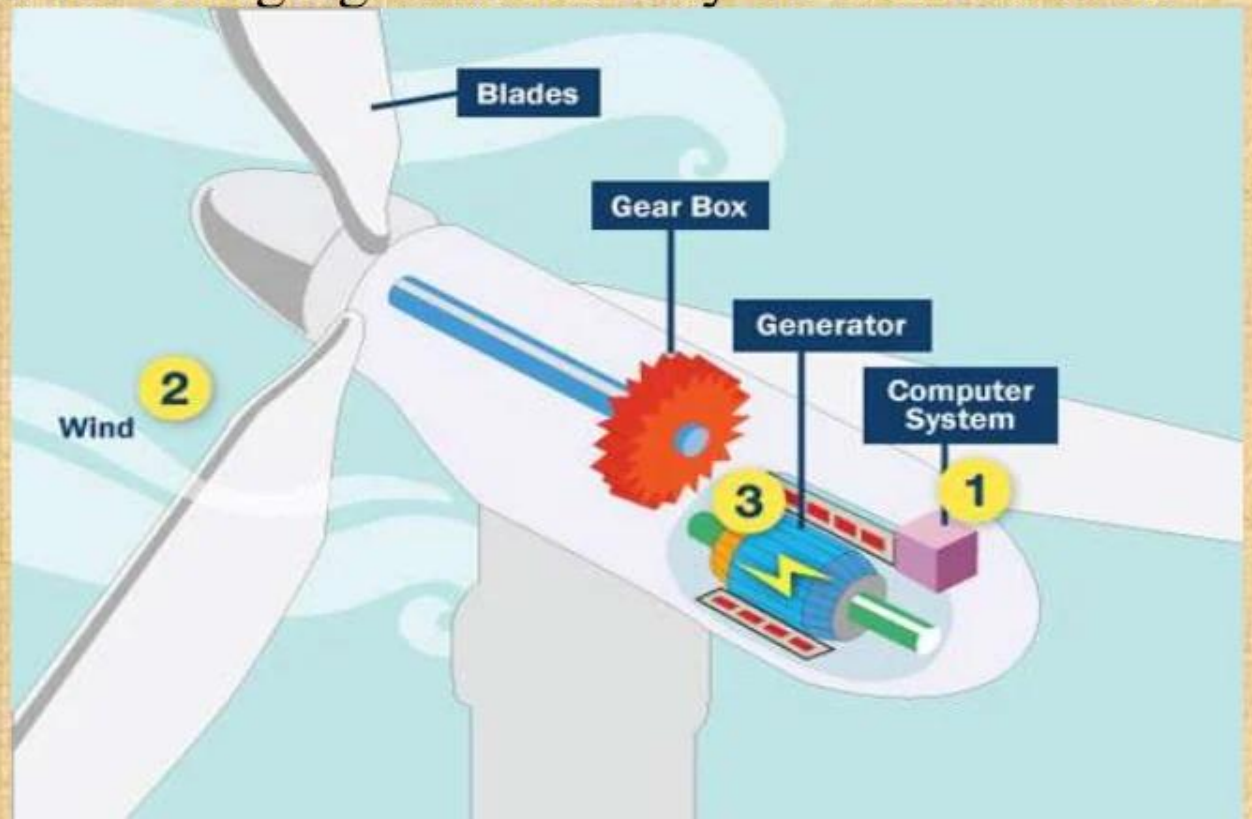
A gas turbine, also called a combustion turbine, is a type of internal combustion engine.

- Gas turbines are used to power aircraft, trains, ships, electrical generators or even tanks.



Wind Turbine

- A wind turbine is a device that converts kinetic energy from the wind into electrical power .
- Conventional horizontal axis turbines can be divided into three components:.
- Wind turbine used for charging batteries may be referred to as a wind charger.



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THANKYOU!