# TURBINES


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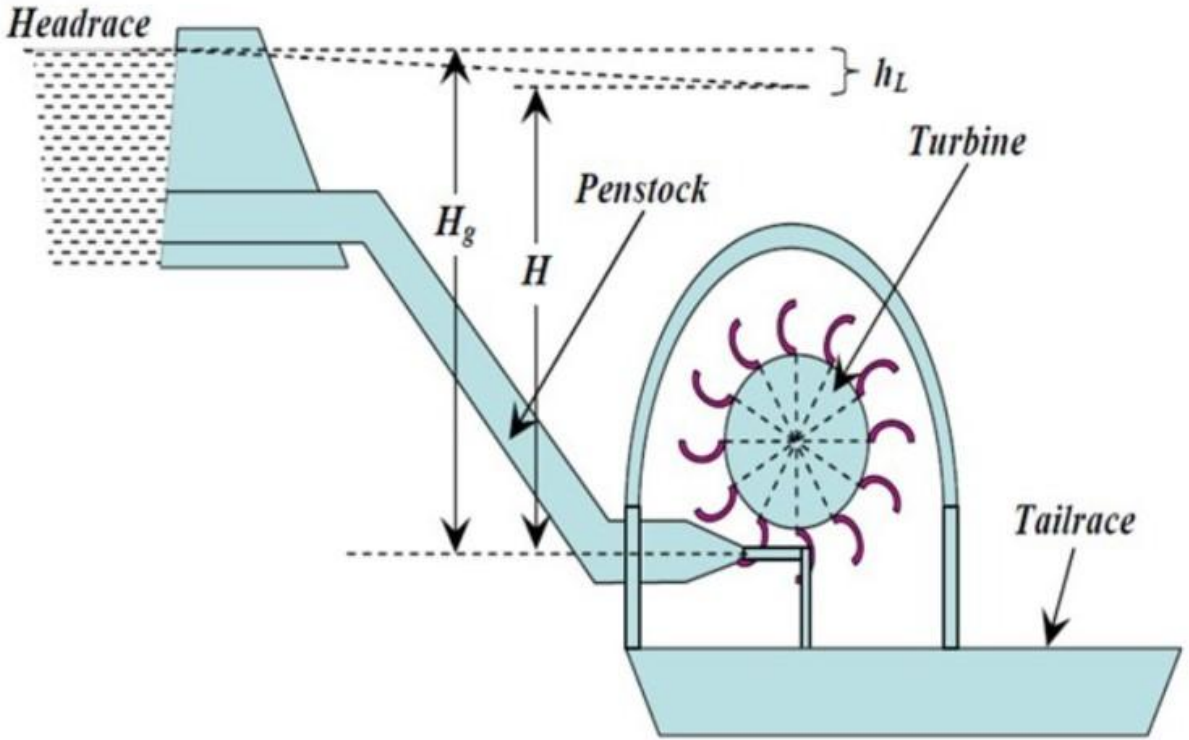
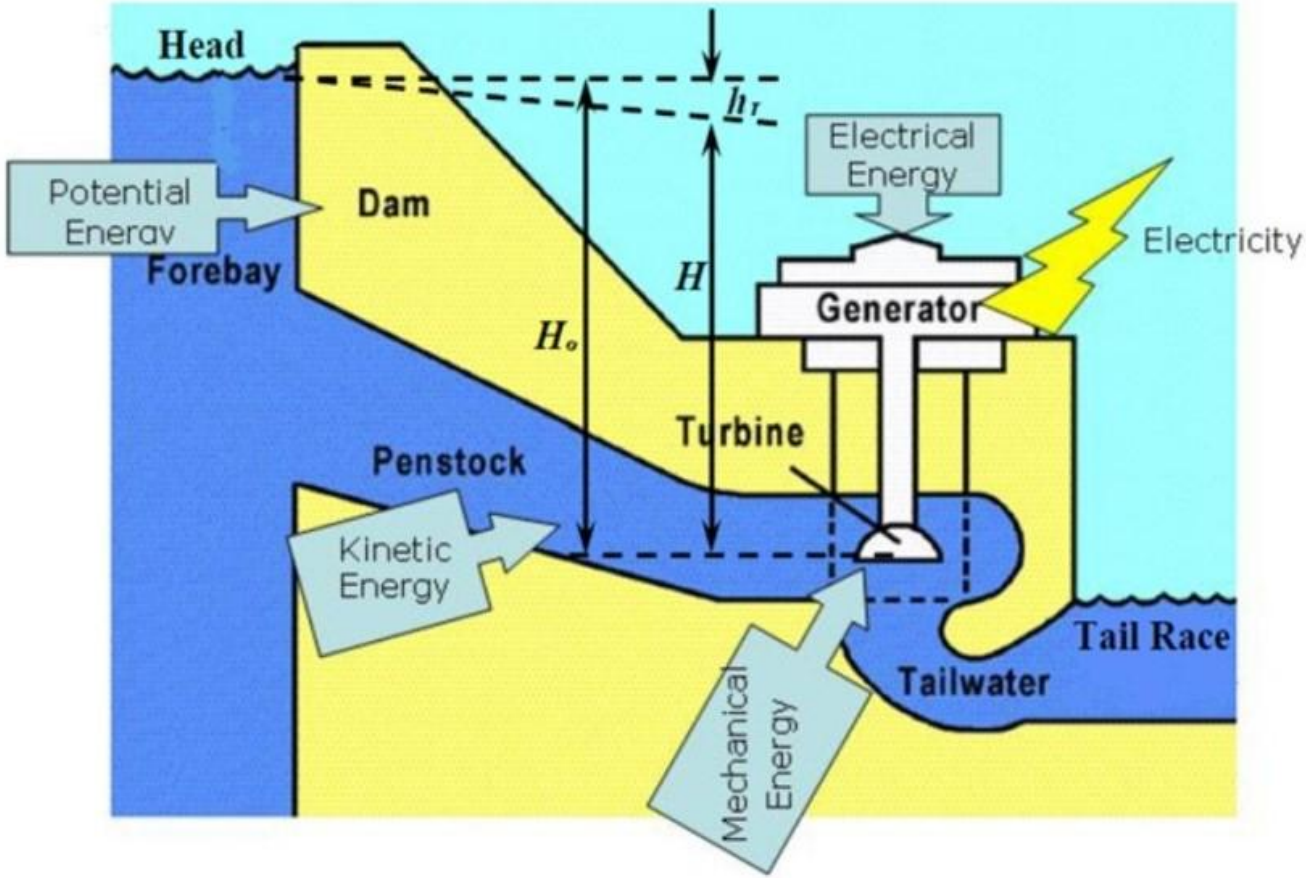
# Intoduction

- 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
Generator
Electricity
$H_o$
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.

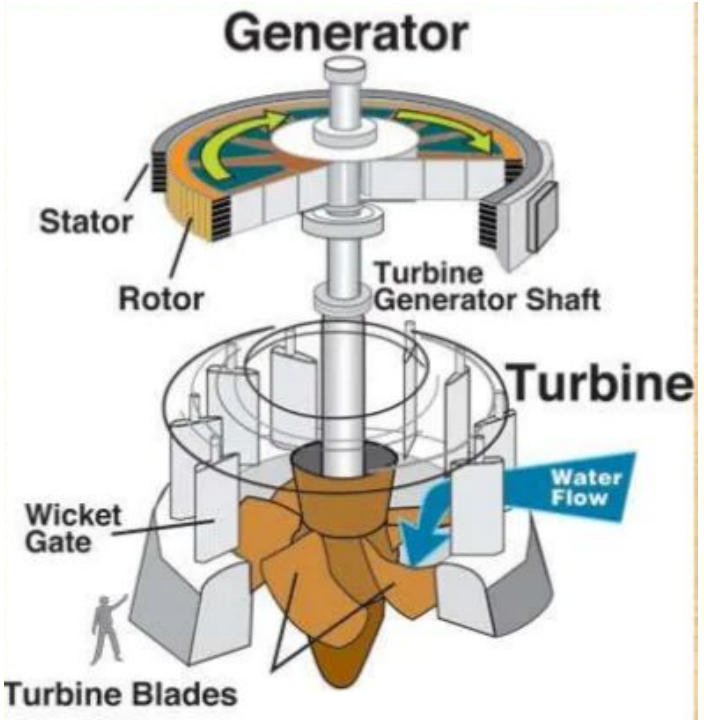
- In a turbine, blades or buckets are provided on a wheel and directed against water to alter the momentum of water. As the momentum is changed with the water passing through the wheel, the resulting force turns the shaft of the wheel performing work and generating power.
- A *hydraulic turbine uses potential energy and kinetic energy of wa 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.

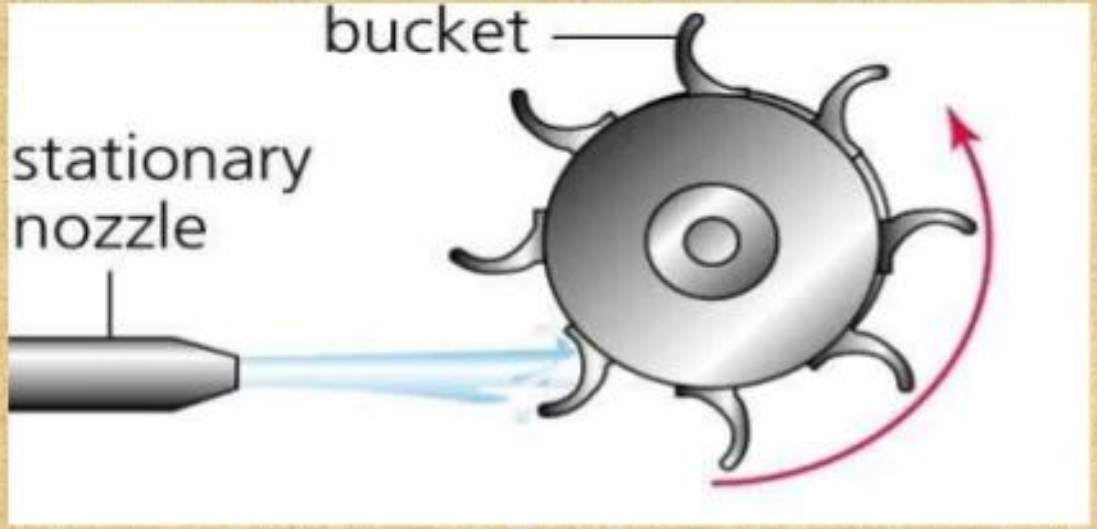
- When the turbine shaft is directly coupled with generator mechanical energy to convert into electrical energy.



# 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.

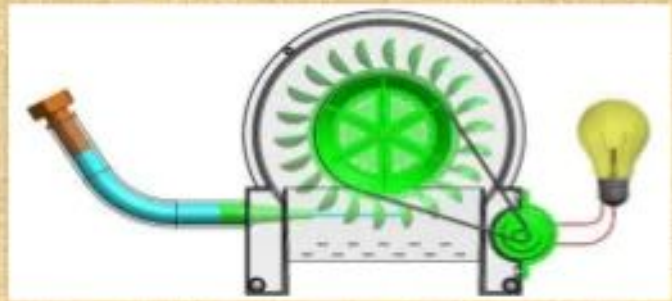



*Types of Impulse Turbines:*

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.

- ***Reaction turbine***
- Reaction turbines on the other hand, are best suited -for higher flow rate and lower head situations.
- In this type of turbines, the rotation of runner or rotor (rotating part of the turbine) is partly due to impulse action and partly due to change in pressure over the runner blades; therefore, it is called as ***reaction turbine*** .
- For, a reaction turbine, the penstock pipe feeds water to a row of fixed blades through casing.

- These fixed blades convert a part of the pressure energy into kinetic energy before water enters the runner.
- The water entering the runner of a reaction turbine has both pressure energy and kinetic energy.
- Water leaving the turbine is still left with some energy (pressure energy and kinetic energy).
- Since, the flow from the inlet to tail race is under pressure, casing is absolutely necessary to enclose the turbine.
- In general, Reaction turbines are *medium to low-head, and high-flow rate devices.*
- The reaction turbines in use are ***Francis*** **and** ***Kaplan***

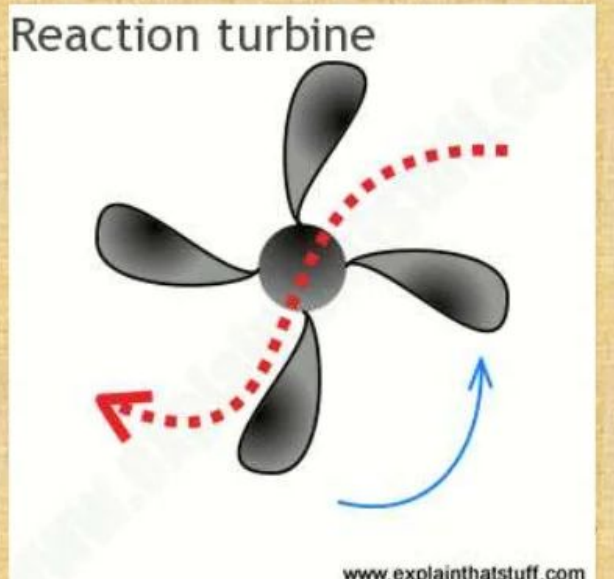
- In a reaction turbine, forces driving the rotor are achieved by the reaction of an accelerating water flow in the runner while the pressure drops.
- In reaction turbines torque developed by reacting to the fluid's pressure. The pressure of the fluid changes as it passes through the turbine rotor blades.

## Types of Reaction Turbines

Kaplan Turbine

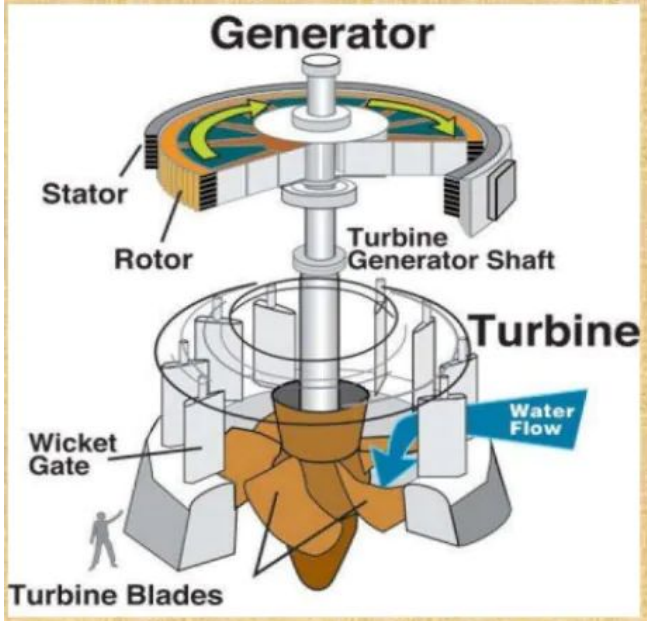
Francis Turbine

Kinetic Turbine



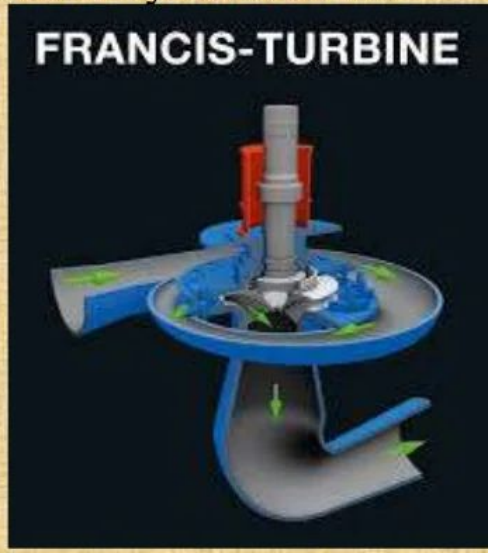
# Kaplan Turbine

- The Kaplan turbine is a water turbine which has adjustable blades and is used for low heads and high discharges.
- 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.



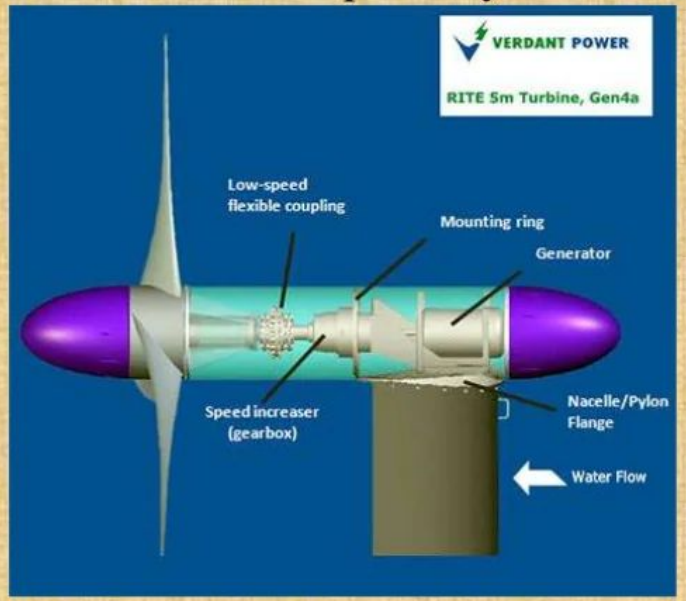

# Francis Turbine

- The Francis turbine is a type of water turbine and are used for medium head(45-400 m) and medium discharge.(10-700 m^3/s)
- The Francis turbine is a type of reaction turbine, a category of turbine in which the working fluid comes to the turbine under immense pressure and the energy is extracted by the turbine blades from the working fluid.



# Kinetic Turbines

- Kinetic energy turbines, also called free-flow turbines, generate electricity from the kinetic energy present in flowing water.
- The systems may operate in rivers, man-made channels, tidal waters, or ocean currents.
- Kinetic systems utilize the water stream's natural pathway.



# 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. accordingly, 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 turbine:

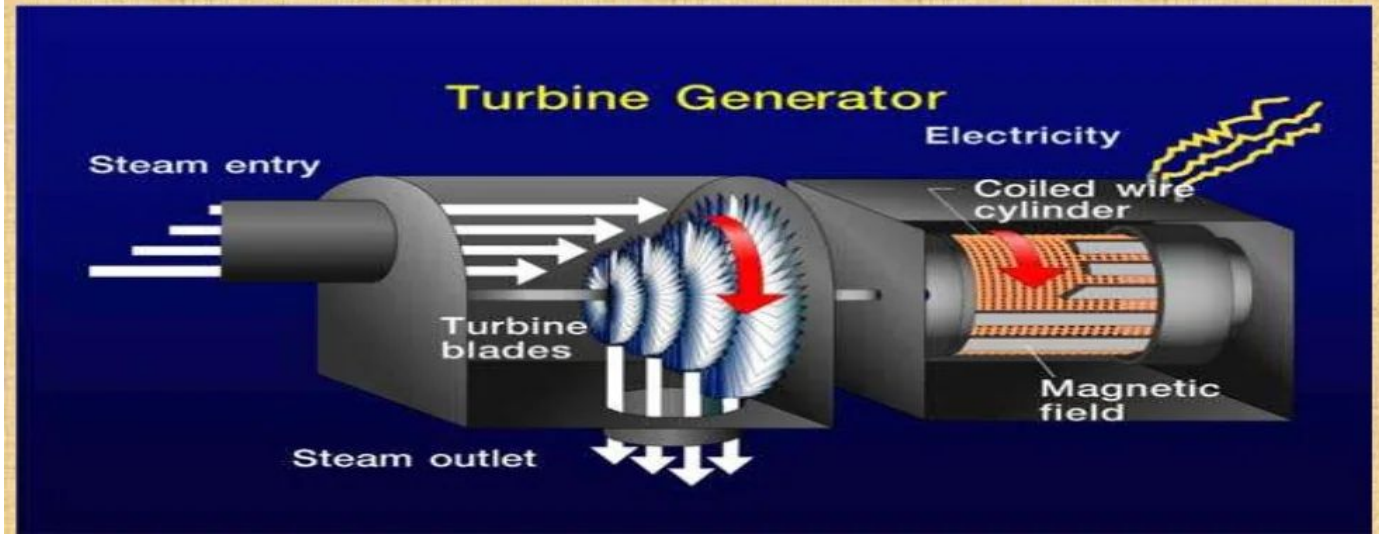
- ***High head turbine:***
- In this type of turbines, the net head varies **from 150m to 2000m or even more** , and these turbines require a small quantity of water. ***Example: Pelton*** **wheel turbine.**
- **Medium head turbine:**
- The net head varies **from 30m to 150m** , and also these turbines 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 turbine.***

# 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). It is prescribed by the relation
- ***Low specific speed 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 is varies from 50 to 250. Example* **Francis turbine.**
- ***High specific turbine:*** *the specific speed is more than 250.* ***Example: Kaplan turbine.***

# Steam Turbine

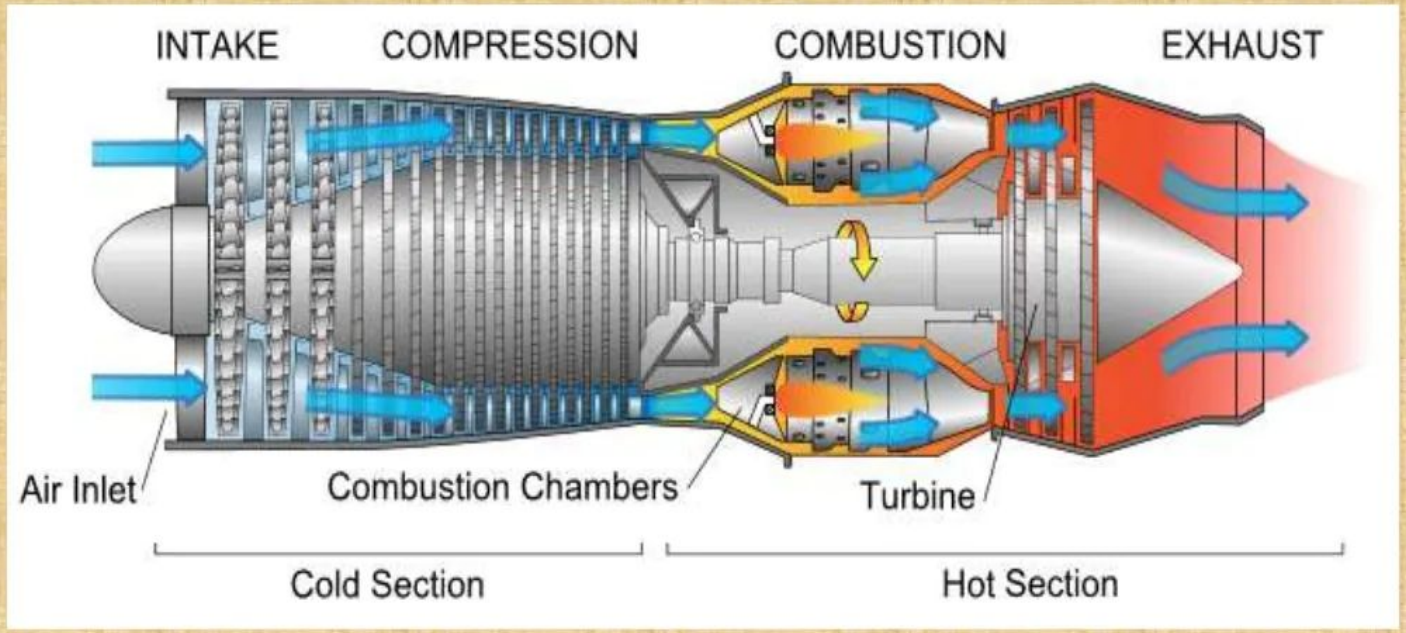
- A steam turbine is a device that extracts thermal energy from pressurized steam and uses it to do mechanical work on a rotating output shaft.
- Steam turbines are used for the generation of electricity in thermal power plants, such as plants using coal fuel oil or nuclear fuel.



# Gas turbine

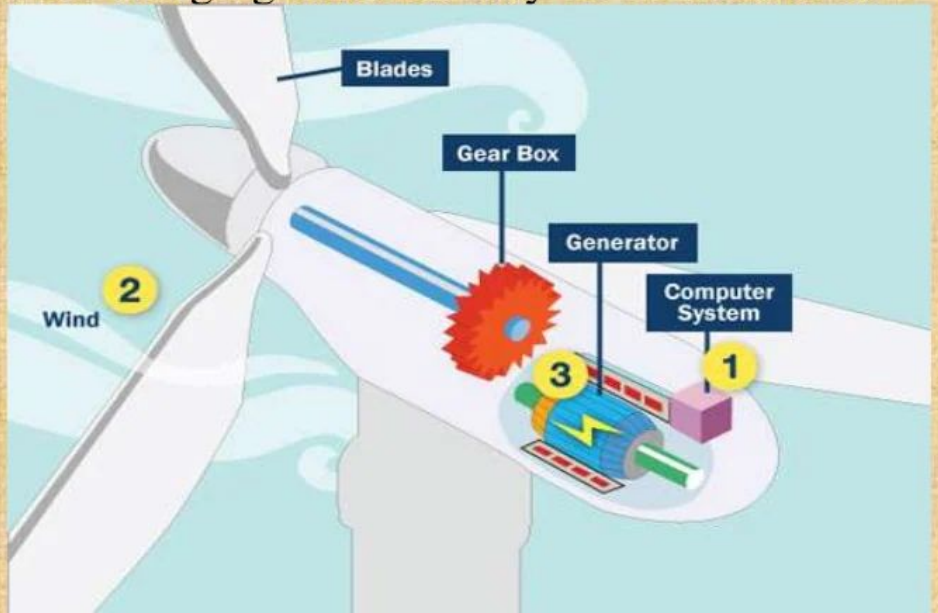
A gas turbine, also called a combustion turbine, is a type of internal combustion engine.

- 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!