



## **Swami Keshvanand Institute of Technology, Management & Gramothan, Ramnagar, Jagatpura, Jaipur-302017, INDIA**

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Recognized by UGC under Section 2(f) of the UGC Act, 1956

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### **Steam Turbine**

The steam turbine is one kind of heat engine machine in which steam's heat energy is converted into mechanical work. The construction of steam turbine is very simple. There is no piston rod, flywheel or slide valves attached to the turbine. So maintenance is quite easy. It consists of a rotor and a set of rotating blades which are attached to a shaft and the shaft is placed in the middle of the rotor. An electric generator known as steam turbine generator is connected to the rotor shaft. The turbine generator collects the mechanical energy from the shaft and converts it into electrical energy. Steam turbine generator also improves the turbine efficiency.

#### **Working principle of steam turbine**

Working principle of steam turbine depends on the dynamic action of steam. A high-velocity steam is coming from the nozzles and it strikes the rotating blades which are fitted on a disc mounted on a shaft. This high-velocity steam produces dynamic pressure on the blades in which blades and shaft both start to rotate in the same direction. Basically, in a steam turbine pressure energy of steam extracts and then it converted into kinetic energy by allowing the steam to flow through the nozzles. The conversion of kinetic energy does mechanical work to the rotor blades and the rotor is connected to a steam turbine generator which acts as a mediator. Turbine generator collects mechanical energy from the rotor and converts into electrical energy. Since the construction of steam turbine is simple, its vibration is much less than the other engines for same rotating speed.

#### **Types of steam turbine**

1. According to the working principle steam turbines are mainly divided into two categories:
  - a) Impulse Turbine
  - b) Reaction Steam Turbine
2. According to the direction of steam flow, it may be classified into two categories:-
  - a) Axial Flow Steam Turbine
  - b) Radial Flow Steam Turbine
3. According to the exhaust condition of steam, it is further divided into two categories:-
  - a) Back Pressure or Non-Condensing types Steam Turbine
  - b) Condensing type Steam Turbine
4. According to pressure of steam, it may be divided following categories:-
  - a) High-pressure or pass-out or Extraction steam turbine



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- b) Medium-pressure or back pressure steam turbine
- c) Low-pressure turbine

5. According to the number of stages, it may be divided following categories:-

- a) Single stage steam turbine
- b) Multi-stage steam turbine

6. According to the blade and wheels arrangement, it may be divided following categories:-

- a) Pressure Compounding Steam Turbine
- b) Velocity Compounding Steam Turbine
- c) Impulse-Reaction Combined Steam Turbine
- d) Pressure-Velocity Compounding Steam Turbine

#### **Difference between Impulse and Reaction Turbine**

S.no	<b>Impulse Turbine</b>	<b>Reaction Turbine</b>
1.	In 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.



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### **Power Plant**

A **power plant** or a **power generating station** is basically an industrial location that is utilized for the generation and distribution of electric power in mass scale, usually in the order of several 1000 Watts. These are generally located at the sub-urban regions or several kilometres away from the cities or the load centres, because of its requisites like huge land and water demand, along with several operating constraints like the waste disposal etc.

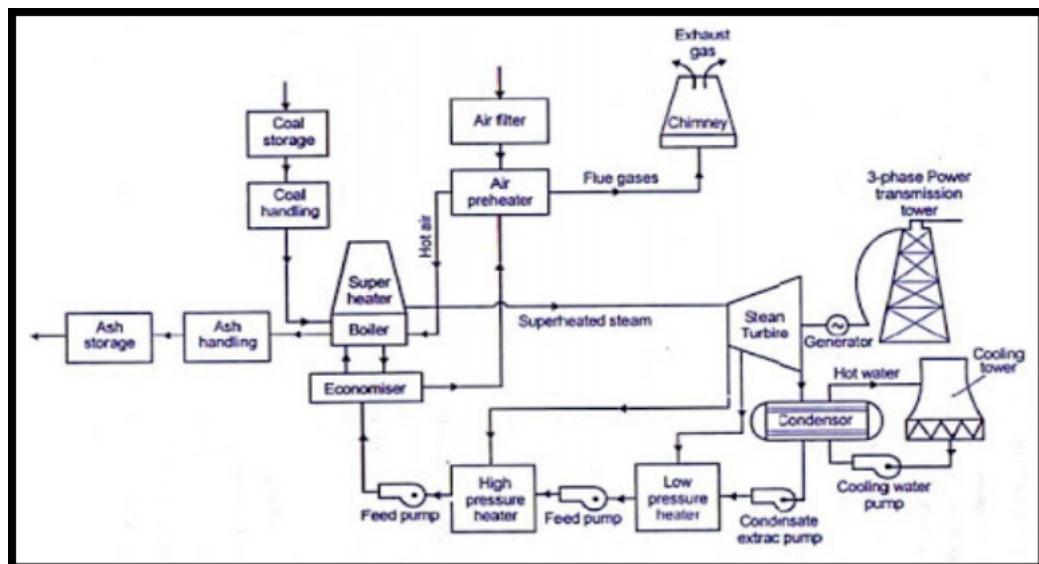
#### **Types of Power plants**

A power plant can be of several types depending mainly on the type of fuel used. Since for the purpose of bulk power generation, only thermal, nuclear and hydro power comes handy, therefore a power generating station can be broadly classified as follows.

- a) Thermal Power plant
- b) Nuclear Power plant
- c) Hydro-Electric Powerplant
- d) Diesel power plant
- e) Gas turbine powerplant

## Thermal Power plant

A thermal power station or a coal fired thermal power plant is by far, the most conventional method of generating electric power with reasonably high efficiency. It uses coal as the primary fuel to boil the water available to superheated steam for driving the steam turbine. The steam turbine is then mechanically coupled to an alternator rotor, the rotation of which results in the generation of electric power. Generally in India, bituminous coal or brown coal are used as fuel of boiler which has volatile content ranging from 8 to 33% and ash content 5 to 16 %. To enhance the thermal efficiency of the plant, the coal is used in the boiler in its pulverized form.



## Layout of steam power plant

In coal fired thermal power plant, steam is obtained in very high pressure inside the steam boiler by burning the pulverized coal. This steam is then super heated in the super heater to extreme high temperature. This super heated steam is then allowed to enter into the turbine, as the turbine blades are rotated by the pressure of the steam. The turbine is mechanically coupled with alternator in a way that its rotor will rotate with the rotation of turbine blades. After entering into the turbine, the steam pressure suddenly falls leading to corresponding increase in the steam volume. After having imparted energy into the turbine rotors, the steam is made to pass out of the turbine blades into the steam condenser of turbine. In the condenser, cold water at ambient temperature is circulated with the help of pump which leads to the condensation of the low pressure wet steam. Then this condensed water is further supplied to low pressure water heater where the low pressure



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steam increases the temperature of this feed water, it is again heated in high pressure. This outlines the basic working methodology of a thermal power plant.

### **Advantages of Thermal Power Plants**

- Fuel used i.e. coal is quite cheaper.
- Initial cost is less as compared to other generating stations.
- It requires less space as compared to hydro-electric power stations.

### **Disadvantages of Thermal Power Plants**

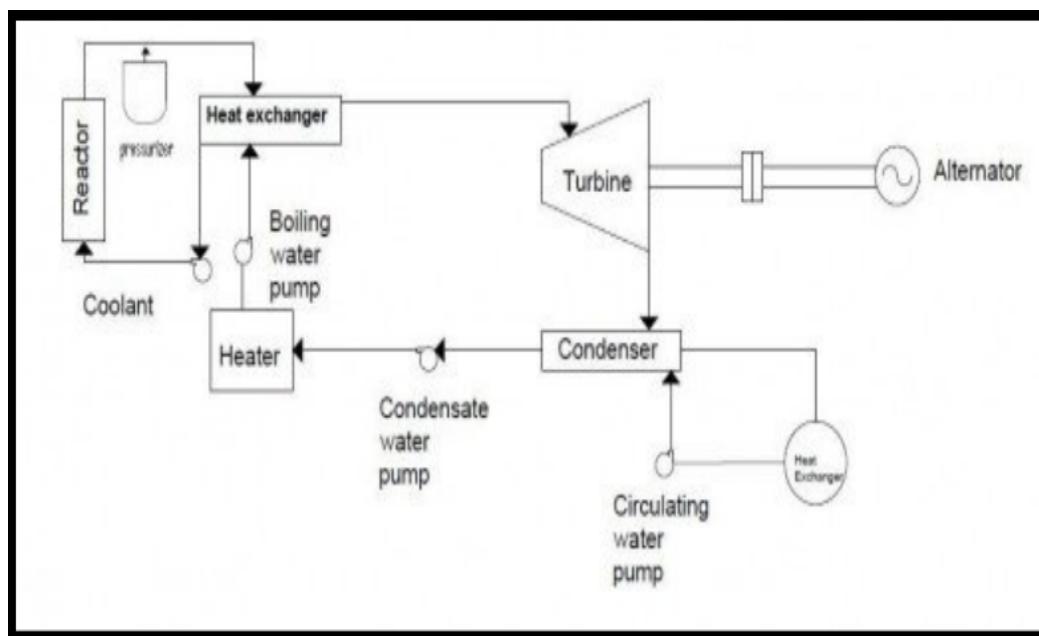
- It pollutes atmosphere due to production of smoke and fumes.
- Running cost of the power plant is more than hydro electric plant.

### **Nuclear Power plant**

Nuclear power plants are similar to the thermal stations in more ways than one. However, the exception here is that, radioactive elements like uranium and thorium are used as the primary fuel in place of coal. Also in a nuclear station the furnace and the boiler are replaced by the nuclear reactor and the heat exchanger tubes.

For the process of nuclear power generation, the radioactive fuels are made to undergo fission reaction within the nuclear reactors. The fission reaction propagates like a controlled chain reaction and is accompanied by unprecedented amount of energy produced, which is manifested in the form of heat.

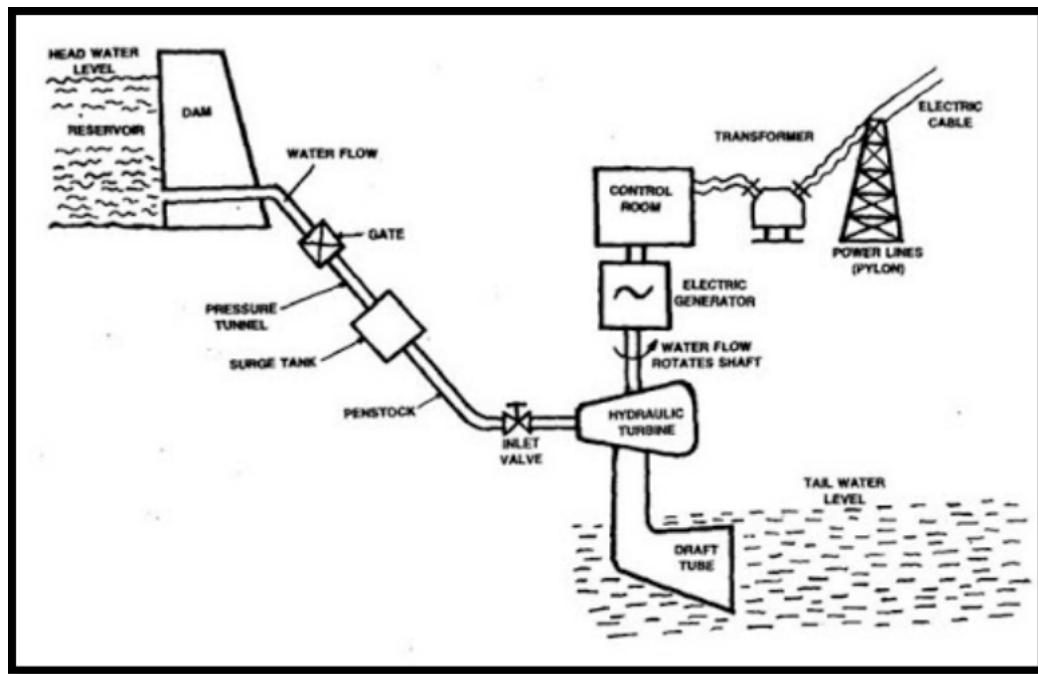
This heat is then transferred to the water present in the heat exchanger tubes. As a result, super heated steam at very high temperature is produced. Once the process of steam formation is accomplished, the remaining process is exactly similar to a thermal power plant, as this steam will further drive the turbine blades to generate electricity.



**Layout of nuclear power plant**

### **Hydro-Electric Power Station**

In Hydro-electric plants the energy of the falling water is utilized to drive the turbine which in turn runs the generator to produce electricity. Rain falling upon the earth's surface has potential energy relative to the oceans towards which it flows. This energy is converted to shaft work where the water falls through an appreciable vertical distance. This power is utilized for rotating the alternator shaft, to convert it to equivalent electrical energy. An important point to be noted is that, the hydro-electric plants are of much lower capacity compared to their thermal or nuclear counterpart. For this reason hydro plants are generally used in scheduling with thermal stations, to serve the load during peak hours. They in a way assist the thermal or the nuclear plant to deliver power efficiently during periods of peak



**Layout of nuclear power plant**

### **Advantages of Hydro Electric Power Station**

- It requires no fuel, water is used for generation of electrical energy.
- It is neat and clean energy generation.
- Construction is simple, less maintenance is required.
- It helps in irrigation and flood control also.

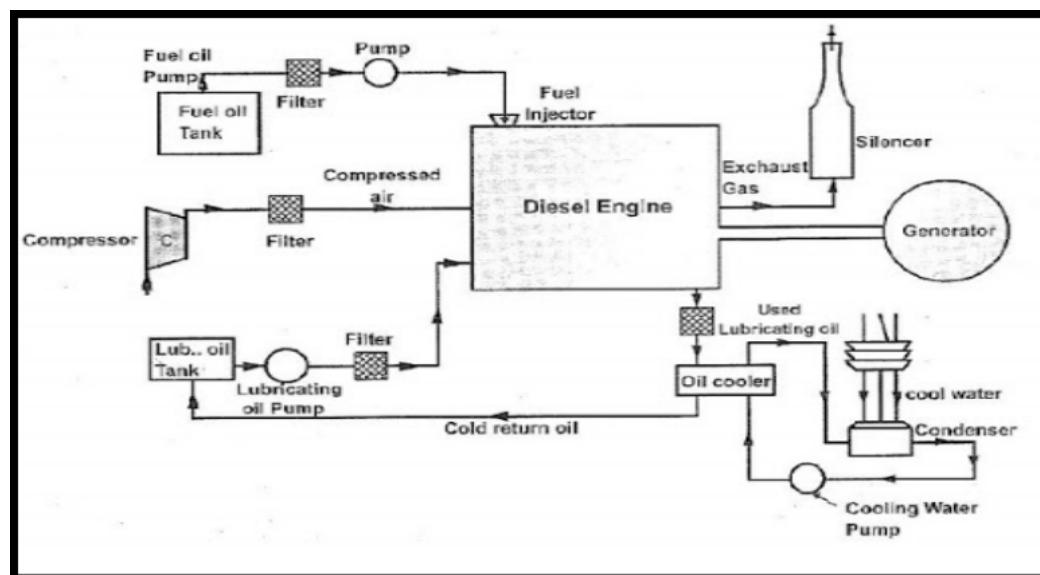
### **Disadvantages Hydro Electric Power Station**

- It involves high capital cost due to dam construction.
- Availability of water depends upon weather conditions.
- It requires high transmission cost as the plant is located in hilly areas.

### **Diesel Power Station**

In a diesel power station, diesel engine is used as the prime mover. The diesel burns inside the engine and the products of this combustion act as the working fluid to produce mechanical energy. The

diesel engine drives alternator which converts mechanical energy into electrical energy. As the generation cost is considerable due to high price of diesel, therefore, such power stations are only used to produce small power. Although steam power stations and hydro-electric plants are invariably used to generate bulk power at cheaper costs, yet diesel power stations are finding favour at places where demand of power is less, sufficient quantity of coal and water is not available and the transportation facilities are inadequate. This plants are also standby sets for continuity of supply to important points such as hospitals, radio stations, cinema houses and telephone exchanges.



**Layout of diesel power plant**

### **Advantages of diesel Power Station**

The advantages of diesel power plants are listed below:

- Diesel power plant design is simple for installation.
- The layout of the diesel power plant is quite simple.
- The limited quantity of cooling water required.
- Standby losses are very less as compared to other Power plants.



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- Low fuel cost for operation.
- Smaller storage is needed for the fuel.
- There is no problem of ash handling.
- Less time monitoring is sufficient required.
- For small capacity power generation, diesel power plant is more efficient than the steam power plant.
- Quickly started and put on load.
- They can respond to varying loads without having any difficulty.

### **Disadvantages:**

- The disadvantages of diesel power plants are listed below:
- High Maintenance and operating cost.
- The plant cost per kW power is comparatively more.
- The working life of diesel power plant is small due to high maintenance.
- The plant produces too much noise.
- Diesel power plants are tough to construct for large scale.

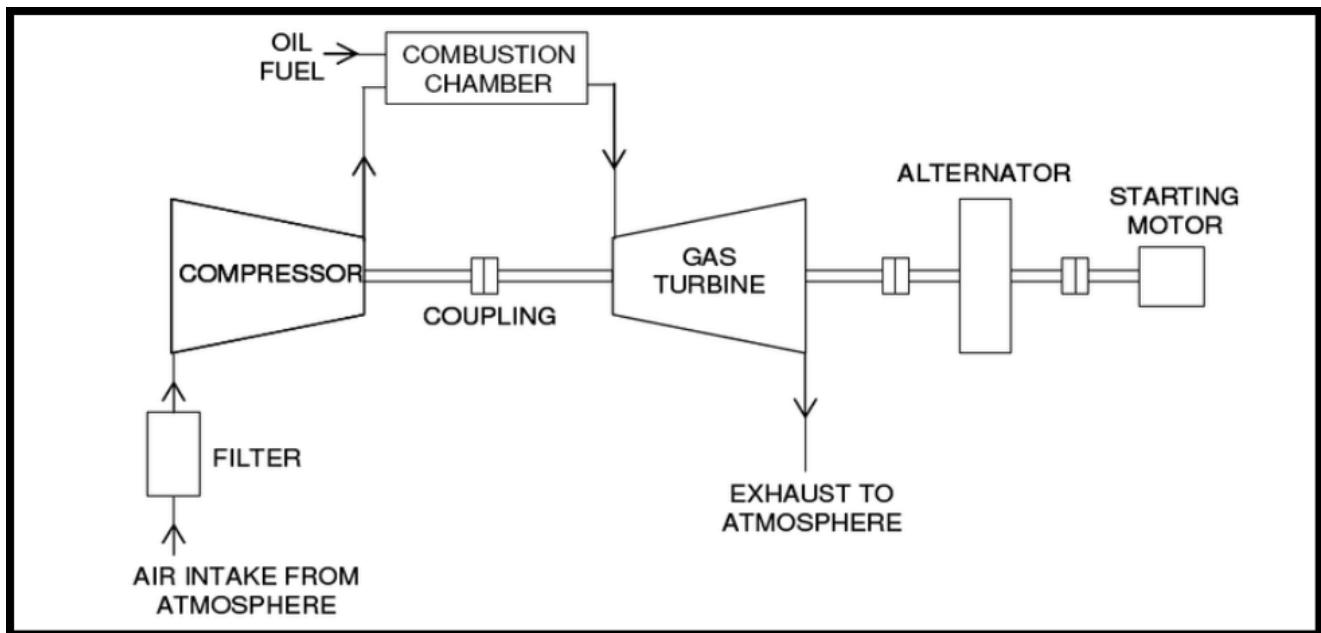
### **Applications:**

Diesel Power Plant finds wide application in the following fields:

- Diesel power plant is used for electrical power generation in capacities ranging from 100 to 5000 H.P.
- They are commonly used for mobile power generation and are widely used in transportation systems consisting of railroads, ships, automobiles, and airplanes.
- They can be used as standby power plants.
- They can be utilized as peak load plants for some other types of power plants.
- For Industries where power requirement is small in the order of 500 kW, diesel power plants become more economical due to higher overall efficiency.

### **Gas Turbine Power Plant**

The gas turbine power plant obtains its power by utilizing the energy of burnt gases and air, which is at high temperature and pressure by expanding through several rings of fixed and moving blades. It thus resembles a steam turbine. To get a high pressure (of the order of 4 to 10 bar) of the working fluid, which is essential for expansion a compressor, is required.



### Layout of gas turbine power plant

The quantity of the working fluid and speed required are more, so, generally, a centrifugal or an axial compressor is employed. The turbine drives the compressor and so it is coupled to the turbine shaft. If after compression the working fluid were to be expanded in a turbine, then assuming that there were no losses in either component the power developed by the turbine would be just equal to that absorbed by the compressor and the work done would be zero.

But increasing the volume of the working fluid at constant pressure, or alternatively increasing the pressure at constant volume can increase the power developed by the turbine. Adding heat so that the temperature of the working fluid is increased after the compression may do either of these.

To get a higher temperature of the working fluid a combustion chamber is required where the combustion of air and fuel takes place giving temperature rise to the working fluid.

Thus, a simple gas turbine cycle consists of

- a) a compressor,
- b) a combustion chamber and
- c) a turbine.
- d)

Since the compressor is coupled with the turbine shaft, it absorbs some of the power produced by the turbine and hence lowers the efficiency. The net work is, therefore, the difference between the turbine work and work required by the compressor to drive it. Gas turbines have been constructed to



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work on the following: oil, natural gas, coal gas, producer gas, blast furnace, and pulverized coal.

### **Advantages of Gas Turbine Power Plant**

- a)** They are small in size, weigh less and have low initial cost per unit output.
- b)** They are easy to install within short periods.
- c)** They are quick-starting and smooth running.
- d)** They offer flexibility by supplying electricity for power generation as well as by supplying compressed air for process needs.
- e)** They are capable of using a range of liquid and gaseous fuels including synthetic fuels.
- f)** They are subjected (put) to fewer environmental restrictions than other prime movers.
- g)** Water consumption is less compared to steam power plant.

### **Disadvantages**

- a)** An electric motor or an I.C. engine is necessary for starting the plant. The starting motor must bring the compressor well towards the operating speed. So, starting is not simple as in the case of other power plants.
- b)** Gas turbine plants have fewer vibrations when compared with reciprocating engines of the same speed. However the high frequency noise from the compressor is objectionable.
- c)** High temperatures impose severe restriction on the servicing conditions of the plant.
- d)** Overall efficiency is low since two-thirds of the total power output is used for driving the compressor.
- e)** The blades of the turbine require special cooling methods due to the severity of operating temperatures and pressures. In practice, the temperatures at the entry of the turbine are as high as 1100°C - 1260°C. Hence they should be made of special metals and alloys.



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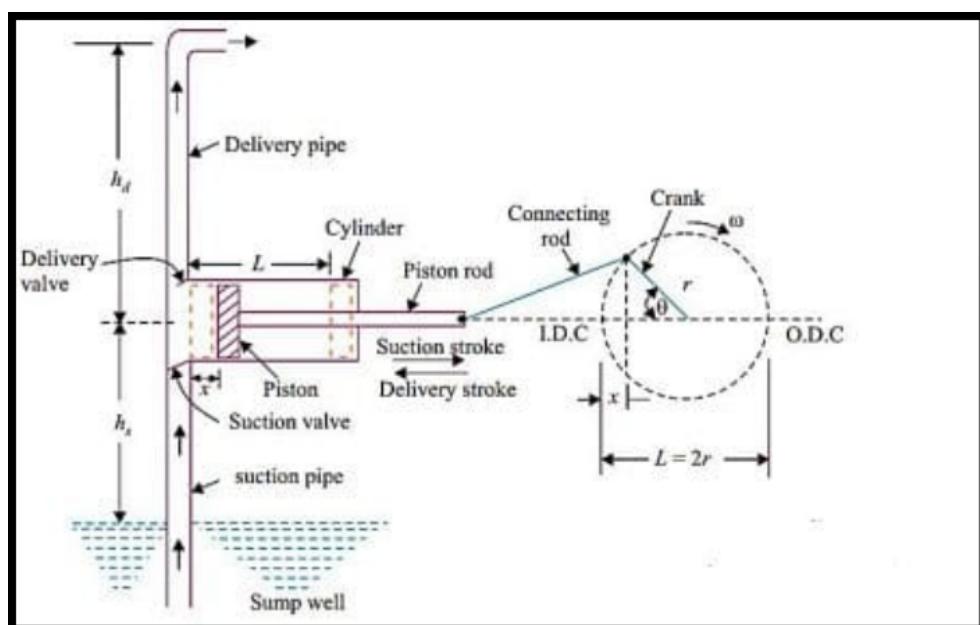
### Reciprocating Pump

Reciprocating pump is a positive displacement pump where certain volume of liquid is collected in enclosed volume and is discharged using pressure to the required application. Reciprocating pumps are more suitable for low volumes of flow at high pressures.

### Components of Reciprocating Pump

The main components of reciprocating pump are as follows:

- a) Suction Pipe
- b) Suction Valve
- c) Delivery Pipe
- d) Delivery Valve
- e) Cylinder
- f) Piston and Piston Rod
- g) Crank and Connecting Rod
- h) Strainer
- i) Air Vessel





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## **Components of Reciprocating pump**

### **1. Suction Pipe**

Suction pipe connects the source of liquid to the cylinder of the reciprocating pump. The liquid is suck by this pipe from the source to the cylinder.

### **2. Suction Valve**

Suction valve is non-return valve which means only one directional flow is possible in this type of valve. This is placed between suction pipe inlet and cylinder. During suction of liquid it is opened and during discharge it is closed.

### **3. Delivery Pipe**

Delivery pipe connects cylinder of pump to the outlet source. The liquid is delivered to desired outlet location through this pipe.

### **4. Delivery Valve**

Delivery valve also non-return valve placed between cylinder and delivery pipe outlet. It is in closed position during suction and in opened position during discharging of liquid.

### **5. Cylinder**

A hollow cylinder made of steel alloy or cast iron. Arrangement of piston and piston rod is inside this cylinder. Suction and release of liquid is takes place in this so, both suction and delivery pipes along with valves are connected to this cylinder.

### **6. Piston and Piston Rod**

Piston is a solid type cylinder part which moves backward and forward inside the hollow cylinder to perform suction and deliverance of liquid. Piston rod helps the piston to its linear motion.

### **7. Crank and Connecting Rod**

Crank is a solid circular disc which is connected to power source like motor, engine etc. for its rotation. Connecting rod connects the crank to the piston as a result the rotational motion of crank gets converted into linear motion of the piston.

### **8. Strainer**

Strainer is provided at the end of suction pipe to prevent the entrance of solids from water source into the cylinder.



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## **9. Air Vessel**

Air vessels are connected to both suction and delivery pipes to eliminate the frictional head and to give uniform discharge rate.

### **Working of Reciprocating Pump**

The working of reciprocating pump is as follows:

- When the power source is connected to crank, the crank will start rotating and connecting rod also displaced along with crank.
- The piston connected to the connecting rod will move in linear direction. If crank moves outwards then the piston moves towards its right and create vacuum in the cylinder.
- This vacuum causes suction valve to open and liquid from the source is forcibly sucked by the suction pipe into the cylinder.
- When the crank moves inwards or towards the cylinder, the piston will move towards its left and compresses the liquid in the cylinder.
- Now, the pressure makes the delivery valve to open and liquid will discharge through delivery pipe.
- When piston reaches its extreme left position whole liquid present in the cylinder is delivered through delivery valve.
- Then again the crank rotate outwards and piston moves right to create suction and the whole process is repeated.
- Generally the above process can be observed in a single acting reciprocating pump where there is only one delivery stroke per one revolution of crank. But when it comes to double acting reciprocating pump, there will be two delivery strokes per one revolution of crank.



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### **Uses of Reciprocating Pump**

Reciprocating pump is mainly used for

- Oil drilling operations
- Pneumatic pressure systems

### **Centrifugal Pump**

The centrifugal pump is, a pump which can be used for handling huge amount of liquids to provide extremely high flow rates, and they have the capability to regulate their flow of liquid rates over a wide range.

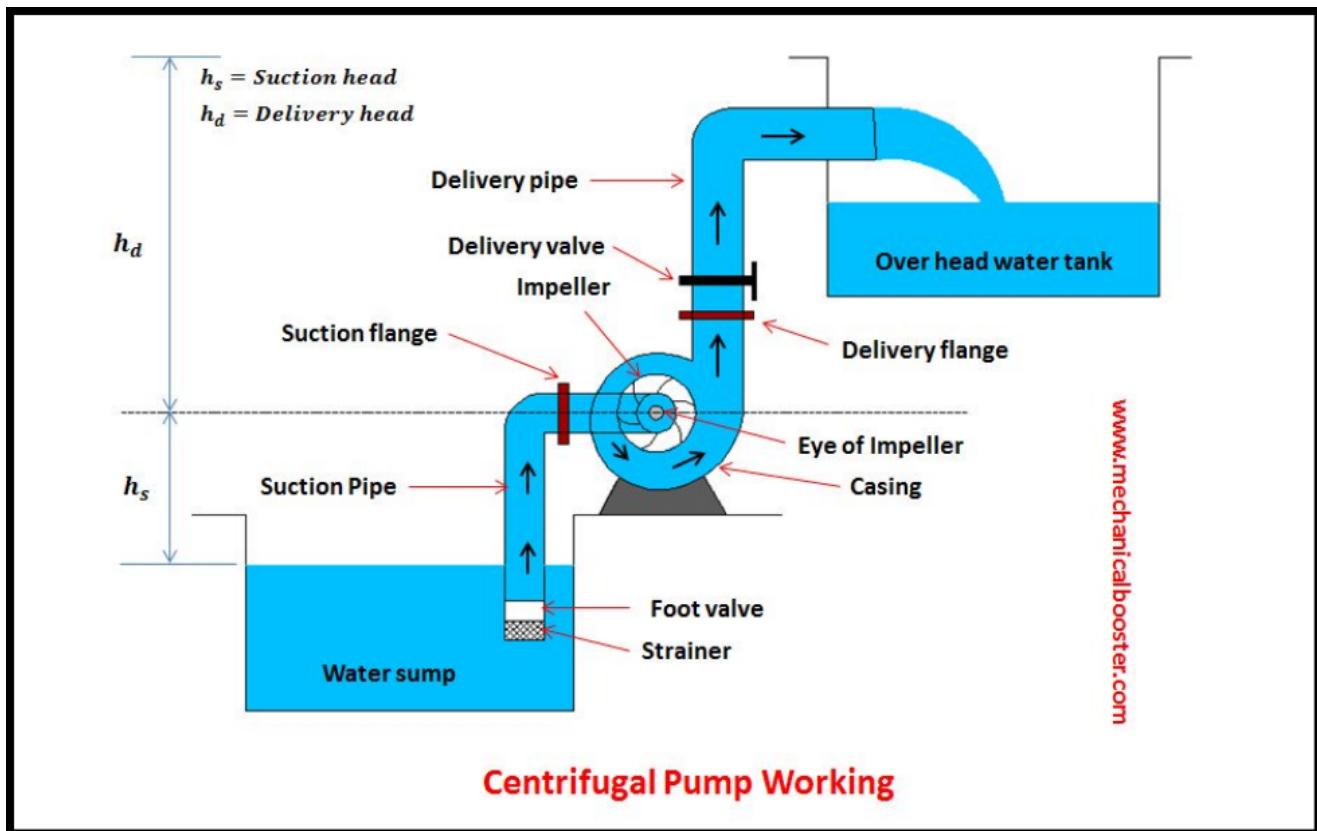
Generally, these pumps are designed for liquids which have a comparatively low viscosity that transfers like light oil otherwise water. Centrifugal pump components mainly include three parts such as an impeller, a casing, suction pipe by a foot valve & strainer delivery pipe.

A centrifugal pump utilizes rotation to pass on velocity in the direction of the fluid. Each centrifugal pump uses a hydraulic component like an impeller that turns to pass on velocity toward the pumped fluid. This pump mainly used to change the velocity into liquid flow.

Each pump uses a hydraulic component like a casing that captures the velocity which is informed by the impeller & directs the pushed fluid toward the pump expulsion end.

### **Centrifugal Pump Working Principle**

The centrifugal pump working principle mainly depends on the flow of forced vortex which means whenever a certain accumulation of liquid or fluid is permitted to turn with an exterior torque than there will be an increase within rotating liquid pressure head takes place. The increase in pressure head can be used to carry water from one site to another site. It is the force performing on the liquid that makes to supply in the casing.



### Priming of Centrifugal Pump

The pump priming is the most important step while starting a centrifugal pump. Because these pumps are not capable of pumping vapors otherwise air. It is the one type of method where the impeller of a pump will obtain totally submerged within fluid exclusive of some air trap inside. This is particularly needed as there is a primary start-up. The priming methods are classified into four types namely manually, with a vacuum pump, with a jet pump, and with separator.

### Advantages of Centrifugal Pumps

The centrifugal pumps advantages include the following.

- These pumps do not include drive seals that reduce leakage risk.
- These pumps are used to pump out harmful and risky fluids.
- These pumps have magnetic coupling that can be damaged simply in overload situations as well as protects the pump from external forces.
- The motor and pump are separated from each other so heat transfer is impossible from the



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motor topump.

### **Disadvantages of CentrifugalPumps**

The centrifugal pumps disadvantages include the following.

- The energy loss can be occurred due to the coupling that generates some magnetic resistance.
- Once the intense load occurs, possibilities are there for the coupling fall.
- If fluids with ferrous particles are pumped out, then rust occurs & over the time pumps stops working.
- When the flow of liquid is less through the pump, then the overheating can occur.

### **Applications of CentrifugalPumps**

The centrifugal pumps applications include the following.

- These pumps are used in the oil and energy industries for pumping oil, mud, slurry, and power generationplants.
- These pumps are used in industrial and fire protection for ventilation & heating, boiler feed, pressure boosting, fire security sprinkler systems, and air conditioning.
- These pumps are used in waste management, agriculture, and manufacturing for wastewater processing plants, gas processing, irrigation, drainage, municipal industry, and overflow security.
- These pumps are used in food, chemical, pharmaceutical industries for hydrocarbons, paints, cellulose, petrochemical, beverage production, sugar refining, and food.