LAKSHMI NARAIN COLLEGE OF TECHNOLOGY, BHOPAL

INTRODUCTION OF FLUID AND HYDRAULIC MACHINES

BT-203
B.M.E

Mr.SACHIN KUMAR NIKAM
ASSISTANT PROFESSOR

LNCT GROUP OF COLLEGES
"WORKING TOWARDS BEING THE BEST"

DEPARTMENT OF MECHANICAL ENGINEERING

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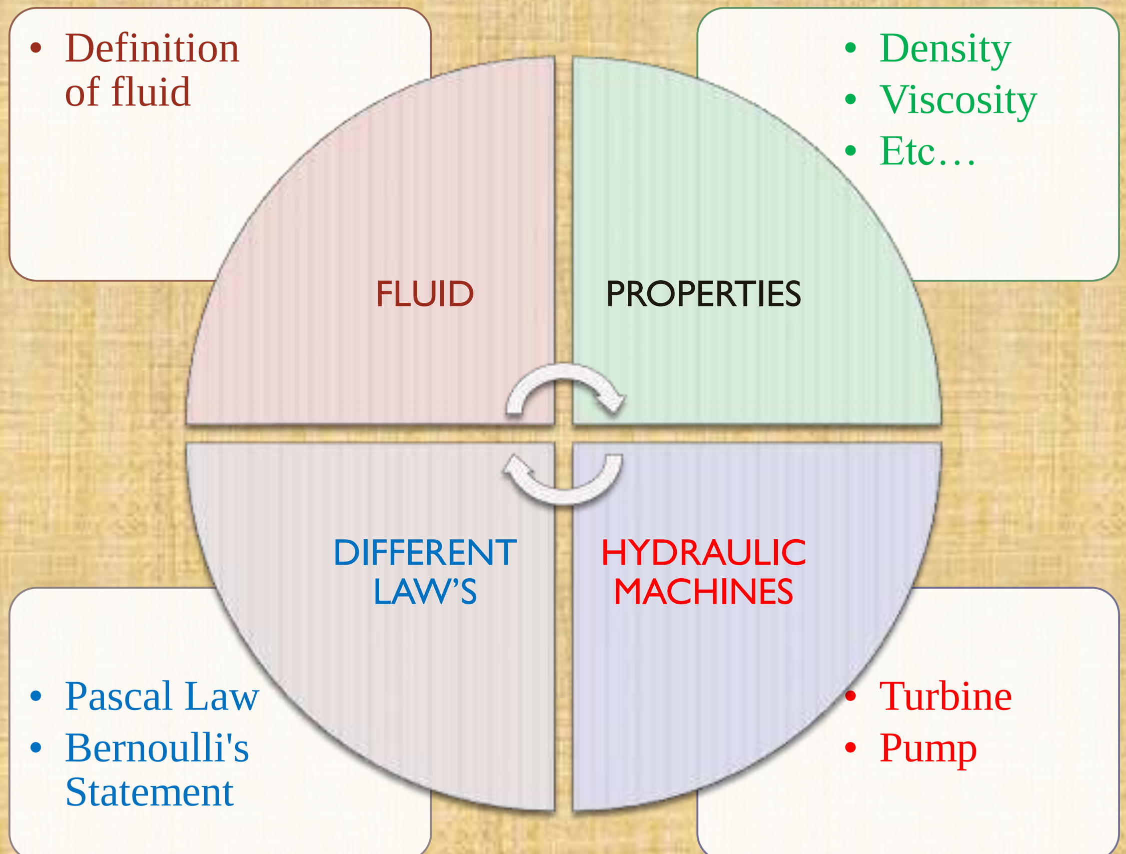

FLUID
Definition of fluid
PROPERTIES
Density
Viscosity
Etc…
DIFFERENT LAW'S
Pascal Law
Bernoulli's Statement
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DEFINITION OF FLUID

A fluid is a substance which is capable to flow or that continually deforms (flows) under an applied shear stress, or external force. In other words “A state of matter, such as liquid or gas, in which the component particles (generally molecules) can move past one another”.

Fluids are a phase of matter that include liquids, gases and plasmas. They are substances with zero shear modulus.

Types of Fluid:

Following are the types of fluid:

- ✓Ideal fluid
- ✓Real fluid
- ✓Newtonian fluid
- ✓Non-Newtonian fluid
- ✓Ideal plastic fluid
- ✓Incompressible fluid
- ✓Compressible fluid

Ideal fluid: A fluid is said to be ideal when it cannot be compressed and the viscosity doesn't fall in the category of an ideal fluid. It is an imaginary fluid which doesn't exist in reality.

Real fluid: All the fluids are real as all the fluid possess viscosity.

Newtonian fluid: When the fluid obeys Newton's law of viscosity, it is known as a Newtonian fluid.

Non-Newtonian fluid: When the fluid doesn't obey Newton's law of viscosity, it is known as Non-Newtonian fluid

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Ideal plastic fluid: When the shear stress is proportional to the velocity gradient and shear stress is more than the yield value, it is known as ideal plastic fluid.

Incompressible fluid: When the density of the fluid doesn't change with the application of external force, it is known as an incompressible fluid.

Compressible fluid: When the density of the fluid changes with the application of external force, it is known as compressible fluid.

DIFFERENT PROPERTIES OF FLUIDS

The term fluid includes both liquid and gases. The main difference between a liquid and a gas is that the volume of a liquid remains definite because it takes the shape of the surface on or in which it comes into contact, whereas a gas occupies the complete space available in the container in which it is kept.

SO we will examine some terms and properties of the liquids. Properties of fluids determine how fluids can be used in engineering and technology.

The following are some of the important basic properties of fluids:

- ✓Density
- ✓Viscosity
- ✓Temperature
- ✓Pressure
- ✓Specific Volume
- ✓Specific Weight
- ✓Specific Gravity

1. Density:

Density is the mass per unit volume of a fluid. In other words, it is the ratio between mass (m) and volume (V) of a fluid.

Density is denoted by the symbol ‘ρ’. Its unit is kg/m^3.

In general, density of a fluid decreases with increase in temperature. It increases with increase in pressure.

The ideal gas equation is given by:

$$PV = mRT \quad \left\{ \text{Where } R \rightarrow \text{Universal Gas Constant} \right\}$$

$$P = \rho RT \quad \left[\text{Since, } \rho = \frac{m}{V}\right]$$

$$P = \left(\frac{m}{V}\right)RT$$

The above equation is used to find the density of any fluid, if the pressure (P) and temperature (T) are known. **Note:** The density of standard liquid (water) is 1000 kg/m^3.

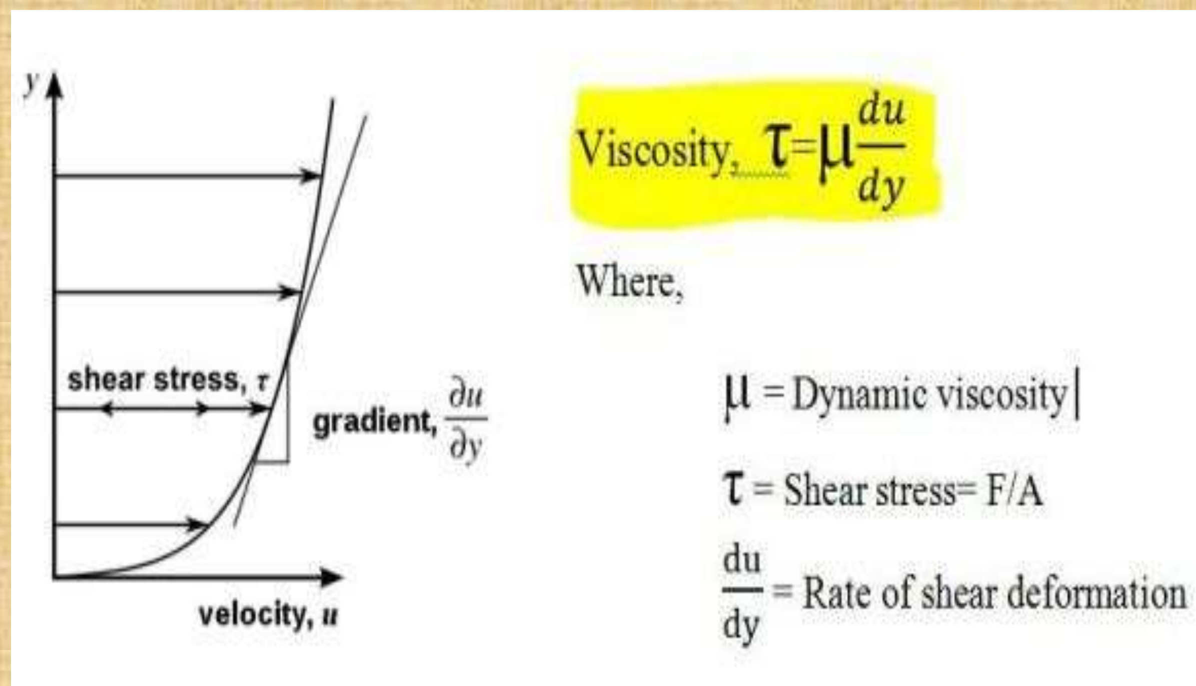
2. Viscosity:

Viscosity is the fluid property that determines the amount of resistance of the fluid to shear stress. It is the property of the fluid due to which the fluid offers resistance to flow of one layer of the fluid over another adjacent layer.

In a liquid, viscosity decreases with increase in temperature. In a gas, viscosity increases with increase in temperature.

Viscosity denotes opposition to flow. The reciprocal of the viscosity is called the fluidity, a measure of the ease of flow. Molasses, for example, has a greater viscosity than water. Because part of a fluid that is forced to move carries along to some extent adjacent parts, viscosity may be thought of as internal friction between the molecules; such friction opposes the development of velocity differences within a fluid. Viscosity is a major factor in determining the forces that must be overcome when fluids are used in lubrication and transported in pipelines. It controls the liquid flow in such processes as spraying, injection molding, and surface coating.

Let see in figure take two adjacent layer of fluid one is moving with U velocity and another is moving U+du velocity and both the layer are dy distance apart then the shear force between the two layer can be expressed by mentioned question in figure.



Kinematic viscosity is defined as **dynamic viscosity** divided by fluid density. **Kinematic viscosity** is a measure of a fluid's internal resistance to flow under gravitational forces.

Kinematic viscosity is defined as dynamic viscosity divided by fluid density:

$$\nu = \eta/\rho.$$

The basic unit of kinematic viscosity ν is the stoke, where 1 stoke is equivalent to 0.0001m2/s

Newton's viscosity law's states that, the shear stress between adjacent fluid layers is proportional to the velocity gradients between the two layers. The ratio of shear stress to shear rate is a constant, for a given temperature and pressure, and is defined as the **viscosity** or coefficient of **viscosity**.

Newton's Law of viscosity, $\tau \propto \frac{du}{dy}$

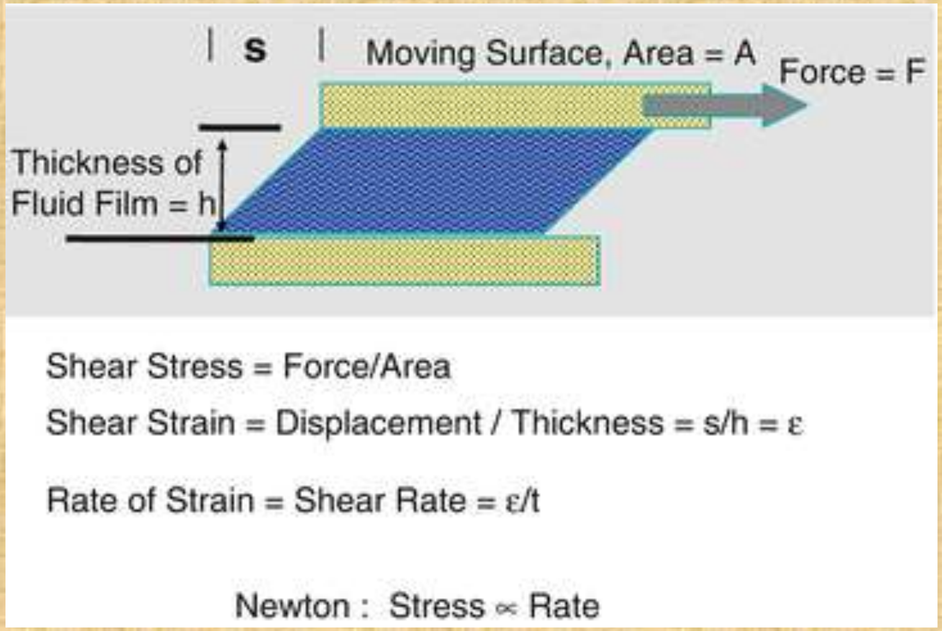
$$\tau = \mu \frac{du}{dy}$$

Where,.

μ = Viscosity

τ = Shear stress= F/A

$\frac{du}{dy}$ = Rate of shear deformation



A Newtonian fluid is defined as one with constant viscosity, with zero shear rate at zero shear stress, that is, the shear rate is directly proportional to the shear stress. i.e those fluid which obey the Newton's law are Newtonian fluid.
EX:-Water, oil, gasoline, alcohol and even glycerin are examples of Newtonian fluids.

A non-Newtonian fluid is a fluid that does not follow Newton's law of viscosity, i.e., constant viscosity independent of stress. In non-Newtonian fluids, viscosity can change when under force to either more liquid or more solid
EX:- custard, honey, toothpaste, starch suspensions, corn starch, paint, blood, and shampoo

3. Temperature:

It is the property that determines the degree of hotness or coldness or the level of heat intensity of a fluid. Temperature is measured by using temperature scales. There are 3 commonly used temperature scales.

They are

✓Celsius (or centigrade) scale

✓Fahrenheit scale

✓Kelvin scale (or absolute temperature scale)

Kelvin scale is widely used in engineering. This is because, this scale is independent of properties of a substance.

4. Pressure:

Pressure of a fluid is the normal force per unit area of the fluid. In other words, it is the ratio of force on a fluid to the area of the fluid held perpendicular to the direction of the force. Pressure is denoted by the letter 'P'. Its unit is N/m^2.

5. Specific Volume:

Specific volume is the volume of a fluid (V) occupied per unit mass (m). It is the reciprocal of density.

Specific volume is denoted by the symbol 'v'. Its unit is m^3/kg.

$$\text{Specific Volume}, v = \frac{V}{m} \ \frac{m^3}{kg}$$

6. Specific Weight:

Specific weight is the weight possessed by unit volume of a fluid. It is denoted by 'w'. Its unit is N/m^3.

Specific weight varies from place to place due to the change of acceleration due to gravity (g).

$$\text{Specific weight}, w = \frac{\text{Weight}}{\text{Volume}} \quad \frac{N}{m^3}$$

7. Specific Gravity:

Specific gravity is the ratio of specific weight of the given fluid to the specific weight of standard fluid. It is denoted by the letter 'S'. It has no unit.

Specific gravity may also be defined as the ratio between density of the given fluid to the density of standard fluid.

$$\text{Specific Gravity}, S = \frac{\text{Specific Weight of Given Fluid}}{\text{Specific Weight of Standard Fluid}}$$

$$S = \frac{\rho_{\text{given fluid}}}{\rho_{\text{standard fluid}}}$$

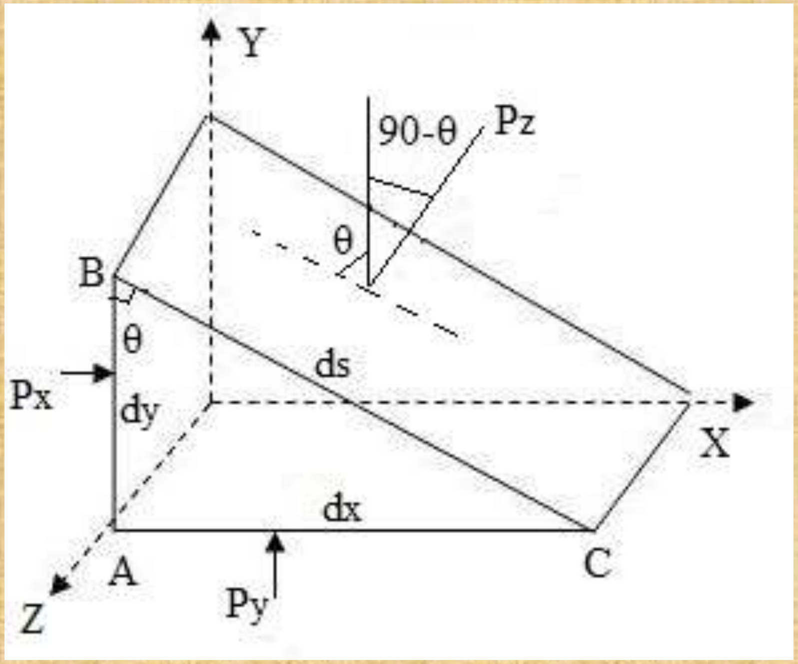
SOME BASIC LAW:

Pascal's principle, also called **Pascal's law**, in fluid (gas or liquid) mechanics, statement that, in a fluid at rest in a closed container, a pressure change in one part is transmitted without loss to every portion of the fluid and to the walls of the container.
The law was established by French mathematician Blaise Pascal in 1647–48.

or

Pascal's law states that the pressure of a gas or liquid exerts force equally in all directions against the walls of its container $P_x = P_y = P_z$

DERIVATION:-



Consider an arbitrary fluid element of wedge shape in a fluid mass at rest as shown in figure. Let the width of the element is unity and P_x, P_y, P_z are the pressure on the face AB, AC, BC respectively. Lets consider the angle ABC= Ө then the forces acting on the element are:

1. Pressure force normal to the surface.
2. Weight of element in the vertical direction.

The forces on the faces are:

We know the pressure = Force/ area

Force = P x A

Forces on the face AB = Px X Area of face AB   X = Multiplication sign

= Px X dy X 1

Similarly Forces on the face AC = Py X dx X 1

Force on the face BC = Pz X ds X 1

Weight of the element = volume X w

Where w = weight density of the fluid

Then weight of element = [(AB X AC) /2] X 1 X w

Resolving the forces in horizontal direction we have

Px X dy X 1 – Pz X ds X cos Ө

But we know from the figure

ds cosϴ = AB= dy

Px X dy X 1- Pz X dy X 1= 0

Px = Pz……………………………………………(1)

Similarly resolving all the forces vertically we get

Py X dx X 1- Pz X ds X 1sinϴ –[(dx.dy)/2] X w = 0

But ds.sinϴ = dx and also the element is very small hence weight is negligible

Py . dx – Pz.dx

Py = Pz ……………………………………………..(2)

From equation 1 and 2 we get

Px= Py= Pz

Proof.

BERNOULLI'S Eq.:

It state that when an incompressible ideal fluid flowing in non uniform cross section tube , when the flow is steady and continuous the sum of pressure energy, potential energy, and kinetic energy is constant at every section, there is no significant change in temperature. Hence internal energy is not considered.

The application of the principle of conservation of energy to frictionless laminar flow leads to a very useful relation between pressure and flow speed in a fluid. This relation is called Bernoulli's equation, named after Daniel Bernoulli (1700–1782), who published his studies on fluid motion in his book *Hydrodynamica* (1738).

$$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = const.$$

$\frac{P}{\rho g}$ = Pressure head

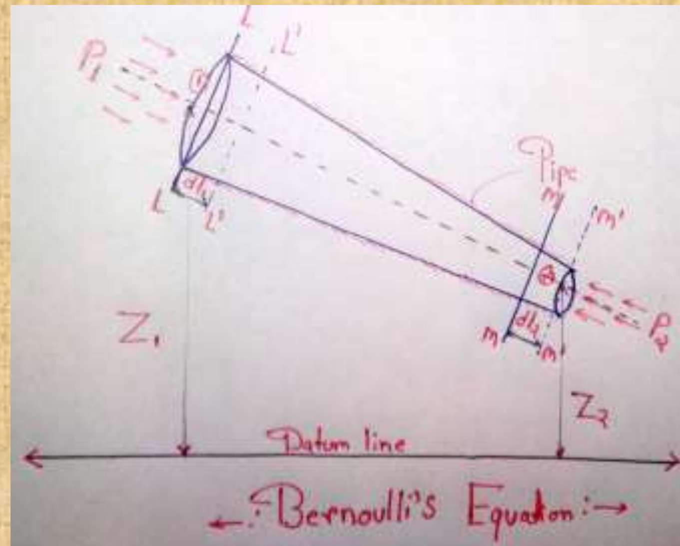
$\frac{V^2}{2g}$ = Kinetic head

Z = Potential or Elevation head

Assumptions:

1. Fluid is ideal, i.e. inviscid and incompressible.
2. Fluid flow is steady, one-dimensional and uniform.
3. Fluid flow is irrational.
4. Forces which are considered are only pressure force and gravity force. Rest forces acting on fluid are neglected.

Derivation:



Bernoulli's Equation :→

$$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \text{Constant}$$

Proof.

Consider an ideal incompressible liquid through a non-uniform pipe as shown in figure. Let us Consider two Sections LL and MM and assume that the pipe is running full and there is Continuity of flow between the two Sections:

Let, P_1 = Pressure at LL.

V_1 = Velocity of liquid at LL.

Z_1 = Height of LL above the datum.

A_1 = Area of Pipe at LL and

P_2, V_2, Z_2, A_2 = Corresponding values at MM.

Let the liquids between the two Sections LL and MM move to L'L' and M'M' through very Small lengths dl_1 and dl_2 as shown in fig. This movement of liquid between LL and MM is equivalent to the movement of liquid between L'L' and M'M'

Let, W = Weight of liquid between LL and L'L'

Let, W = Weight of liquid between LL and L'L'

As the flow is Continuous.

$$W = \omega A_1 . dl_1 = \omega A_2 . dl_2$$

$$A_1 . dl_1 = W/\omega \quad \text{-------------} \quad (1)$$

Similarly,

$$A_2 . dl_2 = W/\omega$$

$$A_1 . dl_1 = A_2 dl_2 = W/\omega$$

Work done by Pressure at LL in moving the liquid to L'L'

$$= \text{Force} \times \text{Distance}$$

$$= P_1 . A_1 . dl_1$$

Similarly, work Done by the Pressure at MM in moving the liquid to M'M' = $-P_2 . A_2 . dl_2$ [∵ –ve Sign for opposite direction]

Total Work done by the Pressure

$$= P_1 . A_1 dl_1 - P_2 A_2 dl_2 \qquad \because A_1 dl_1 = A_2 dl_2$$

$$= P_1 . A_1 dl_1 - P_2 A_1 dl_1$$

$$= A_1 . dl_1 (P_1 - P_2)$$

$$= \frac{W}{\omega} (P_1 - P_2)$$

Loss of Potential energy $= W(Z_1 - Z_2)$

Gain in K.E $= W\left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g}\right) = \frac{W}{2g}(V_2^2 - V_1^2)$

Also, loss of Potential energy + Work done = Gain in K.E

$$W(Z_1 - Z_2) + \frac{W}{\omega}(P_1 - P_2) = \frac{W}{2g}(V_2^2 - V_1^2)$$

$$(Z_1 - Z_2) + \left(\frac{P_1}{\omega} - \frac{P_2}{\omega}\right) = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

$$\frac{P_1}{\omega} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\omega} + \frac{V_2^2}{2g} + Z_2$$

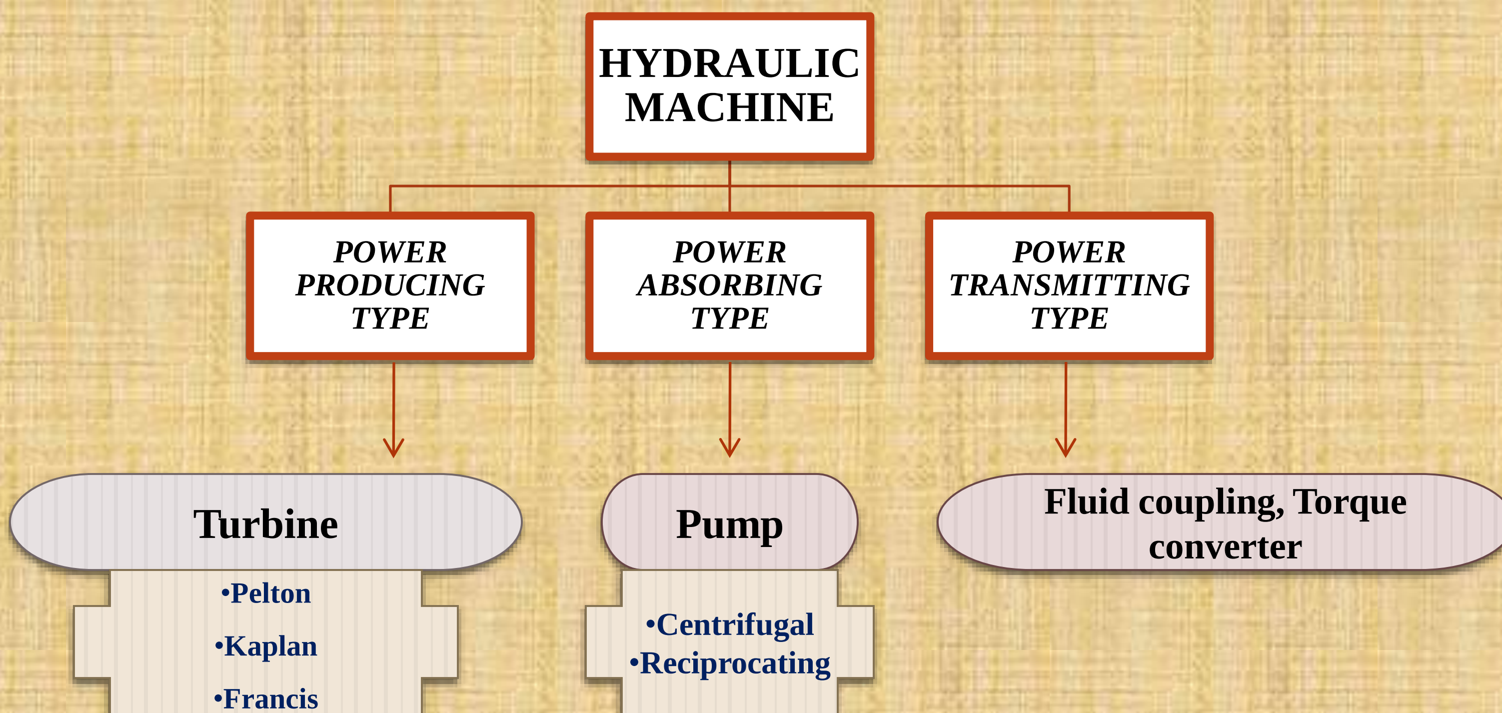
$$\boxed{\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \text{Constant}}$$

HYDRAULIC MACHINE

HYDRAULIC MACHINE is a machine which convert hydraulic energy into other form of energy.

Or

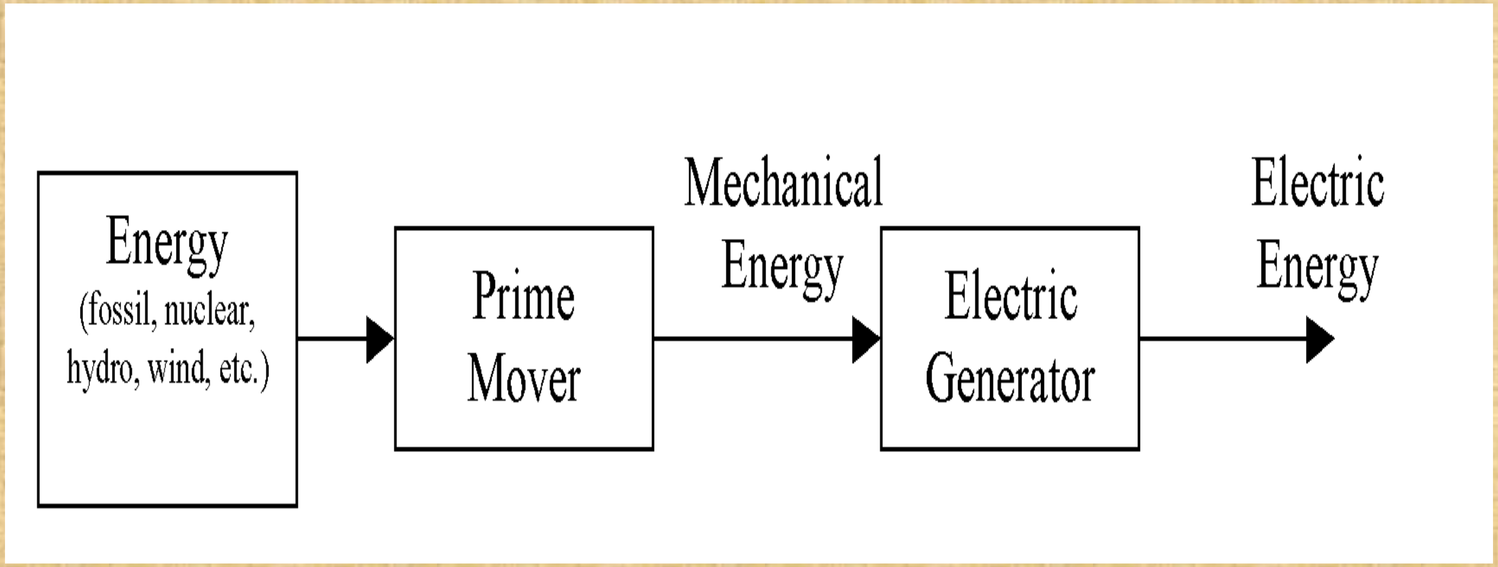
The machine in which force is transmitted by liquids under pressure is known as **hydraulic machine.**



Hydraulic-Turbines

Hydraulic turbines are Machines which convert hydraulic energy in to mechanical energy. hydraulic turbines have a row of blades fitted to the rotating shaft or a rotating plate. Flowing liquid, mostly water, when pass through the Hydraulic Turbine it strikes the blades of the turbine and makes the shaft rotate.

Turbines are the power generating machine which produce electrical energy.



CLASSIFICATION OF HYDRAULIC TURBINES:

1) Based on type of energy at inlet to the turbine:

- **Impulse Turbine** : The energy is in the form of kinetic form. e.g: Pelton wheel, Turbo wheel.
- **Reaction Turbine** : The energy is in both Kinetic and Pressure form. e.g: Tubular, Bulb, Propellar, Francis turbine.

2) Based on direction of flow of water through the runner:

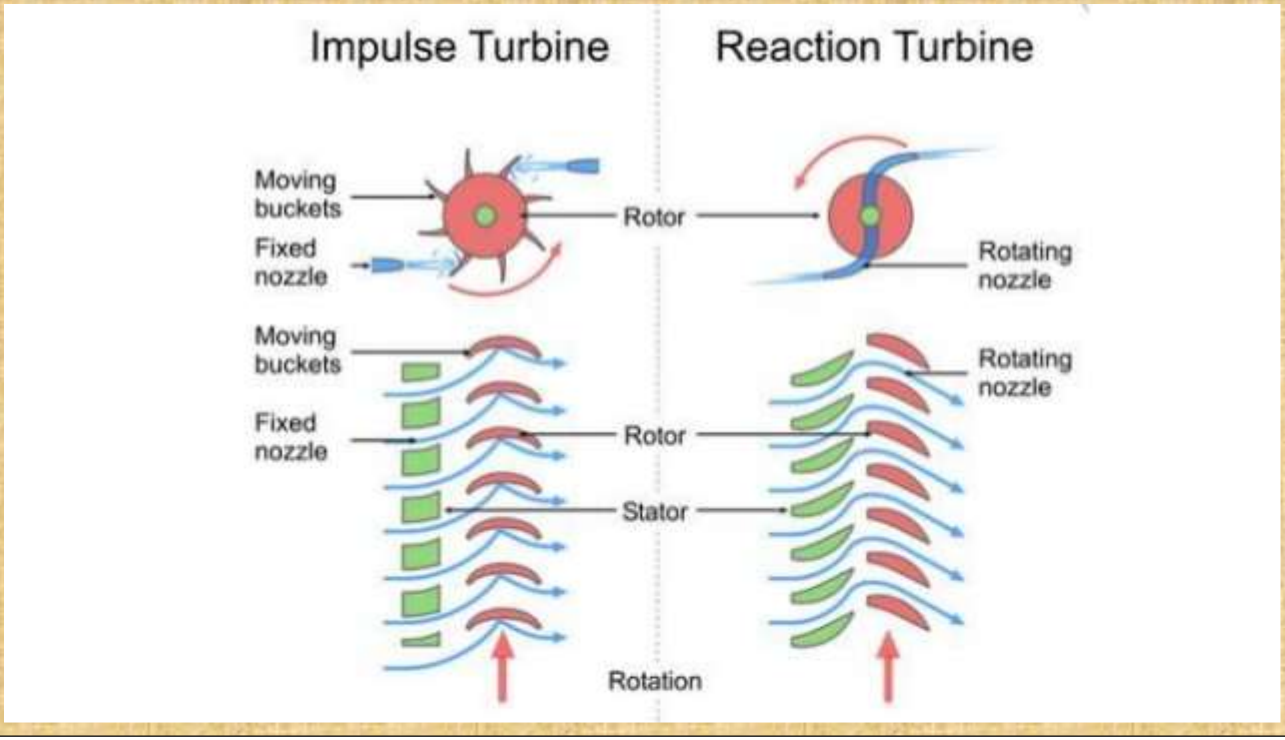
- ✓**Tangential flow:** water flows in a direction tangential to path of rotational, i.e. Perpendicular to both axial and radial directions.
- ✓**Radial outward flow** e.g : Forneyron turbine.
- ✓**Axial flow :** Water flows parallel to the axis of the turbine. e.g: Girard, Jonval, Kalpan turbine.
- ✓**Mixed flow :** Water enters radially at outer periphery and leaves axially. e.g : Modern Francis turbine.

3) Based on the head under which turbine works:

- ➢High head, impulse turbine. e.g : Pelton turbine.
- ➢Medium head, reaction turbine. e.g : Francis turbine.
- ➢Low head, reaction turbine. e.g : Kaplan turbine, propeller turbine.

4) Based on the specific speed of the turbine:

- ❖Low specific speed, impulse turbine. e.g : Pelton wheel.
- ❖Medium specific speed, reaction turbine. e.g : Francis wheel.
- ❖High specific speed, reaction turbine. e.g : Kaplan and Propeller turbine.



PELTON-TURBINE

The Pelton-wheel is an impulsive turbine used for high heads of water. This turbine was discovered by the American engineer L.A. Pelton. mid 1870s The energy available at the inlet of the Pelton turbine is only kinetic energy. The pressure at the inlet and outlet of the turbine is atmospheric pressure.

Main components of Pelton turbine:

1. Penstock
2. Spear and nozzle
3. Runner with buckets
4. Casing
5. Breaking jet

1. Penstock: It is a large sized channel which conveys water from the high level reservoir to the turbine. It is made of wood, concrete, and steel. It consists of control valve for regulating the water flow towards the turbine.

2. Spear and nozzle: It is fitted to penstock and converts the whole of the hydraulic energy into high speed jet to regulate the water flow through nozzle spear is used which is a control device of flow.

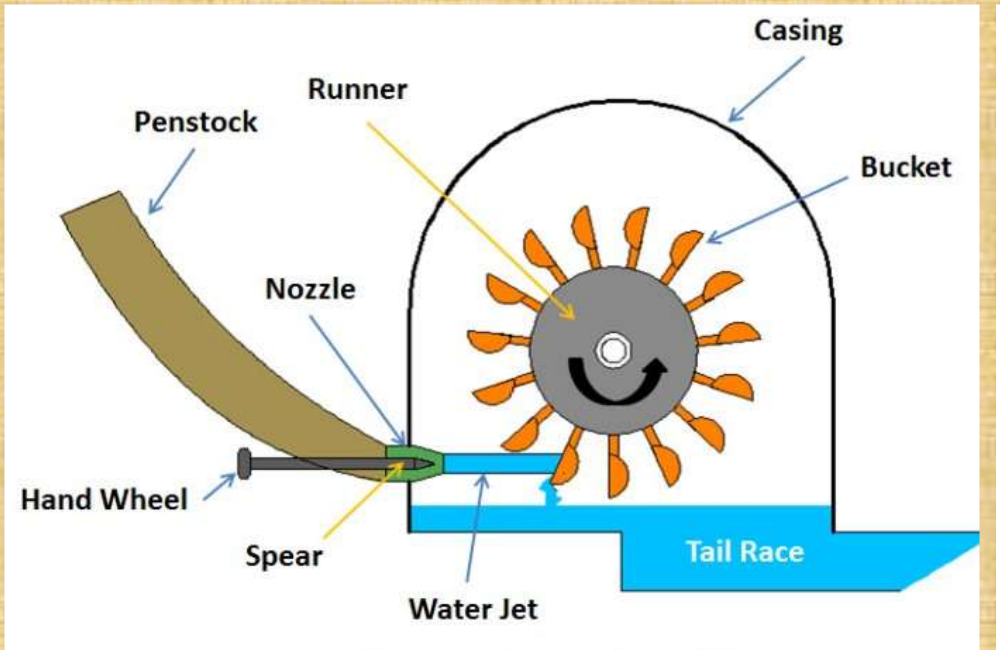
3. Runner with buckets: The turbine rotor is called runner circular disk carrying a number of cup shaped buckets. The runner is generally mounted on a horizontal circular shaft. The water jet strike the buckets and runner will starts rotates.

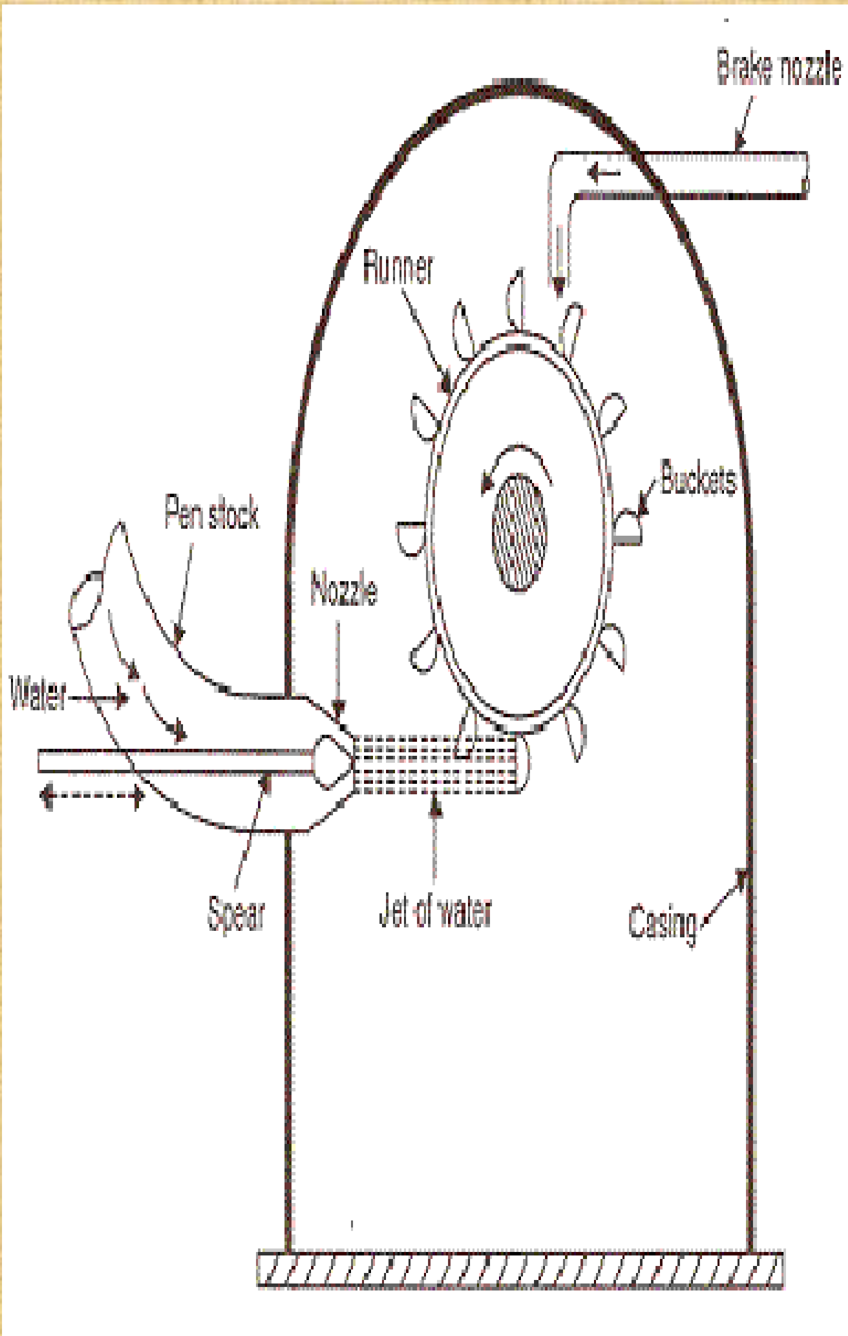
4. Casing: Out flow from the runner buckets in the form of strong splash which scatters in all directions to prevent this and to guide the water to the tail race a casing is provided.

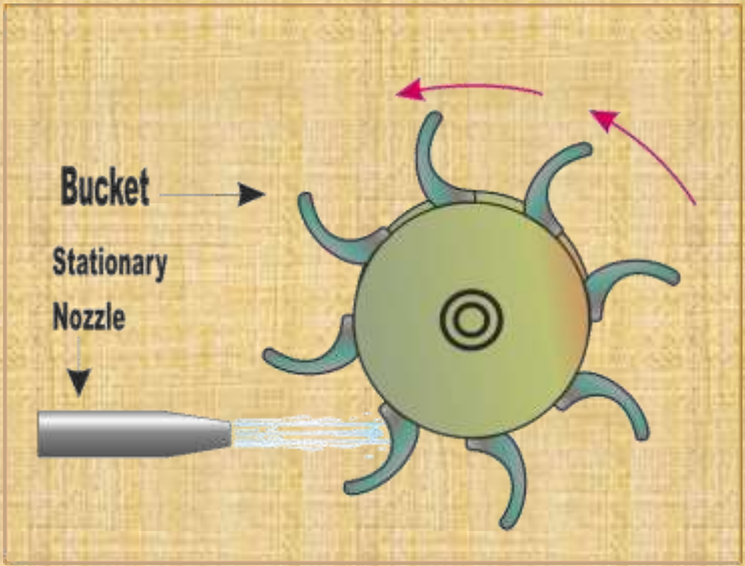
5. Breaking jet: At the maintains condition when we shut down the turbine according to demand we have to stop the supply of water jet. Due to inertia its rotes at some r.p.m without the strike of water jet on it. At that condition a water jet is strike on buckets from the opposite side to stop the rotation of the runner. This is known as breaking jet.

Working of Pelton Turbine:

The water is transferred from the high head source through a long conduit called Penstock. Nozzle arrangement at the end of penstock helps the water to accelerate and it flows out as a high speed jet with high velocity and discharge at atmospheric pressure. The jet will hit the the buckets which will distribute the jet into two halves of bucket and the wheel starts revolving. The K.E of the jet is reduced when it hits the bucket and also due to spherical shape of buckets the directed jet will change its direction and takes U-turn and falls into tail race. In general, water collected in tail race should not submerge the Pelton wheel in any case. To generate more power, two Pelton wheels can be arranged to a single shaft or two water jets can be directed at a time to a single Pelton wheel.


Casing
Runner
Penstock
Bucket
Nozzle
Hand Wheel
Spear
Tail Race
Water Jet

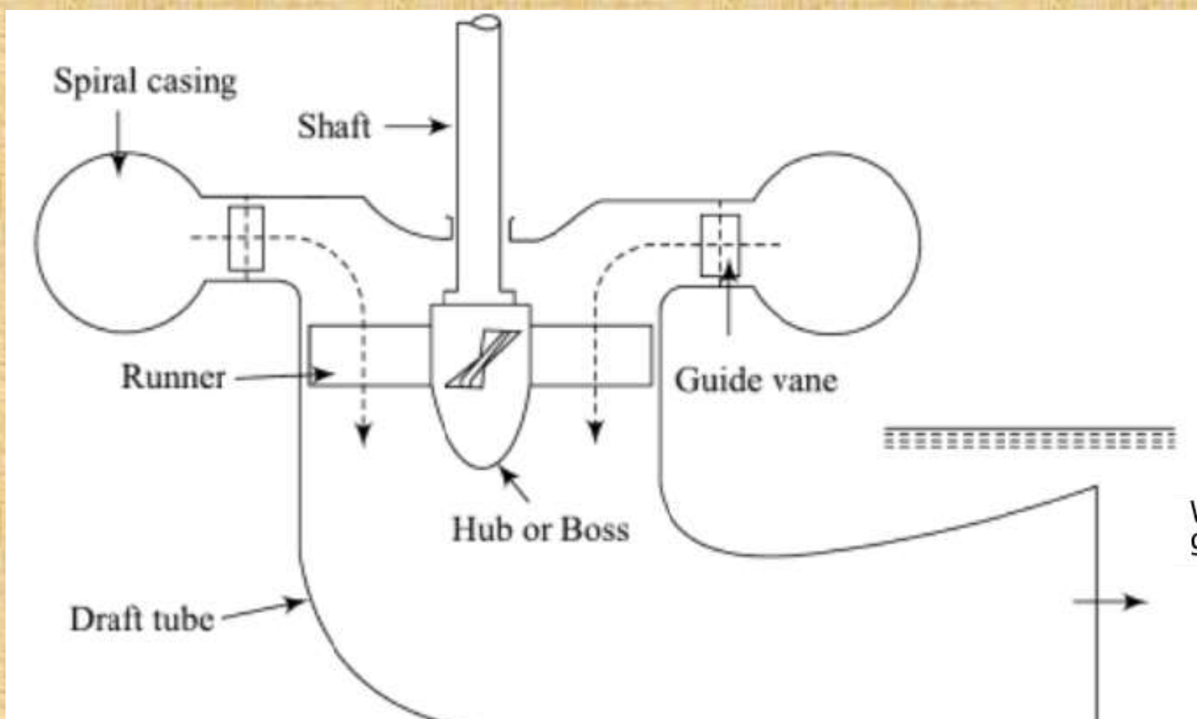

Brake nozzle
Runner
Buckets
Pen stock
Nozzle
Water
Spear
Jet of water
Casing

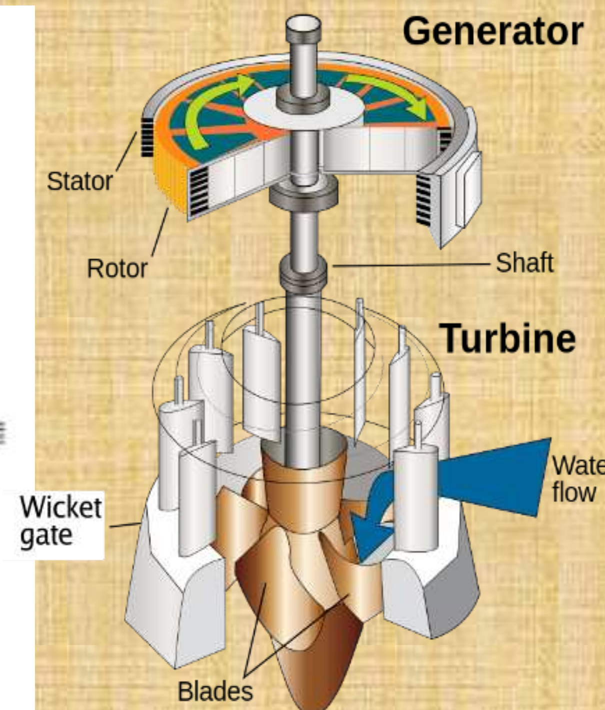

Bucket
Stationary
Nozzle

KAPLAN-TURBINE

The **Kaplan turbine** is an axial flow reaction **turbine**, which means that the **working** fluid changes pressure as it moves through the **turbine** and gives up its energy. Power is recovered from both the hydrostatic head and from the kinetic energy of the flowing water.

The **Kaplan turbine** is a propeller-type water turbine which has adjustable blades. It was developed in 1913 by Austrian professor Viktor Kaplan.





Operating parameters of Kaplan Turbine

Head: 10 m to 70 m

RPM: 54.5 to 429

Power output: 5 MW to 200 MW

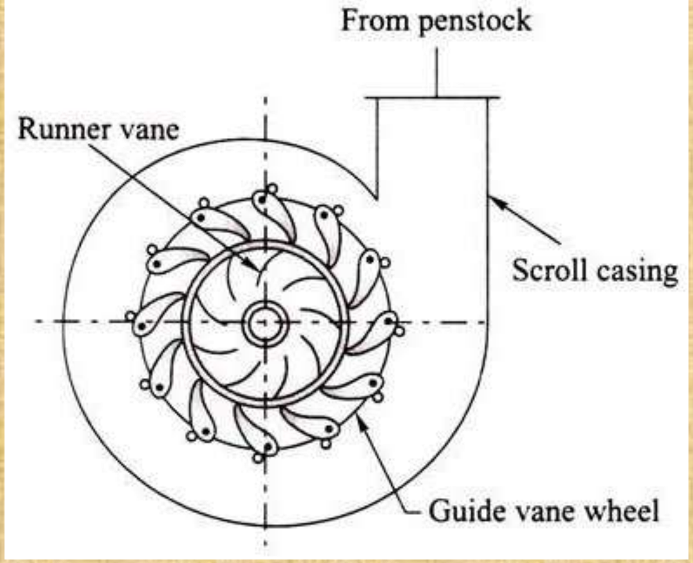
Runner diameter: 2 m to 11 m

The main parts of Kaplan Turbine are,

1. **Scroll Casing**
2. **Guide Vane Mechanism**
3. **Draft Tube**
4. **Runner Blades**

1. Scroll Casing

It is a spiral type of casing that has decreasing cross section area. The water from the penstocks enters the scroll casing and then moves to the guide vanes where the water turns through 90° and flows axially through the runner. It protects the runner, runner blades guide vanes and other internal parts of the turbine from an external damage.

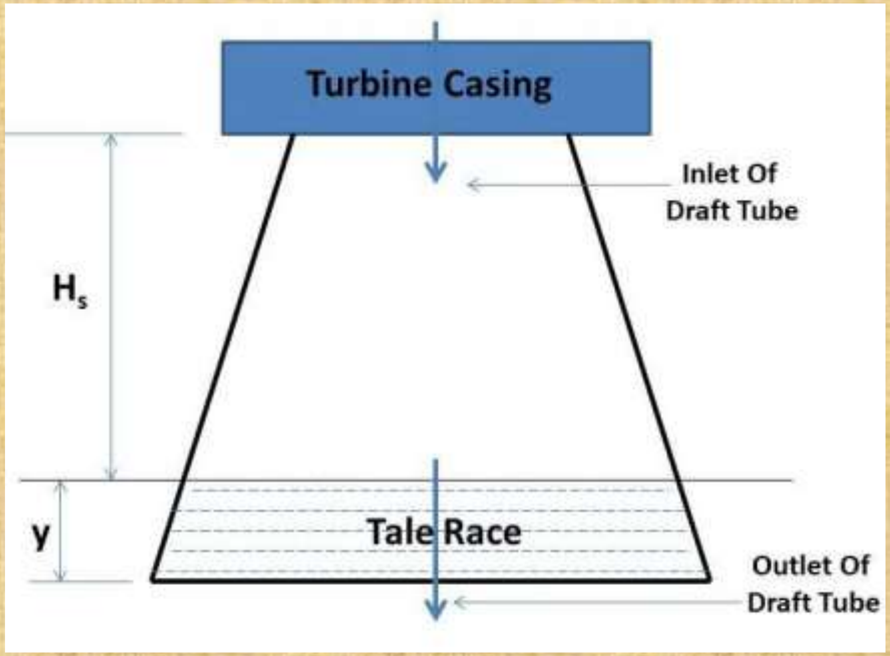


2. Guide Vane Mechanism

It is the only controlling part of the whole turbine, which opens and closes depending upon the demand of power requirement. In case of more power output requirements, it opens wider to allow more water to hit the blades of the rotor and when low power output requires it closes itself to cease the flow of water. If guide vanes is absent than the turbine can not work efficiently and its efficiency decreases.

3. Draft Tube

The pressure at the exit of the runner of Reaction Turbine is generally less than atmospheric pressure. The water at exit cannot be directly discharged to the tail race. A tube or pipe of gradually increasing area is used for discharging water from the exit of turbine to the tail race. This tube of increasing area is called Draft Tube. One end of the tube is connected to the outlet of runner while the other end is sub-merged below the level of water in the tail-race.



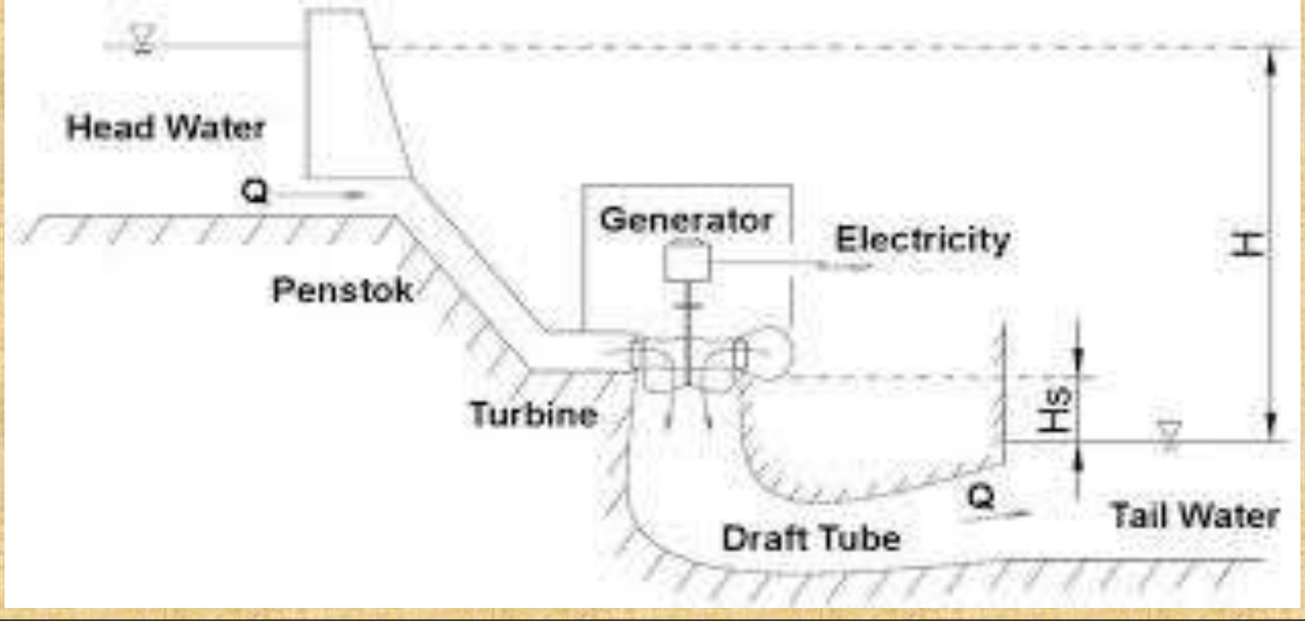
4. Runner Blades

The heart of the component in Kaplan turbine are its runner blades, as it the rotating part which helps in production of electricity. Its shaft is connected to the shaft of the generator. The runner of the this turbine has a large boss on which its blades are attached and the blades of the runner is adjustable to an optimum angle of attack for maximum power output. The blades of the Kaplan turbine has twist along its length.

WORKING:

The water coming from the pen-stock is made to enter the scroll casing. The scroll casing is made in the required shape that the flow pressure is not lost. The guide vanes direct the water to the runner blades. The vanes are adjustable and can adjust itself according to the requirement of flow rate. The water takes a 90 degree turn, so the direction of the water is axial to that of runner blades. The runner blades start to rotate as the water strikes due to reaction force of the water. The runner blades has twist along its length in order to have always optimum angle of attack for all cross section of blades to achieve greater efficiency. From the runner blades, the water enters into the draft tube where its pressure energy and kinetic energy decreases. Kinetic energy is gets converted into pressure energy results in increased pressure of the water.

The rotation of the turbine is used to rotate the shaft of generator for electricity production.



Applications of Kaplan Turbine:

1. At places were head is low and discharge is high
2. Electrical power generation

Advantages of Kaplan turbine:

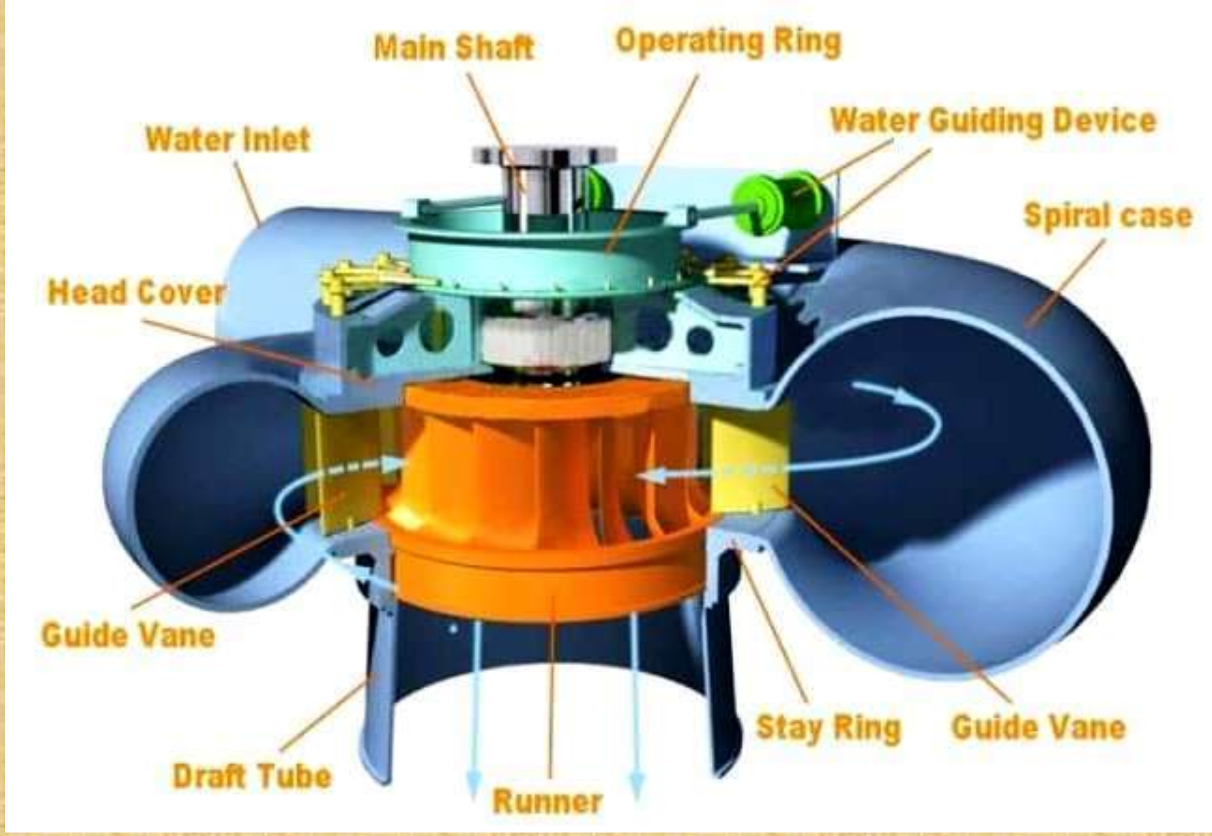
1. It can work at low head
2. Number of blades is less
3. It requires less space
4. It has adjustable runner vanes

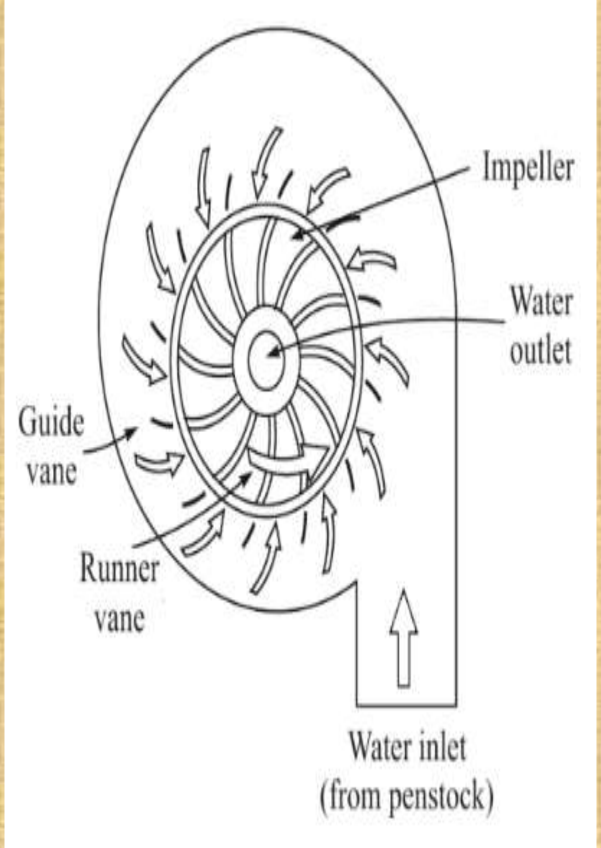
Disadvantages of Kaplan Turbine:

1. Cavitations problem(the formation of bubbles in a liquid, typically by the movement of a propeller through it).
2. High flow rate is required
3. It is very expensive to design, manufacture and install

FRANCIS TURBINE

Francis turbines are the most well-known type of reaction turbines. This turbine has a radial flow runner or a mixed radial/axial flow runner. Developed by James B. Francis in Lowell, Massachusetts Francis turbines are the most common water turbine in use today. It is also known as low head turbine.





The Various main components of Francis turbine are:

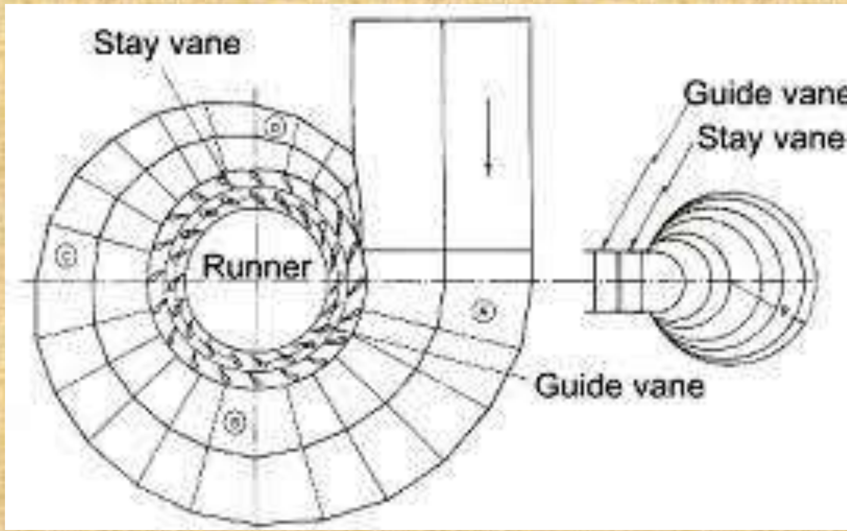
1. Spiral casing
2. Stay vanes
3. Guide vanes
4. Runner blades
5. Draft tube

1. Spiral casing

It is a spiral casing, with uniformly decreasing cross- section area, along the circumference. Its decreasing cross-section area makes sure that we have a uniform velocity of the water striking the runner blades, as we have openings for water flow in-to the runner blades from the very starting of the casing, so flow rate would decrease as it travels along the casing. So we reduce its cross-section area along its circumference to make pressure uniform, thus uniform momentum or velocity striking the runner blades.

2. Stay vanes

Stay vanes and guide vanes guides the water to the runner blades. Stay vanes remain stationary at their position and reduces the swirling of water due to radial flow, as it enters the runner blades. Thus making turbine more efficient.



3. Guide vanes

Water after passing through stay vanes, glides through guide vanes to enter the runner blades. Guide vanes can change their angle thus can control the angle of attack of water to the runner blades, making them work more efficiently. Moreover they also regulate the flow rate of water into the runner blades thus controlling the power output of a turbine according to the load on the turbine.

4. Runner blades

Design of the runner blades decides how well a turbine is going to perform. So runner blades of mixed flow turbine can be divided into two parts, the upper part of the blades use the reaction force of water flowing through it and the lower half is in the shape of a small bucket using the impulse action of water flowing through it. These two forces together makes the runner to rotate.

5. Draft tube

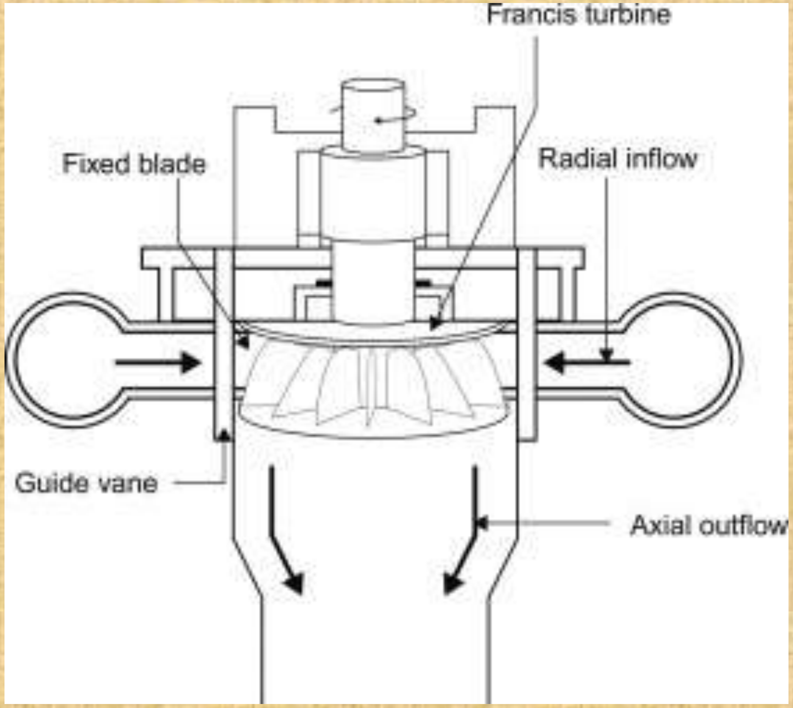
Draft tube connects the runner exit to the tail race. Its cross-section area increases along its length, as the water coming out of runner blades is at considerably low pressure, so its expanding cross-section area help it to recover the pressure as it flows towards tail race.

Working of Francis Turbine:

Water enters the turbine through spiral casing, and starts entering the runner blades, passing through stay vanes and guide vanes, as it moves along the length of casing the decreasing cross-section area of the spiral casing makes sure that the pressure energy of water would remain uniform along its length, as a portion of water is also entering the runner blades, which would reduce its flow rate along the length of the casing. The stay vanes being stationary at their place, removes the swirls from the water, which are generated due to flow through spiral casing and tries it to make the flow of water more linear to be deflected by adjustable guide vanes. The angle of guide vanes decides the angle of attack of water at the runner blades thus make sure the output of the turbine. Guide vanes also controls the flow rate of water in-to the runner blades thus acting according the load on the turbine. The runner blades are stationary and can-not pitch or change their angle so it’s all about the guide vanes which controls the power output of a turbine.

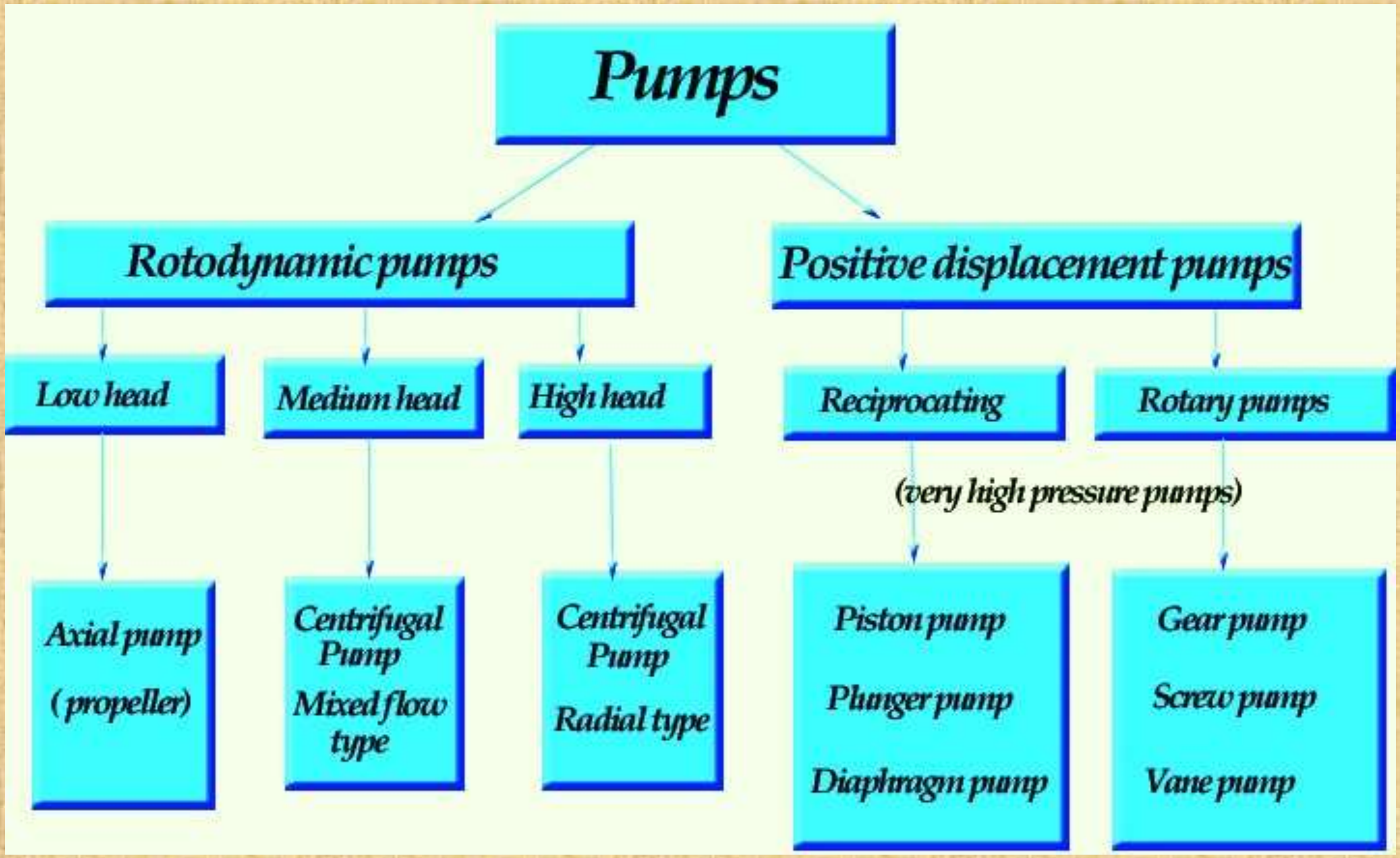
Further-more the upper part of runner blades are designed in such a way that they use the pressure difference between the opposite faces of a blade created by water flowing through it, same as the air-foil uses the pressure difference to generate lift force. And the remaining part of the blade is designed like a small bucket, which makes use of water's kinetic energy. Thus runner blades make use of both pressure energy and kinetic energy of water and rotates the runner in most efficient way.

The water coming out of runner blades would lack both the kinetic energy and pressure energy, so we use the draft tube to recover the pressure as it advances towards tail race, but still we cannot recover the pressure to that extent that we can stop air to enter into the runner housing thus causing cavitations.



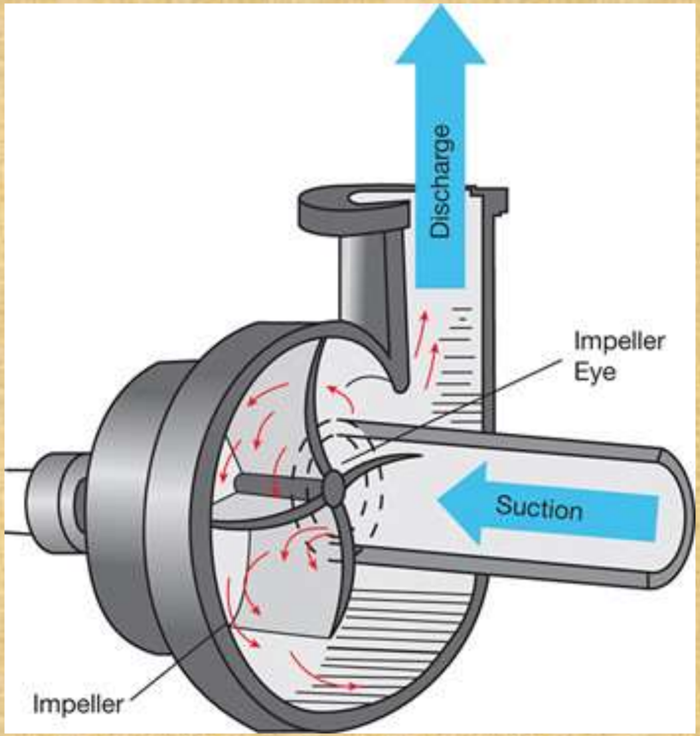
HYDRAULIC-PUMP

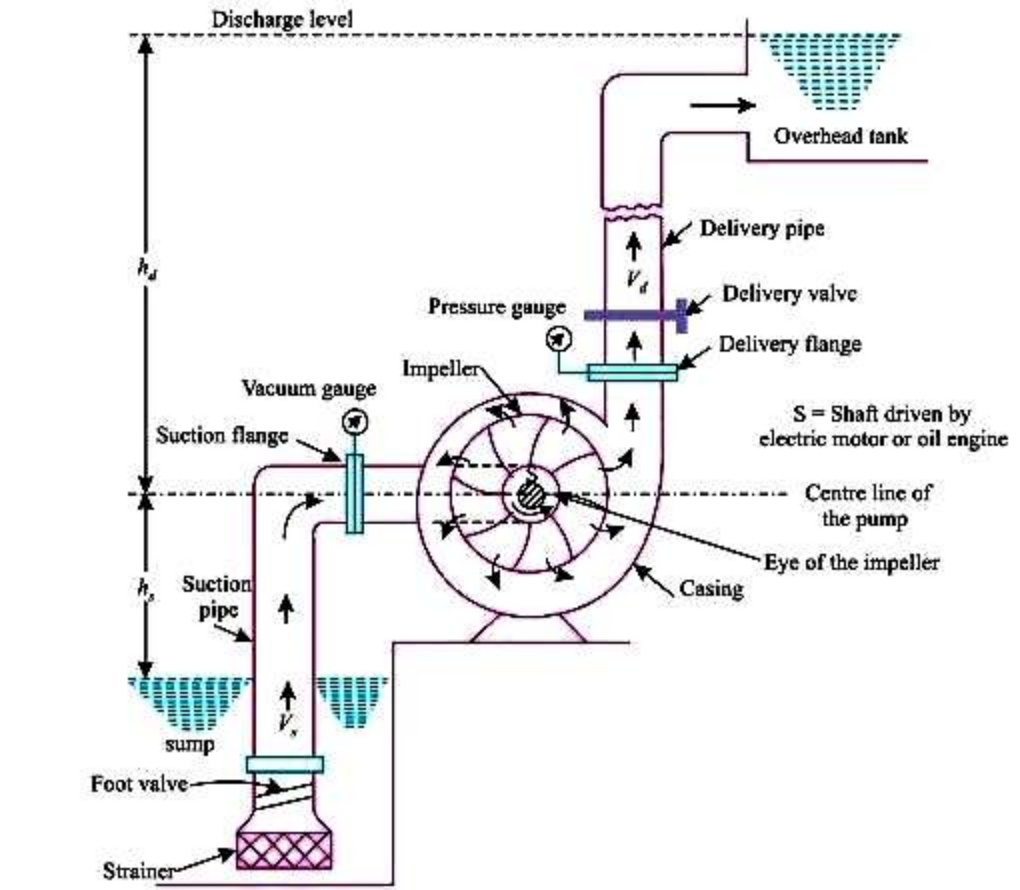
A hydraulic pump is a mechanical device that converts mechanical power into hydraulic energy. It also known as power absorbing type hydraulic machine.



CENTRIFUGAL- PUMP

A **centrifugal pump** is a mechanical device designed to move a fluid by means of the transfer of rotational energy from one or more driven rotors, called impellers. Fluid enters the rapidly rotating impeller along its axis and is cast out by **centrifugal** force along its circumference through the impeller's vane tips





Main Parts of Centrifugal Pump:

Following are the main parts-

1. Impeller
2. Casing
3. Delivery Pipe
4. Suction Pipe with Foot Valve and Strainer

1. Impeller

It is a wheel or rotor which is provided with a series of backward curved blades or vanes. It is mounded on the shaft which is coupled to an external source of energy which imparts the liquid energy to the impeller there by making it to rotate.

Impellers are divided into 3 types,

1. Open Impeller
2. Semi enclosed Impeller
3. Enclosed Impeller

2. Casing

It is a pipe which is connected at the upper end to the inlet of the pump to the centre of impeller which is commonly known as eye. The double end reaction pump consists of two suction pipe connected to the eye from both sides. The lower end dips into liquid in to lift. The lower end is fitted in to foot valve and strainer.

Commonly three types of casing are used in centrifugal pump,

1. Volute Casing
2. Vortex Casing
3. Casing with Guide Blades

3. Delivery Pipe

It is a pipe which is connected at its lower end to the out let of the pump and it delivers the liquid to the required height. Near the outlet of the pump on the delivery pipe, a valve is provided which controls the flow from the pump into delivery pipe.

4. Suction Pipe with Foot Valve and Strainer

suction pipe is connected with the inlet of the impeller and the other end is dipped into the sump of water. At the water end, it consists of foot value and strainer. The foot valve is a one way valve that opens in the upward direction. The strainer is used to filter the unwanted particle present in the water to prevent the centrifugal pump from blockage.

Working of Centrifugal Pump:

The first step in the operation of a centrifugal pump is priming. Priming is the operation in which suction pipe casing of the pump and the position of fluid with the liquid which is to be pumped so that all the air from the position of pump is driven out and no air is left.

The necessity of priming of a centrifugal pump is due to the fact that the pressure generated at the centrifugal pump impeller is directly proportional to density of fluid that is in contact with it. After the pump is primed the delivery valve is still kept closed and electric motor is started to rotate the impeller. The delivery valve is kept closed in order to reduce valve is opened the liquid is made to flow in an outward radial direction there by vanes of impeller at the outer circumference with high velocity at outer circumference due to centrifugal action vacuum is created.

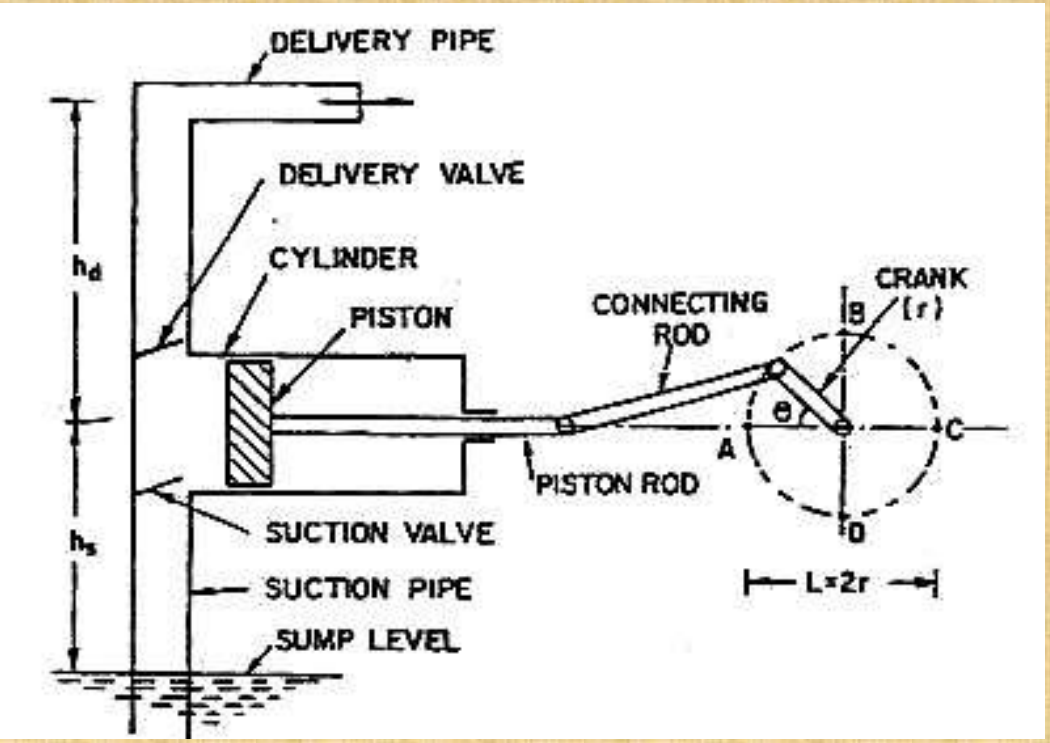
This cause liquid from sump to rush through suction pipe to eye of impeller thereby replacing long discharge from center circumference of the impeller is utilized in lifting liquid to required height through delivery pipe.

Application of Centrifugal Pumps:

1. Oil & Energy – pumping crude oil, slurry, mud; used by refineries, power generation plants
2. Industrial & Fire Protection Industry – Heating and ventilation, boiler feed applications, air conditioning, pressure boosting, fire protection sprinkler systems.
3. Waste Management, Agriculture & Manufacturing – Wastewater processing plants, municipal industry, drainage, gas processing, irrigation, and flood protection
4. Pharmaceutical, Chemical & Food Industries – paints, hydrocarbons, petro-chemical, cellulose, sugar refining, food and beverage production
5. Various industries (Manufacturing, Industrial, Chemicals, Pharmaceutical, Food Production, Aerospace etc.) – for the purposes of cryogenics and refrigerants.

RECEPROCATING PUMP:

A **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 Reciprocating pump is mainly used for Oil drilling operations, Pneumatic pressure systems, Light oil pumping, Feeding small boilers condensate return.



The main components of reciprocating pump are as follows:

1. Suction Pipe
2. Suction Valve
3. Delivery Pipe
4. Delivery Valve
5. Cylinder
6. Piston and Piston Rod
7. Crank and Connecting Rod
8. Strainer
9. Air Vessel

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 mot.

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.

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:

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.

THANK YOU

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