4022 FLUID MECHANICS & HYDRAULIC MACHINERY

Module 4

Course Outline

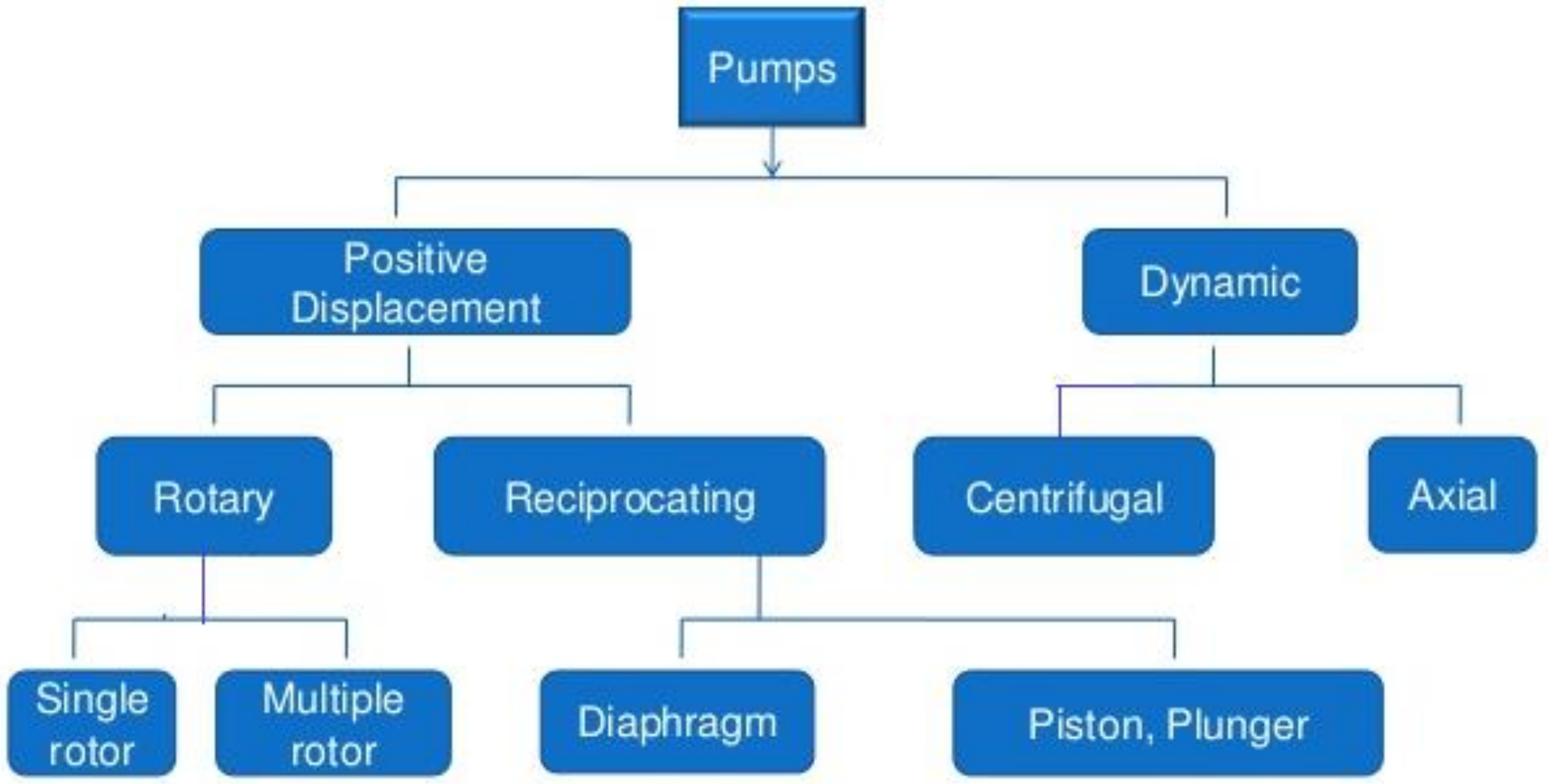
- **CO4 Describe the construction, working and performance testing of hydraulic pumps.**
- M4.01 Explain the working, parts and types of centrifugal pumps.
- M4.02 Describe Priming and its methods, Cavitation.
- M4.03 Explain the terms Manometric head, Work done, Manometric efficiency, Overall efficiency of Centrifugal pump.
- M4.04 Solve numerical problems related to the performance of centrifugal pump.
- M4.05 Explain the Construction, working principle and applications of single and double acting reciprocating pumps.
- M4.06 Solve numerical problems related to the performance of reciprocating pump.
- M4.07 Describe Concept of slip, Negative slip, Cavitation and separation.
- M4.08 Explain hydraulic ram and special pumps like air lift pump, jet pump the mono block coupled submersible (open well &deep well) - propeller pumps – turbine pumps.

Pumps

- The hydraulic machines which convert the mechanical energy into hydraulic energy are called pumps.
- It is the heart of any hydraulic system because it generates the force necessary to move the load.
- Mechanical energy is delivered to the pump using a prime mover such as an electric motor.
- Partial vacuum is created at the inlet due to the mechanical rotation of pump shaft. Vacuum permits atmospheric pressure to force the fluid through the inlet line and into the pump.

Pumps

Classification of pumps



Positive displacement pumps

- It displaces a known quantity of liquid with each revolution of the pumping elements.
- This is done by trapping liquid between the pumping elements and a stationary casing.
- The pumping elements may be gears, lobes, rotary piston, vanes and screws.
- They are found in a wide range of applications such as marine, chemical processing, food, dairy and pharmaceutical industries.

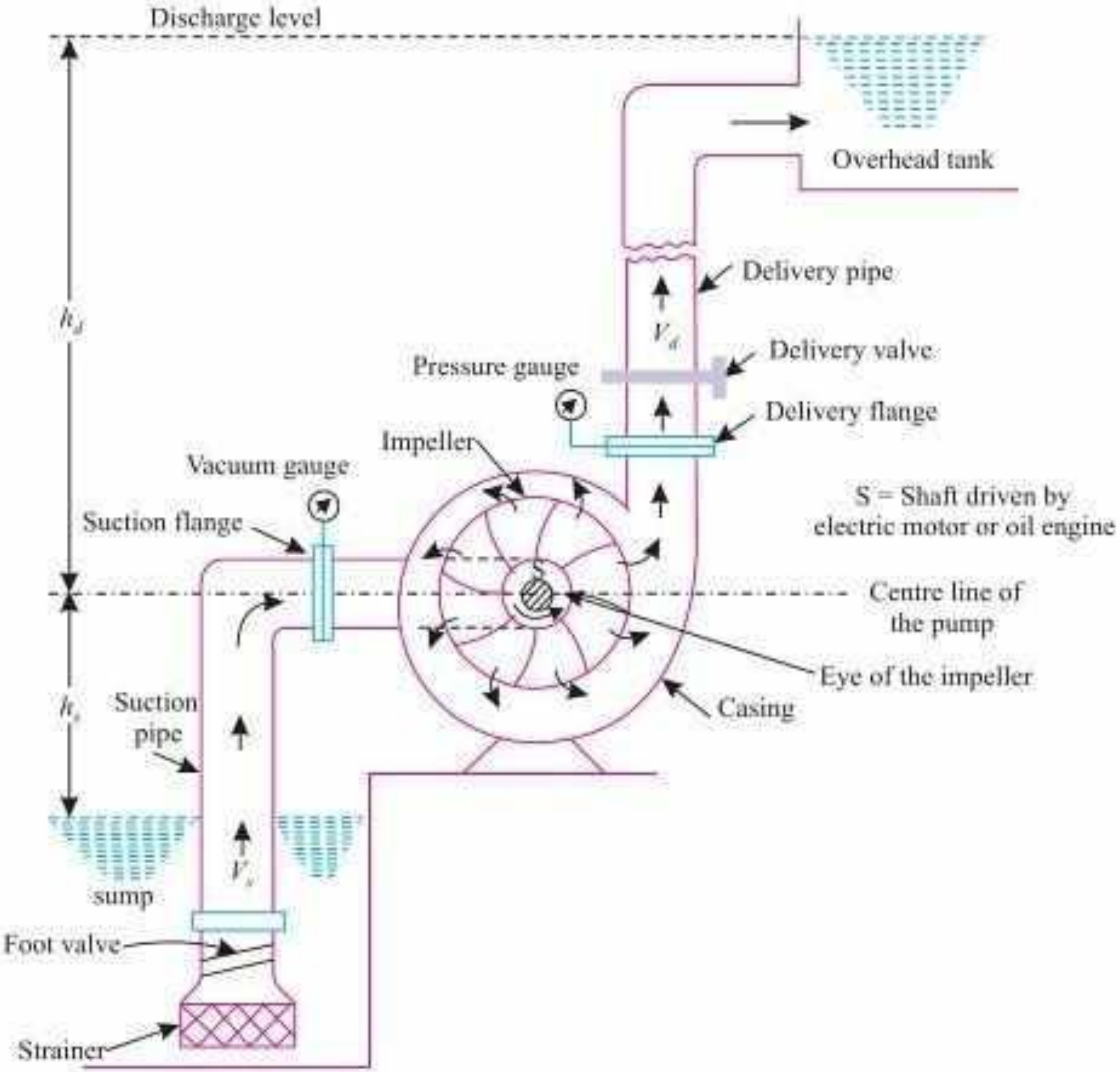
Rotodynamic Pumps

- A centrifugal pump is the most common among the rotodynamic pumps.
- Unlike a positive displacement pump, in which the liquid is simply pushed out of the pump, a centrifugal pump changes the hydraulic energy such that the liquid is lifted to a higher level.
- The basic principle on which a centrifugal pump works is that when a certain mass of liquid is made to rotate by an external force, it is thrown outwards from the axis of rotation and a centrifugal head is impressed on it. This enables the liquid to rise to a higher level.
- If more liquid is made available at the centre of rotation, a continuous supply of the liquid to the higher level may be ensured.
- The mechanism by which a liquid is made to rotate consists of a revolving wheel with vanes which is called an impeller.
- During the passage of the liquid through the impeller, angular momentum changes, and this circumstance also results in the increase of the pressure head of the liquid.

Centrifugal Pumps

- The hydraulic machines which convert the mechanical energy into hydraulic energy are called pumps. The hydraulic energy is in the form of pressure energy.
- If the mechanical energy is converted into pressure energy by means of centrifugal force acting on the fluid, the hydraulic machine is called centrifugal pump.
- The centrifugal pump acts as a reverse of an inward radial flow reaction turbine. This means that the flow in centrifugal pumps is in the radial outward directions.
- The centrifugal pump works on the principle of forced vortex flow which means that when a certain mass of liquid is rotated by an external torque, the rise in pressure head of the rotating liquid takes place.
- The rise in pressure head at any point of the rotating liquid is proportional to the square of tangential velocity of the liquid at that point (i. e. rise in pressure head $= \frac{\mathrm{V}^2}{2g}$)
- Thus at the outlet of the impeller, where radius is more, the rise in pressure head will be more and the liquid will be discharged at the outlet with a high pressure head. Due to this high pressure head, the liquid can be lifted to a high level.

Centrifugal Pumps



Main parts of a Centrifugal Pump

The following arc the main parts of a centrifugal pump :

1. Impeller.
2. Casing.
3. Suction pipe with a foot valve and a strainer.
4. Delivery pipe.

1. Impeller.

- ✓ The rotating part of a centrifugal pump is called 'impeller'.
- ✓ It consists of a series of backward curved vanes.
- ✓ The impeller is mounted on a shaft which is connected to the shaft of an electric motor.

Main parts of a Centrifugal Pump

2. Casing.

- ✓ The casing of a centrifugal pump is similar to the casing of a reaction turbine.
- ✓ It is an air-tight passage surrounding the impeller and is designed in such a way that the kinetic energy of the water discharged at the outlet of the impeller is converted into pressure energy before the water leaves the casing and enters the delivery pipe.

Types of casings

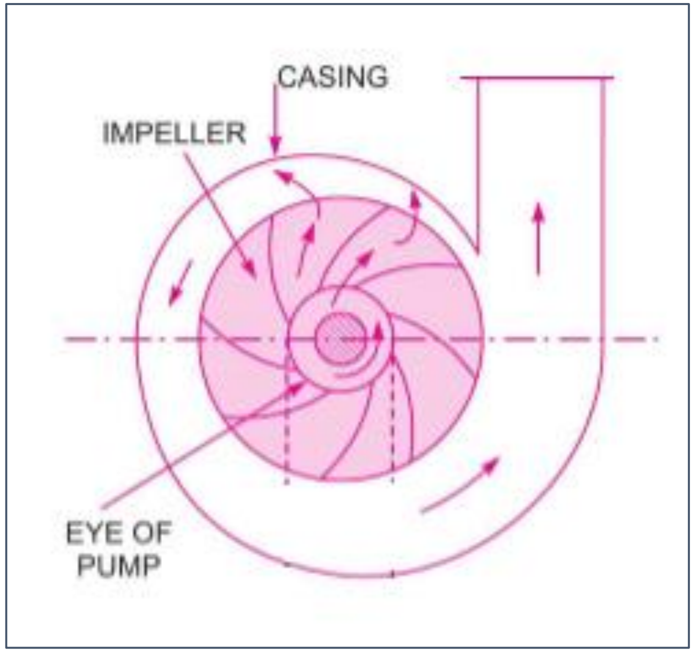
a. Volute casing
b. Vortex casing
c. Casing with guide blades

Main parts of a Centrifugal Pump

Types of casings

a. Volute Casing.

- ✓ The volute casing, which surrounds the impeller.
- ✓ It is of spiral type in which area of flow increases gradually.
- ✓ The increase in area of flow decreases the velocity of flow.
- ✓ The decrease in velocity increases the pressure of the water flowing through the casing.
- ✓ It has been observed that in case of volute casing, the efficiency of the pump increases slightly as a large amount of energy is lost due to the formation of eddies in this type of casing.

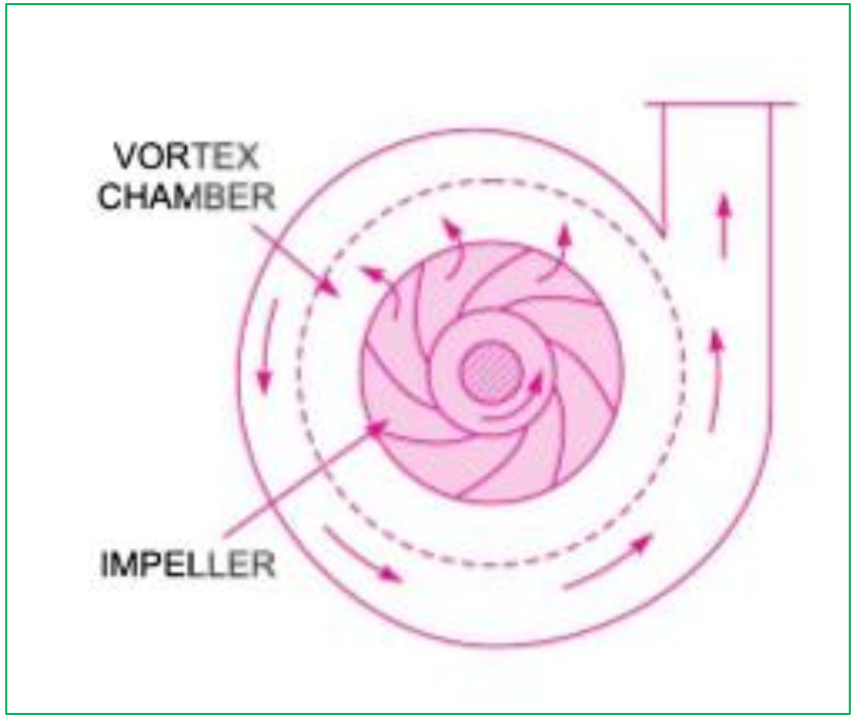


Main parts of a Centrifugal Pump

Types of casings

b. Vortex Casing.

- ✓ If a circular chamber is introduced between the casing and the impeller .
- ✓ By introducing the circular chamber, the loss of energy due to the formation of eddies is reduced to a considerable extent.
- ✓ Thus the efficiency of the pump is more than the efficiency when only volute casing is provided.

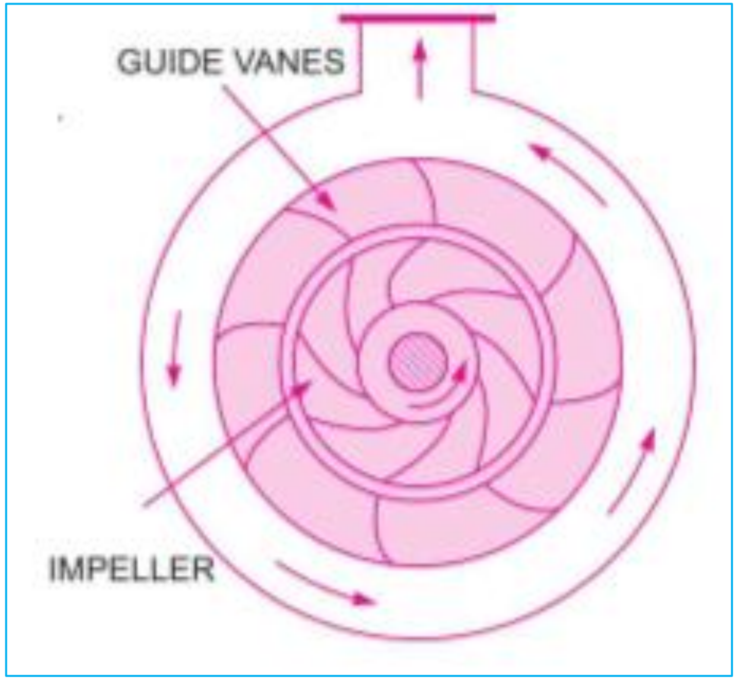


Main parts of a Centrifugal Pump

Types of casings

c. Casing with Guide Blades.

- ✓ This casing in which the impeller is surrounded by a series of guide blades mounted on a ring which is known as diffuser.
- ✓ The guide vanes are designed in such a way that the water from the impeller enters the guide vanes without shock.
- ✓ Also the area of the guide vanes increases, thus reducing the velocity of flow through guide vanes and consequently increasing the pressure of water.
- ✓ The water from the guide vanes then passes through the surrounding casing which is in most of the cases concentric with the impeller.



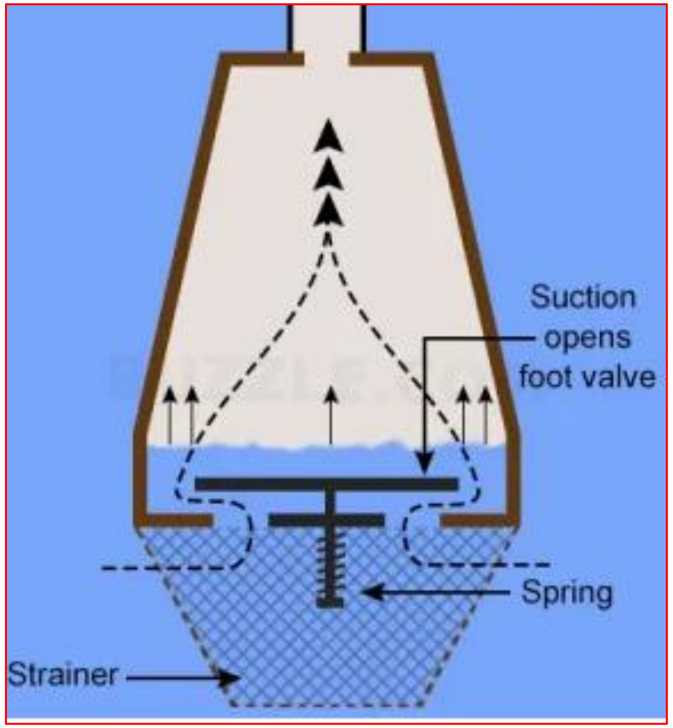
Main parts of a Centrifugal Pump

3. Suction Pipe with a Foot valve and a Strainer.

- ✓ A pipe whose one end is connected to the inlet of the pump and other end dips into water in a sump is known as suction pipe.
- ✓ A foot valve which is a non-return valve or one-way type of valve is fitted at the lower end of the suction pipe.
- ✓ The foot valve opens only in the upward direction. A strainer is also fitted at the lower end of the suction pipe.

4. Delivery Pipe

- ✓ A pipe whose one end is connected to the outlet of the pump and other end delivers the water at a required height.



Working

- Centrifugal Pump Animation.mp4
- Before starting the pump the air present in the casing is removed. This is done by filling the casing with liquid or water through the delivery pipe. This process is called priming.
- After priming the impeller is rotated by means of an electric motor. When the pump is started the impeller will rotate inside the casing the water trapped between the vanes will also rotate.

- The rotating motion of the impeller causes a centrifugal force to act on it.
- The centrifugal force forces the liquid to flow radially outward with a high pressure and velocity.
- During that time a partial vacuum is created at the centre of the impeller.
- The atmospheric pressure acting on the sump pushes the water through the suction pipe into the casing.

- While the liquid flows through the rotating impeller it receives energy from the vanes which results in an increase of both pressure and velocity.
- The kinetic energy thus increased is converted into pressure energy while flowing through the volute casing.
- Thus the liquid is discharged from the pump to the delivery pipe with very high pressure.

Work done, Heads and Efficiencies of a Centrifugal Pump

1. Work done by the impeller on water per second (Power at impeller)

$$= \frac{W}{g}[v_{w2}\, u_2]$$

$$= \frac{\rho g Q}{g}[v_{w2}\, u_2]$$

$$= \rho Q[v_{w2}\, u_2] \qquad \text{Watts}$$

Where,

W = Weight of fluid in N

u = Peripheral (or circumferential) velocity of impeller

$= u_1 = u_2 = \frac{\pi D N}{60}$

v_{w2} = Velocity of whirl at outlet

Q = Discharge in m^3/s

B_1 = Width of runner at inlet

D_1 = Inside dia. of runner

v_{f1} = Velocity of flow at inlet

2. Discharge (Q)

$$Q = \pi D_1 B_1 v_{f1} = \pi D_2 B_2 v_{f2}$$

3. Heads of a centrifugal pump

i. Suction Head (h_s).

It is the vertical height of the centre line of the centrifugal pump above the water surface in the tank or pump from which water is to be lifted .

Work done, Heads and Efficiencies of a Centrifugal Pump

ii. Delivery Head (h_d).

The vertical distance between the centre line of the pump and the water surface in the tank to which water is delivered is known as delivery head.

iii. Static Head (H_s).

The sum of suction head and delivery head is known as static head.

$$H_s = h_s + h_d$$

iv. Manometric head (Hm).

The manometric head is defined as the head against which a centrifugal pump has to work. It is the head measured across the pump inlet and outlet flanges.

$$H_m = h_s + h_d + h_{fs} + h_{fd} + \frac{v_d^2}{2g}$$

h_s = Suction head

h_d = Delivery head,

h_{fs} = frictional loss in suction pipe

h_{fd} = frictional loss in delivery pipe

v_d = velocity of water in delivery pipe

Work done, Heads and Efficiencies of a Centrifugal Pump

Efficiencies of a Centrifugal Pump.

In case of a centrifugal pump, the power is transmitted from the shaft of the electric motor to the shaft of the pump and then to the impeller. From the impeller, the power is given to the water. Thus power is decreasing from the shaft of the pump to the impeller and then to the water.

The following are the important efficiencies of a centrifugal pump :

(a) Manometric efficiency (η_{man})

(b) Mechanical efficiency (η_m) and

(c) Overall efficiency (η_o)

Work done, Heads and Efficiencies of a Centrifugal Pump

Efficiencies of a Centrifugal Pump.

(a) Manometric Efficiency

The ratio of the manometric head to the head imparted by the impeller to the water is known as manometric efficiency.

Mathematically, it is written as

$$\eta_{man} = \frac{\text{Manometric head}}{\text{Head imparted by impeller to water}}$$

$$= \frac{g\,Hm}{V_{w2}\,u_2}$$

Work done, Heads and Efficiencies of a Centrifugal Pump

Efficiencies of a Centrifugal Pump.

(b) Mechanical Efficiency

The power at the shaft of the centrifugal pump is more than the power available at the impeller of the pump.

The ratio of the power available at the impeller to the power at the shaft of the centrifugal pump is known as mechanical efficiency.

Mathematically, it is written as

$$\eta_m = \frac{\text{Power at the impeller}}{\text{Power at the shaft (or Shaft power)}}$$

$$= \frac{\frac{W}{g}(v_{w2}\, u_2)}{P}$$

$$= \frac{\rho Q(v_{w2}\, u_2)}{P}$$

Work done, Heads and Efficiencies of a Centrifugal Pump

Efficiencies of a Centrifugal Pump.

(c) Overall Efficiency

It is defined as ratio of power output of the pump to the power input to the pump.

It is written as

$$\eta_o = \frac{\text{Power output}}{\text{Power supplied at the shaft}}$$

$$= \frac{\text{Weight of water lifted x } H_m}{P}$$

$$= \frac{\rho g Q H_m}{P}$$

$$= \eta_{man} \times \eta_m$$

A centrifugal pump is required to lift 0.05 m^3/s of water from a well with a depth of 40 m. If rating of the pump motor is 32 kilowatt find the overall efficiency of the pump. *(April 2019, 7 marks)*

A centrifugal pump delivers 0.03 cubic meters of water per second against a manometric head of 30 m. If the overall efficiency of the pump is 70%, find the power required to drive the pump. *(April 2020, 7 marks)*

A centrifugal pump delivers 0.03 m^3/s water to a height of 20 m through a pipe of 80m long and of 100 mm diameter. If the overall efficiency of the pump is 72%, find the power required to drive the pump. take coefficient of friction as 0.01

(April 2018, 7 marks)

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(April 2018, 7 marks)

Multi Stage Centrifugal Pumps

If a centrifugal pump consists of two or more impellers, the pump is called a multistage centrifugal pump. The impellers may be mounted on the same shaft or on different shafts.

A multistage pump is having the following two important functions :

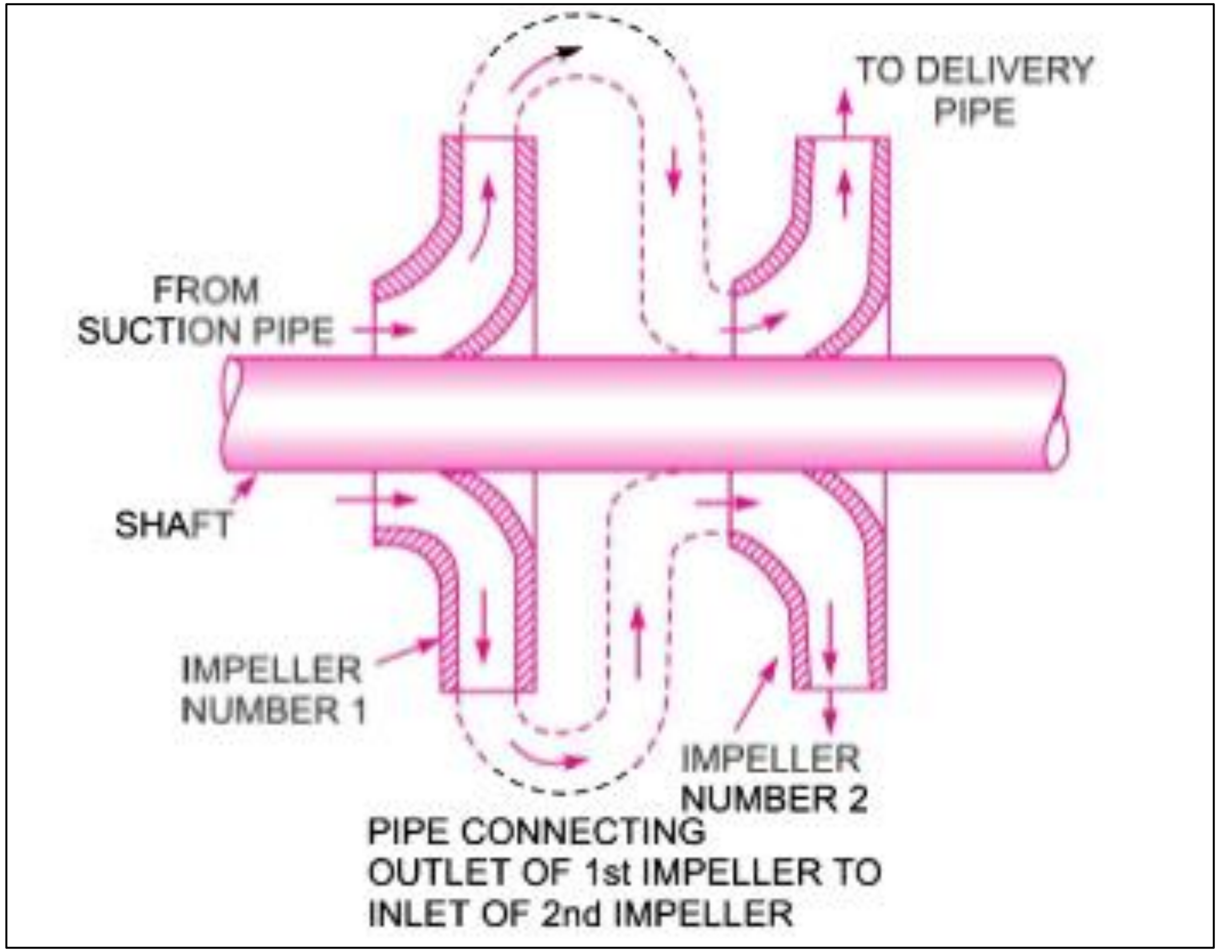
1. To produce a high head *(Pumps in series)*
2. To discharge a large quantity of liquid. *(Pumps in parallel)*

3. *Multistage Centrifugal Pumps for High Heads.*

For developing a high head, a number of impellers are mounted in series or on the same shaft. The water from suction pipe enters the 1st impeller at inlet and is discharged at outlet with increased pressure. The water with increased pressure from the outlet of the 1_{st} impeller is taken to the inlet of the 2_{nd} impeller with the help of a connecting pipe as shown in Fig.

Multi Stage Centrifugal Pumps

1. Multistage Centrifugal Pumps for High Heads.



Multi Stage Centrifugal Pumps

1. Multistage Centrifugal Pumps for High Heads.

At the outlet of the 2_{nd} impeller, the pressure of water will be more than the pressure of water at the outlet of the 1st impeller. Thus if more impellers are mounted on the same shaft, the pressure at the outlet will be increased further.

Let n = *Number of identical impellers mounted on the same shaft,*

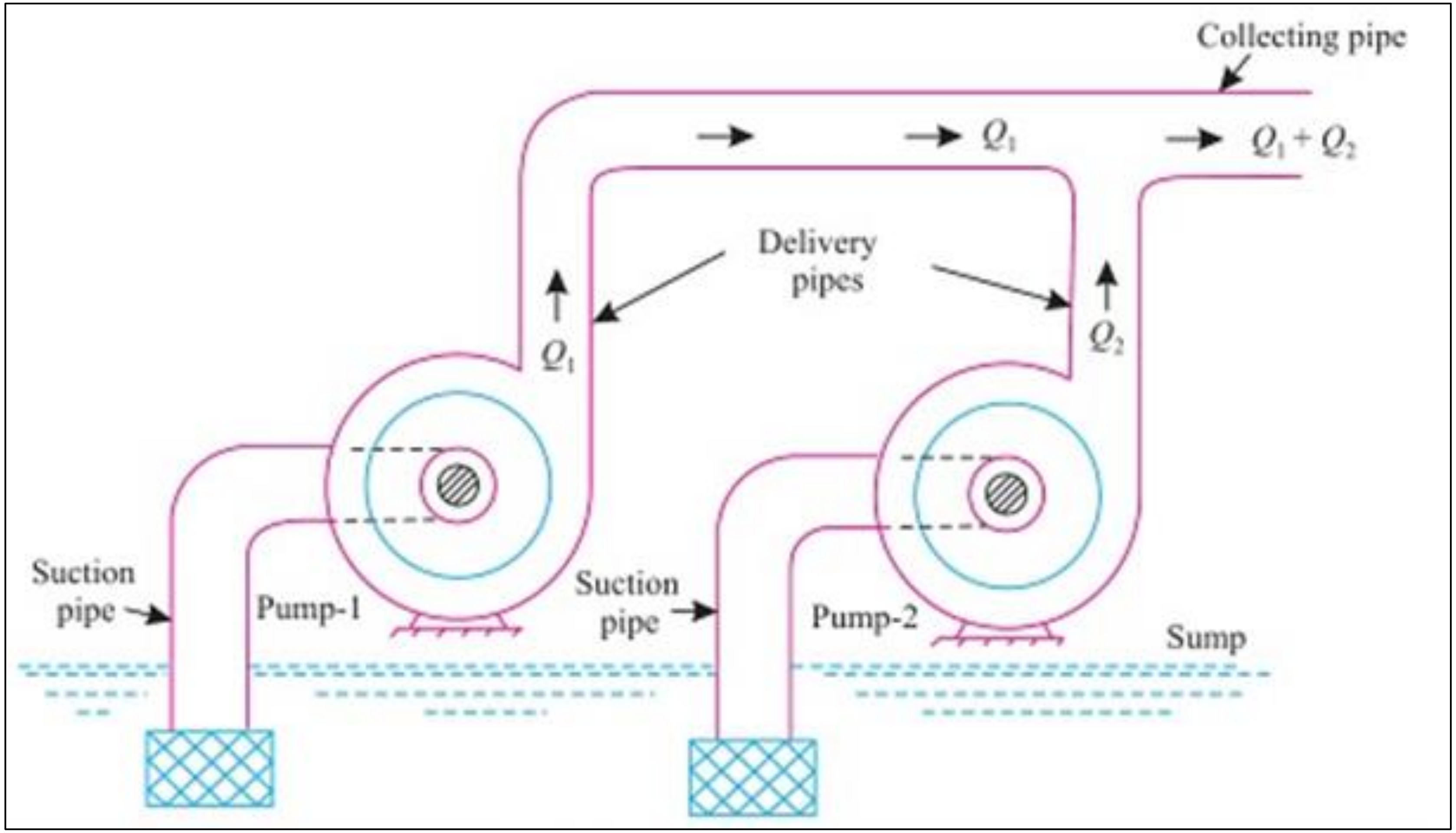
H_m = *Head developed by each impeller.*

Then total head developed = n x H_m

The discharge passing through each impeller is same

Multi Stage Centrifugal Pumps

2. Multistage Centrifugal Pumps for High Discharge.



Multi Stage Centrifugal Pumps

2. Multistage Centrifugal Pumps for High Discharge.

Multistage Centrifugal Pumps for High Discharge. For obtaining high discharge, the pumps should be connected in parallel as shown in Fig. Each of the pumps lifts the water from a common pump and discharges water to a common pipe to which the delivery pipes of each pump is connected. Each of the pump is working against the same head.

Let n = *Number of identical pumps arranged in parallel,*

Q = *Discharge from one pump*

Then total discharge = $n \times Q$

CAVITATION IN PUMPS

Cavitation is the formation of bubbles or cavities in liquid, developed in areas of relatively low pressure around an impeller. The imploding or collapsing of these bubbles trigger intense shockwaves inside the pump, causing significant damage to the impeller and/or the pump housing.

If left untreated, pump cavitation can cause:

- Failure of pump housing.
- Destruction of impeller
- Excessive vibration- leading to premature seal and bearing failure
- Higher than necessary power consumption
- Decreased flow and/or pressure

There are two types of pump cavitation: *suction* and *discharge.*

CAVITATION IN PUMPS

1. Suction Cavitation

When a pump is under low pressure or high vacuum conditions, suction cavitation occurs. If the pump is "starved" or is not receiving enough flow, bubbles or cavities will form at the eye of the impeller. As the bubbles carry over to the discharge side of the pump, the fluid conditions change, compressing the bubble into liquid and causing it to implode against the face of the impeller.

2. Discharge Cavitation

When a pump's discharge pressure is extremely high or runs at less than 10% of its best efficiency point (BEP), discharge cavitation occurs. The high discharge pressure makes it difficult for the fluid to flow out of the pump, so it circulates inside the pump. Liquid flows between the impeller and the housing at very high velocity, causing a vacuum at the housing wall and the formation of bubbles.

Priming of Centrifugal pump

The operation of filling the suction pipe, casing of the pump and a portion of the delivery pipe completely from outside source with the liquid to be raised, before starting the pump, to remove any air, gas or vapour from these parts of the pump is called priming of a centrifugal pump. If a centrifugal pump is not primed before starting, air pockets inside the impeller may give rise to vortices and cause discontinuity of flow. Further, dry running of the pump may result in rubbing and seizing of the wearing rings and cause serious damage.

- *Small pumps* are usually primed by pouring liquid into the funnel provided for the purpose. While doing priming, the air-vent valve provided in the pump casing is opened; the air escapes through the valve. The priming is continued till all air from the suction pipe, impeller and casing has been removed.
- *Large pumps* are primed by evacuating the casing and the suction pipe by a vacuum pump or by an ejector; the liquid is thus drawn up the suction pipe from the sump and the pump is filled with liquid.
- The internal construction of some pumps is such that special arrangements containing a supply of liquid are provided in the suction pipe due to which automatic priming of the pump occurs; such pumps are known as *'self priming pumps'*

RECIPROCATING PUMPS

Reciprocating pump is a device which converts the mechanical energy into hydraulic energy by sucking the liquid into a cylinder.

In this pump, a piston is reciprocating, which use thrust on the liquid and increase its hydraulic energy. Reciprocating pump is also known a called a positive displacement pump, because it discharges a definite quantity of liquid.

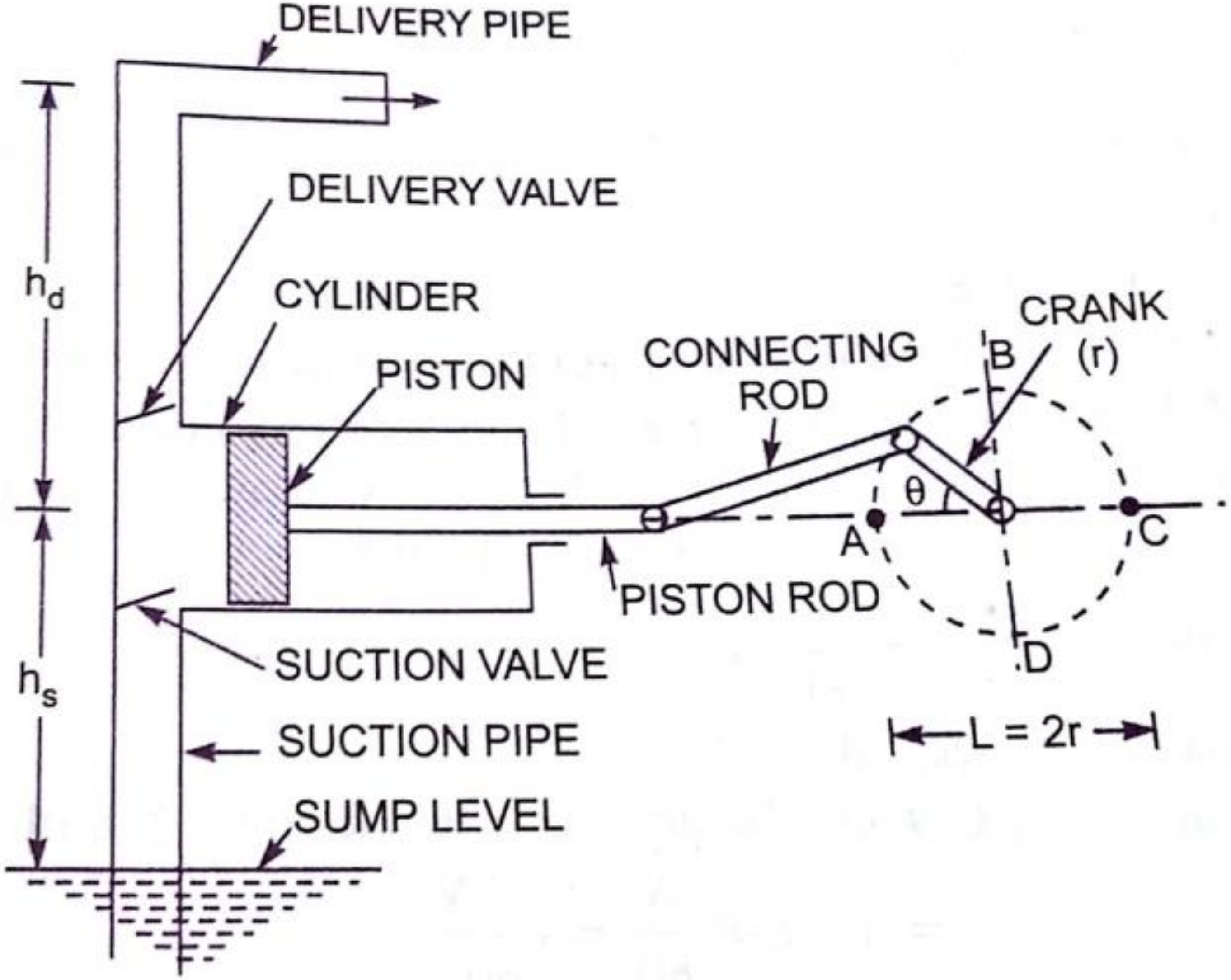
It is often used where a small quantity of liquid is to handled and where delivery pressure is quite large.

RECIPROCATING PUMPS

Classification of Reciprocating pump:

1. According to contact of water on the piston
    a. Single acting pump
    b. Double acting pump
2. According to number of cylinders provided
    a. Single cylinder pump
    b. Double cylinder pump
    c. Triple cylinder pump

SINGLE ACTING RECIPROCATING PUMPS



Main parts of a reciprocating pump.

SINGLE ACTING RECIPROCATING PUMPS

Components:

1. Cylinder
2. Suction Pipe
3. Delivery Pipe
4. Suction valve
5. Delivery valve
6. Piston and piston rod
7. Crank and Connecting rod
8. Air vessel
9. Strainer

Components of Reciprocating pumps

1. Cylinder:

A cylinder, in which piston is moving to and fro. The moment of the piston obtains by a connecting rod which connects the piston and and crank.

2. Suction Pipe:

Suction pipe is used to suck the water from the water reservoir to the cylinder. .

3. Delivery Pipe:

It is a pipe that is used to deliver the water from the cylinder to the desired location. It connects the outlet of the pump to the tank where the water is to be delivered.

Components of Reciprocating pumps

4. Suction valve:

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

5. Delivery valve:

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

6. Piston and piston rod

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

Components of Reciprocating pumps

7. Crank and Connecting rod

Crank is a solid circular disc which is connected to the power source like motor, engine, etc. for its rotation.

A Connecting rod connects the crank to the piston, as a result, the rotational motion of the crank gets converted into linear motion of the piston.

8. Strainer:

A strainer is provided at the end of the suction pipe to prevent the entrance of the solid particles from the water source into the cylinder. Otherwise, solid particles choked the delivery.

9. Air vessels:

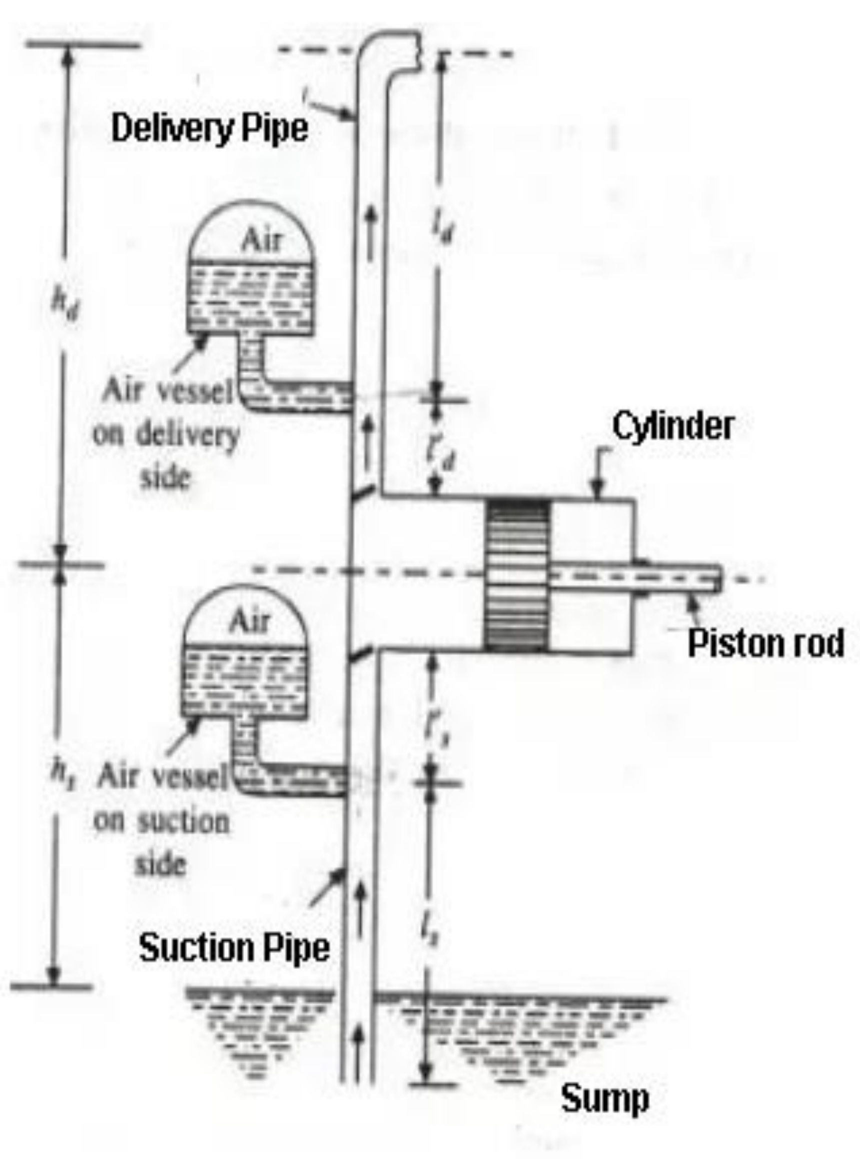
It is a closed chamber made up cast iron. Having two ends one end is open at its base through which the water flows into the vessel cylinder. The air vessels fitted to the suction pipe and delivery pipe of this pump to get a uniform discharge.

Functions of Air Vessels

1. The air vessels use to get the continuous flow of water at a uniform rate.

2. To reduce the amount of work in overcoming the frictional resistance in the suction pipe and delivery pipe.

3. To run the pump at high speed with separation.



Working of a single acting Reciprocating Pump

In this pump, A cylinder, in which a piston moves forward and backwards. The piston is reciprocating by means of the connecting rod. The connecting rod connects the piston and the rotating crank. The crank is rotating by means of an electric motor.

The suction and delivery pipes with suction and delivery valve are arranged to the cylinder.

- The suction valve allows the water to the cylinder and
- The delivery valve leaves the water from the cylinder.

As the crank rotates, during the first stroke of the piston (called suction stroke), the water enters into the cylinder. In a suction stroke, the crank is rotating from A to C (from 0° to 180°) the piston is moving towards the right side of the cylinder. Due to this, the vacuum creates in the cylinder. This vacuum causes the suction valve to open and the water enters the cylinder.

Working of a single acting Reciprocating Pump

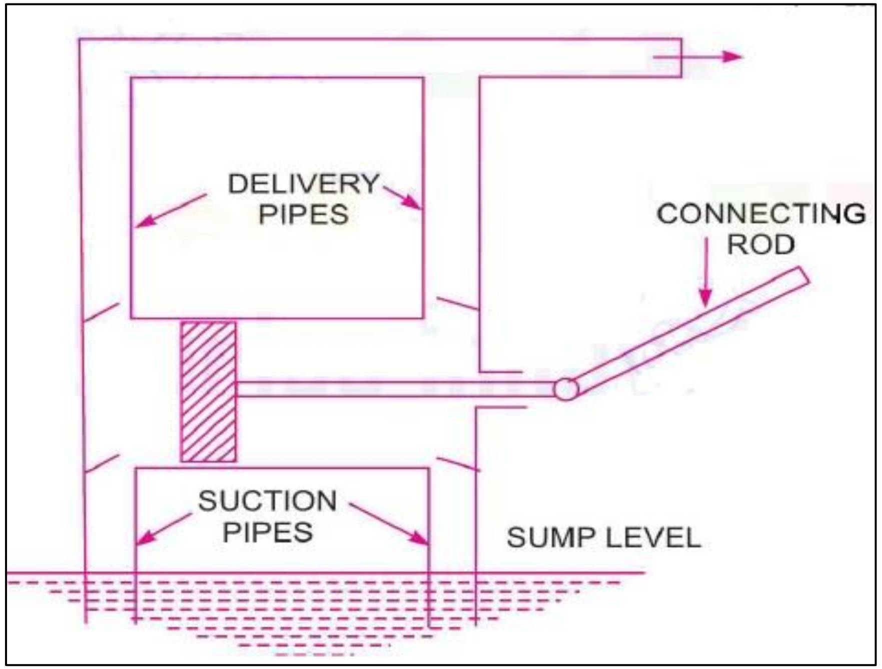
In the next stroke called delivery stroke, the water leaves the cylinder. In the delivery stroke, the crank is rotating from C to A (from 180° to 360°) the piston is moving to the left side of the cylinder. Due to this, the pressure of the liquid increases inside the cylinder. This pressure causes the suction valve to close and delivery valve to open. Then the water is forced into the delivery pipe and raised to a required height.

Working of a Double acting Reciprocating Pump

In double acting pumps, the water is acting on both sides of the piston as shown in the figure.

Thus, two suction pipes and two delivery pipes are required for a double-acting pump. When there is a suction stroke on one side of the piston, at the same time there is a delivery stroke on the other side of the piston.

Hence for one complete revolution of the crank, there is two delivery stroke and the water is delivered to the pipes by the pump during these two delivery strokes.



Discharge through a Reciprocating Pump

Theoretical Discharge,

$$\mathbf{Q_{th}} = \frac{LAN}{60} \ \mathrm{m^3/s} \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{for single acting pump}$$

$$\mathbf{Q_{th}} = \frac{2LAN}{60} \ \mathrm{m^3/s} \ \ldots\ldots\ldots\ldots\ldots\ldots \textit{for double acting pump}$$

Where, L = *Length of stroke = 2* x *Crank radius (r)*

A = *Area of cross section of cylinder or piston* = $\frac{\Pi}{4} D^2$

N = *rpm of the crank*

Work done by a Reciprocating Pump

Wok done / second or Power

1. For Single acting pump:

We have,

Hydraulic Power, $P = \rho g Q H$

$$= \frac{\rho g L A N H}{60} \qquad (\because Q = \frac{LAN}{60})$$

$$P = \frac{\rho g L A N (hs+hd)}{60} \text{ Watts}$$

Where,

h_s = Suction head

h_d = delivery head

H = Total head = hs + hd

2. For Double acting pump:

$$P = \frac{2\rho g L A N H}{60} = \frac{2\rho g L A N (hs+hd)}{60}$$

Slip in a Reciprocating Pump

- Slip in reciprocating pump is basically defined as the difference between the theoretical discharge and actual discharge of the reciprocating pump.
- Actual discharge of a reciprocating pump will be less than the theoretical discharge of the pump due to leakage of water during operation of pump.
- The difference of the theoretical discharge and actual discharge will be called as slip of reciprocating pump.
- Mathematically, we can express the slip in reciprocating pump as mentioned below

$$\text{Slip} = Q_{th} - Q_{act}$$

$$\text{Percentage slip} = \left(\frac{Q_{th} - Qact}{Q_{th}}\right) \times 100$$

$$= \left(1 - \frac{Q_{act}}{Q_{th}}\right) \times 100$$

$$= (1 - C_d) \times 100$$

Where, Cd= Coefficient of discharge

Slip in a Reciprocating Pump

Negative slip in reciprocating pump

- As we have discussed above that slip in reciprocating pump is basically the difference between the theoretical discharge and actual discharge of the reciprocating pump. If actual discharge is more than the theoretical discharge, slip of the reciprocating pump will be negative and it could be concluded by considering the equation of slip of reciprocating pump.

- Negative slip will occur when suction pipe is long, delivery pipe is short and pump is running at high speed.

Problems

A double acting reciprocating pump running at 60rpm is discharging 33.5 liters of water per second. The pump has a stroke of 0.35m. The diameter of the piston is 0.25m. The delivery and suction head are 18m and 45m respectively. Find the slip and power required to drive the pump. (Oct 2018, 7 marks)

Solution:

Given,

$N = 60$ rpm

$Q_a = 33.5$ lit/s $= 0.0335\ m^3/s$

$L = 0.35$ m

$D = 0.25$ m

$h_d = 18$ m

$h_s = 45$ m

Find:

1. Slip (S)
2. Power (P)

Problems

1. Slip, S $= \left(\frac{Q_{th} - Qact}{Q_{th}}\right)$

Q_{th} $= 2LAN/60$

$= (2x\ 0.35\ x\ \frac{\Pi}{4}\ x\ 0.25^2 x\ 60)/60$

$= 0.03436\ m^3/s$

$\therefore$ S $= (0.03436- 0.0335)/ 0.03436$

$= 0.025$

= **2.5 % *Ans***

2. Power, P $= \frac{2\rho gLAN(hs+hd)}{60}$

$= 2\rho gQ_{th}\ (hs+hd)$ $\left(\frac{LAN}{60} = Q\right)$

$= 2\ x1000x\ 9.81x\ 0.03436\ x\ (45+\ 18)$

$= 42472.47\ W$

= **42.47247 kW *Ans***

Problems

A double acting reciprocating pump running at 40rpm is discharging 1m3 of water per minute. The pump has a stroke of 400mm. The diameter of the piston is 200mm.The delivery and suction head are 20m and 5m respectively. Find the slip of the pump and power required to drive the pump. (Apr 2018, 7 marks)

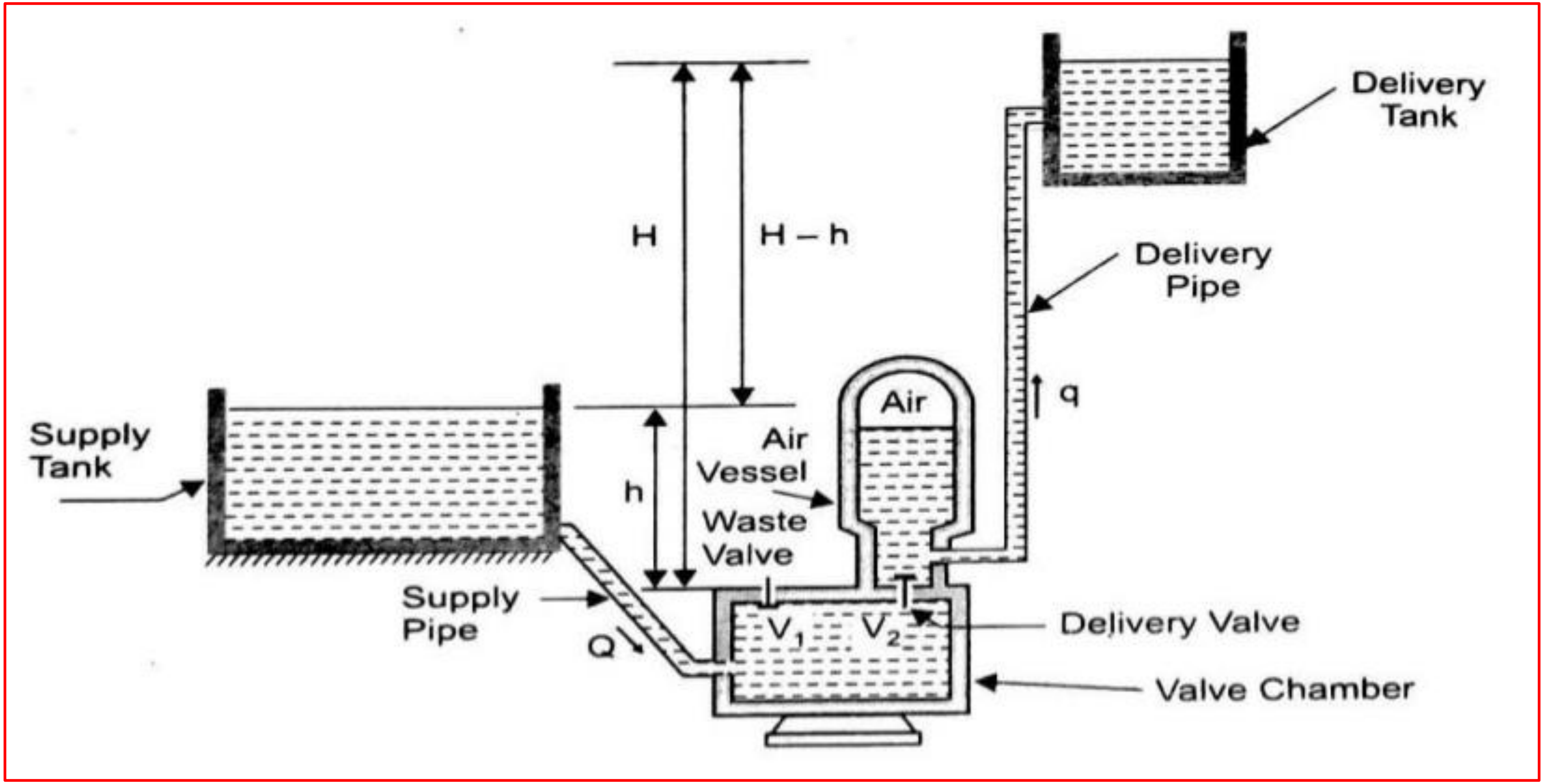
A single acting reciprocating pump having a piston of 250mm diameter and a stroke of 175mm runs at 45rpm. It delivers water at a rate of 6 litres per second. Find the coefficient of discharge, slip and percentage slip of the pump.

(Apr 2020, 7 marks)

Comparison of Centrifugal pump and Reciprocating pump

Centrifugal Pumps	Reciprocating Pumps
1. Steady and even flow	1. Intermittent and pulsating flow
2. For large discharge, small heads	2. For small discharge, high heads.
3. Can be used for viscous fluids e.g. oils, muddy water.	3. Can handle pure water or less viscous liquids only otherwise valves give frequent trouble.
4. Low initial cost	4. High initial cost.
5. Can run at high speed. Can be coupled directly to electric motor.	5. Low speed. Belt drive necessary.
6. Low maintenance cost. Periodic check up sufficient.	6. High maintenance cost. Frequent replacement of parts.
7. Compact less floors required.	7. Needs 6-7 times area than for centrifugal pumps.
8. Low head pumps have high efficiency	8. Efficiency of low head pumps as low as 40 per cent due to the energy losses.
9. Uniform torque	9. Torque not uniform.
10. Simple constructions. Less number of spare parts needed	10. Complicated construction. More number of spare parts needed.

Hydraulic ram



Hydraulic ram

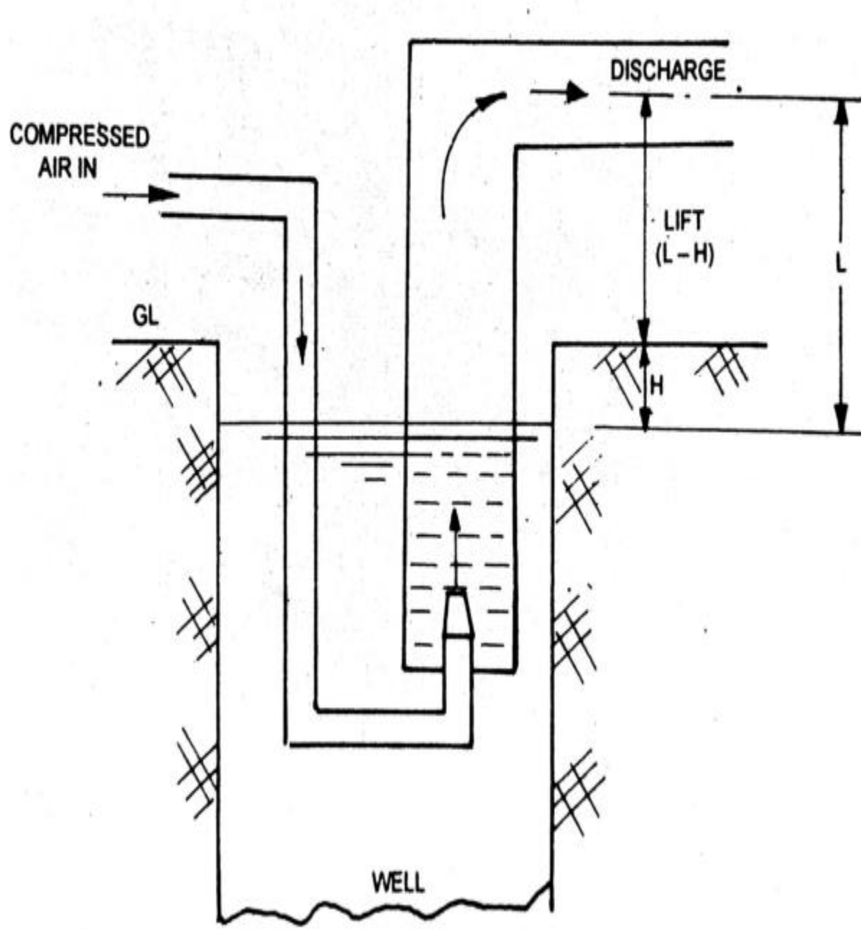
- ✓ The hydraulic ram is a pump which raises water without any external power for its operation.
- ✓ When large quantity of water is available at a small height, a small quantity of water can be raised to a greater height with the help of hydraulic ram.
- ✓ It works on the principle of water hammer.
- ✓ When the inlet valve fitted to the supply pipe is opened, water starts flowing from the supply tank to the chamber, which has two valves at v_1 and v_2.
- ✓ The valve v_1 is called waste valve and valve v_2 is called the delivery valve and it is fitted to an air vessel.
- ✓ As the water is coming into the chamber from supply tank, the level of water rises in the chamber and waste valve starts moving upward. A stage comes, when the waste valve v_1 suddenly closes.
- ✓ This sudden closure of waste valve creates high pressure inside the chamber. This high pressure force opens the delivery valve v_2. Because this water being forced uphill through the delivery pipe.
- ✓ When the water in the chamber loses its momentum, the waste valve v_1 opens in the downward direction and the flow of water from supply tank starts flowing to the chamber and the cycle will be repeated.

Air-Lift Pump

- This pump does not belong to the category of positive displacement or roto-dynamic pump.
- The air-lift pump utilises compressed air for raising water.
- The density of a mixture of air in water is much lower than that of pure water.
- If such a mixture is balanced against a water column, the mixture of air and water will rise to greater height.

Working

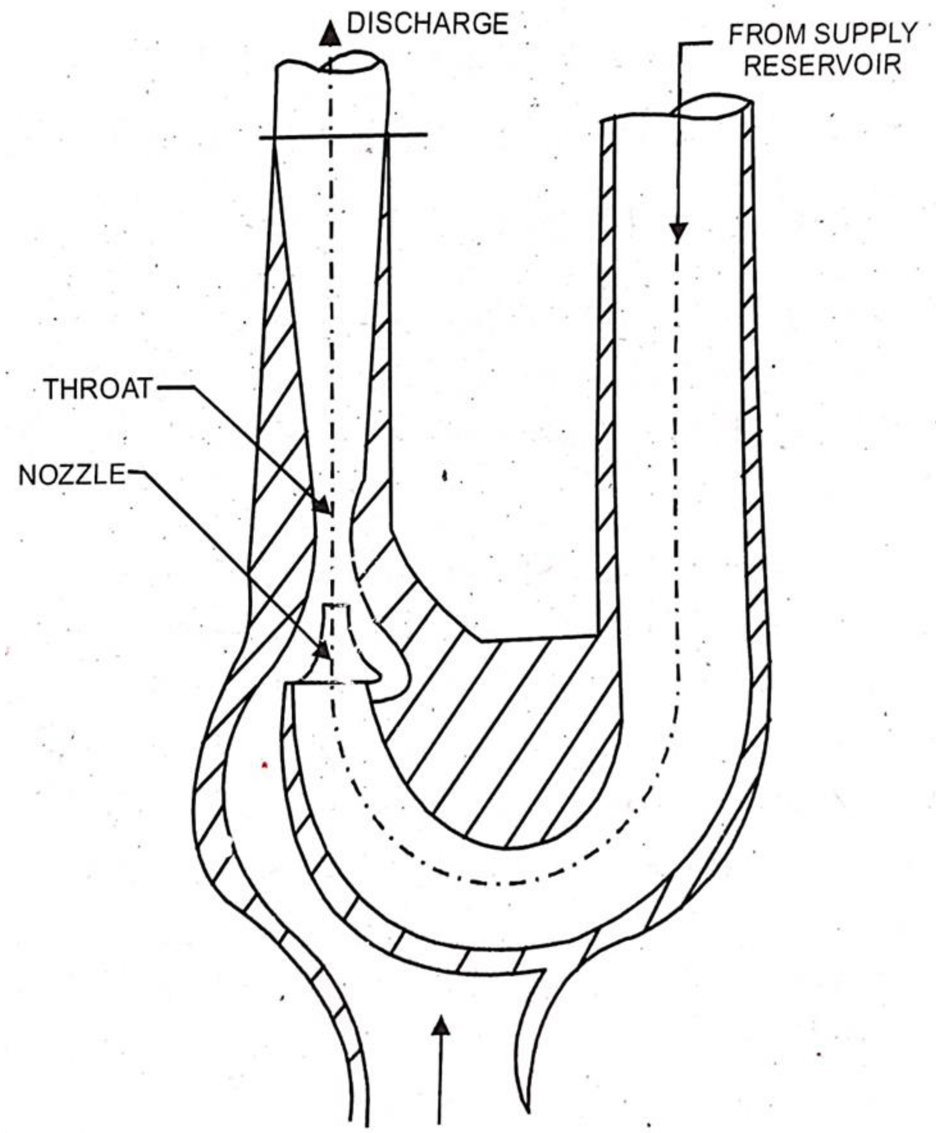
- how air lift pumps work.mp4
- Fig. shows the simplest method of raising water from a deep-well.



- Compressor installed at ground level supplies compressed air.
- The steam of compressed air produces a jet and entraps water in the well.
- The air-water mixture can rise above the water level because of its low density.
- The air is introduced at a considerable depth below water surface in the well.

Jet Pump

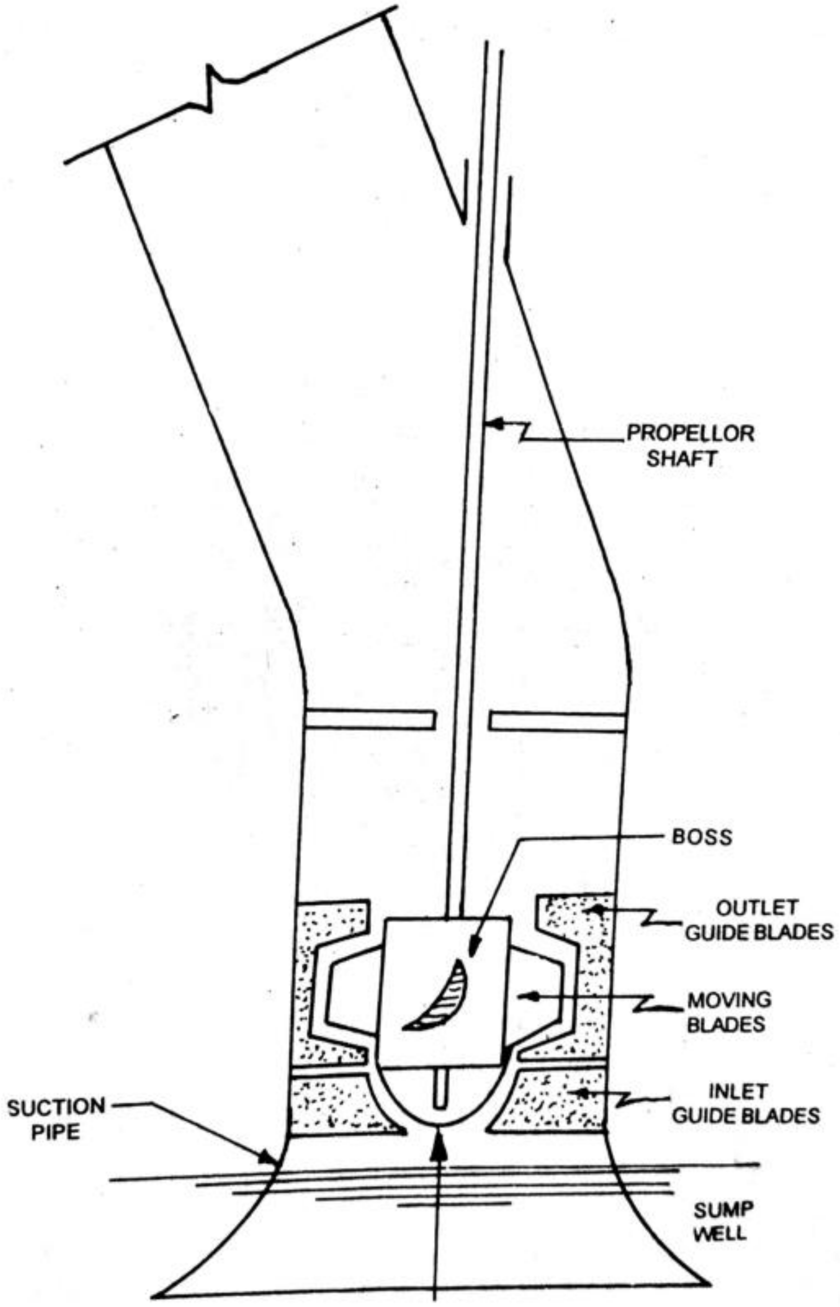
- [Jet Pumps.mp4]
- This pump does not belong to the category of positive displacement or roto-dynamic pump.

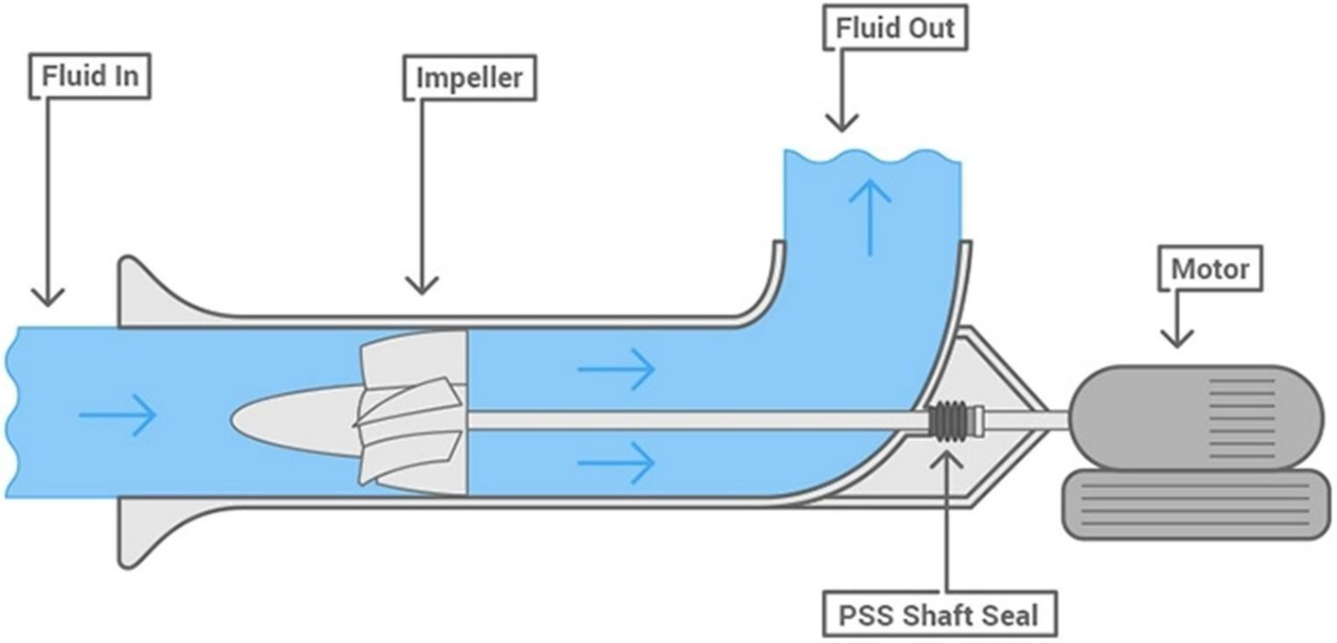


- Steam or water under high pressure is forced through a nozzle, thereby converting pressure energy into kinetic energy in the high velocity jet of fluid coming out of nozzle.
- It results in lowering of pressure which causes suction.
- When steam is used, condensation of steam at low pressure produces suction.

Propeller Pump

- propeller pumps.mp4
- It is an axial flow roto-dynamic pump.
- It resembles a reversed Kaplan turbine.
- In this pump, pressure is developed by flow of liquid over blades of aerofoil section which is sufficient to lift water.

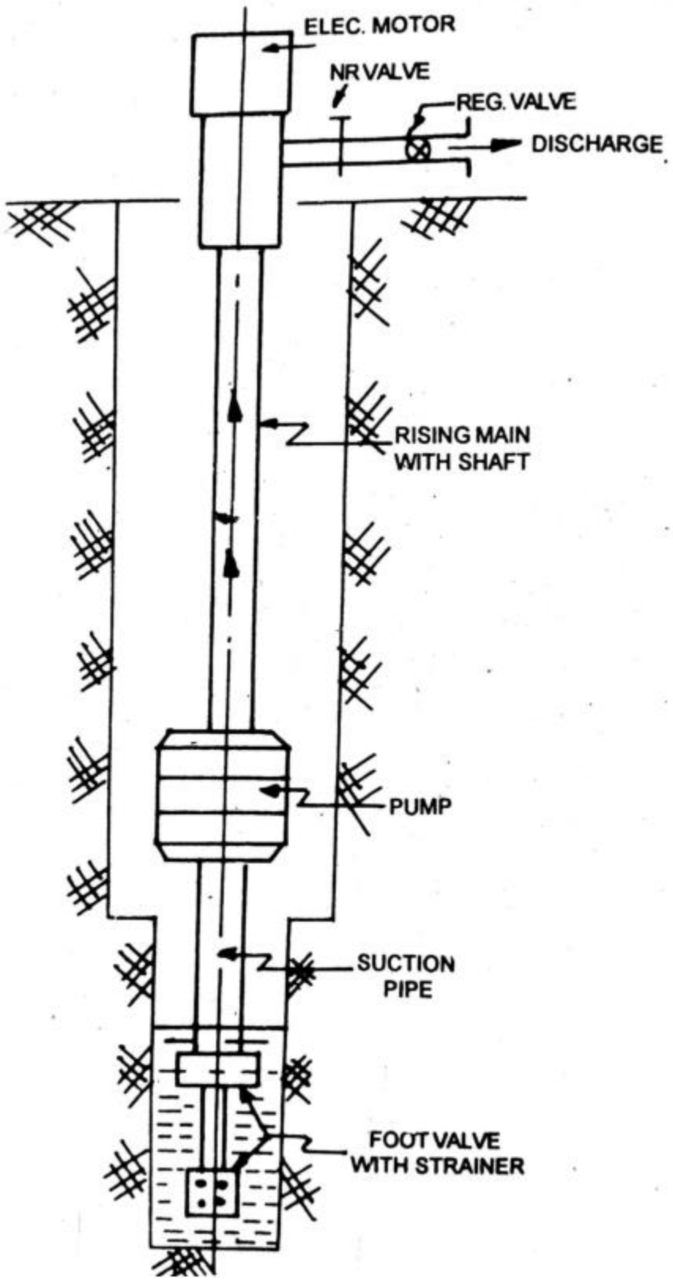

PROPELLOR SHAFT
BOSS
OUTLET GUIDE BLADES
MOVING BLADES
INLET GUIDE BLADES
SUCTION PIPE
SUMP WELL

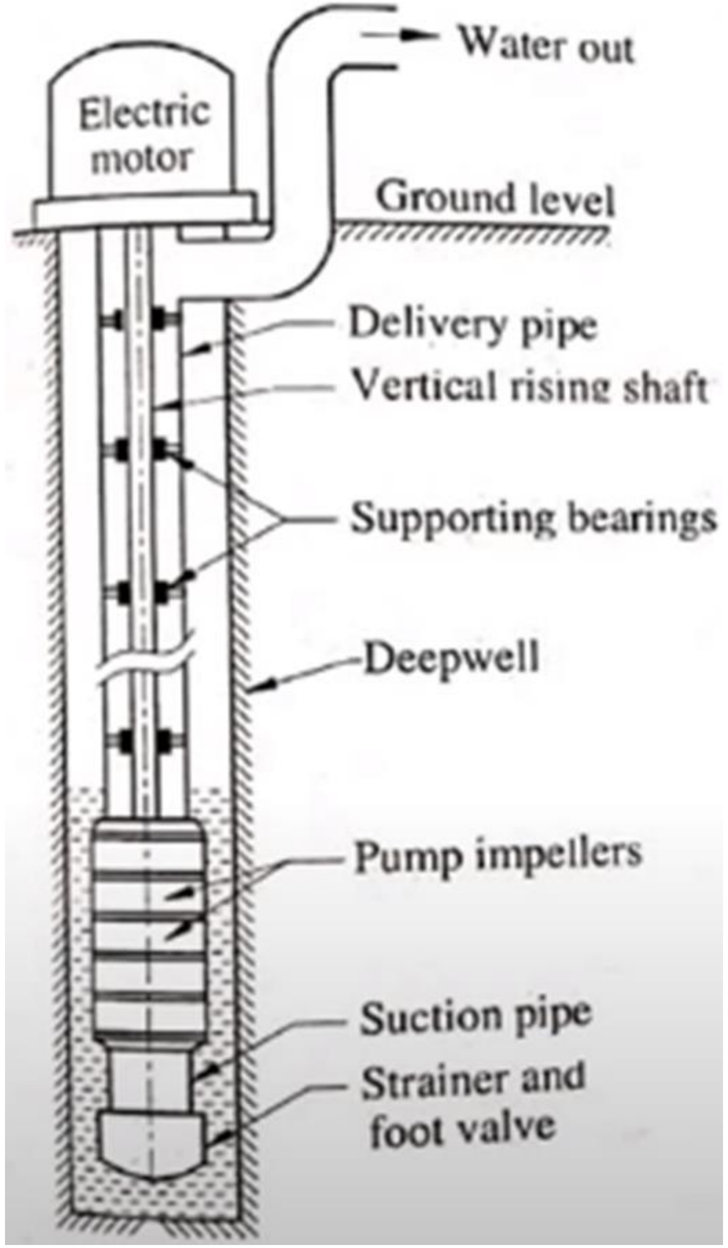

Fluid In
Impeller
Fluid Out
Motor
PSS Shaft Seal

- It consists of a small suction pipe.
- It has a few guide blades or vanes as shown.
- A shaft carrying a set of vanes on its boss is driven by prime mover.
- The speed of this pump is greater than that of a centrifugal pump.
- When propeller blades rotate suction is created and water is drawn up and pressure energy is added for delivery to a required height.
- With some changes and more number of blades sets it may be used as a bore-hole pump.

Deep-Well Pump

- This pump belongs to the category of roto-dynamic pumps.
- It is one of the varieties of centrifugal pump.


ELEC. MOTOR
NR VALVE
REG. VALVE
DISCHARGE
RISING MAIN WITH SHAFT
PUMP
SUCTION PIPE
FOOT VALVE WITH STRAINER


Water out
Electric motor
Ground level
Delivery pipe
Vertical rising shaft
Supporting bearings
Deepwell
Pump impellers
Suction pipe
Strainer and foot valve

- It consists of a group of impellers at the lower end of pump shaft.
- All the impellers are atleast three meters of suction pipe, with a strainer at the end, are placed below the water level. That is why it is also called a bore-hole pump.
- All the impellers are mounted in series on the same shaft.
- It is also called a vertical turbine pump and resembles a reversed Kaplan turbine.

- It works on the principle of working of a centrifugal pump.
- The pressure head developed by centrifugal action is entirely due to velocity imparted to the liquid by the rotating impellers.
- Generally the pump is driven by a directly coupled electrical motor installed at ground level.
- When impellers start rotating, water is sucked from the source and delivered out continuously.