(a) *Closed impeller*: An ordinary centrifugal pump is equipped with a closed impeller in which the vanes are covered with shrouds (covere) on both sides. This type is meant to handle non-viscous liquid such as ordinary water, hot water, hot oils and chemicals like acid etc. The material of the impeller should be selected according to the chemical properties of liquid used. For hot water at temperature exceeding 150°C Cast steel impeller is recommended.

(b) *Semi-open impeller*: The impeller is provided with shroud on one side only. This pump is used for viscous liquid such as sewage, paper pulp etc.

(c) *Open impeller pump*: The impeller is not provided with any shroud, such pumps are used in to handle slurries, mixture of water and clay etc. Open impeller generally made of forged steel. Figure 20 shows the impellers.

Reciprocating pump may be classified as:

1. On the basis of piston side: On the basis of piston sides, pumps may be classified as:
(a) Single acting pump (b) Double acting pump

(a) *Single acting pump*: If these is only one suction and one delivery pipe and the liquid is filled only one side of the piston, it is called single acting reciprocating pump (Fig. 22).

(b) *Double acting pump*: A double acting reciprocating pump has two suction and two delivery pipes. Liquid is received on both sides of the piston in the cylinder and is delivered into the respective delivery pipes. (Fig. 23).

2. On the basis of number of cylinder: On the basis of number of cylinder, pumps may be classified as:
(a) Single cylinder pump (b) Double cylinder pump
(c) Multi-cylinder pump

(a) *Single cylinder pump*: A reciprocating pump having only one cylinder is known as single cylinder pump. It may be either single acting or double acting pump.

(b) *Double cylinder pump*: A double cylinder pump consists of two cylinders connected to the same shaft. Each cylinder has its own suction and delivery pipes. Each piston is connected by cranks which are set at 180° to each other. Thus, when there is suction stroke in one pump in the other it is delivery stroke. So liquid is delivered to the delivery pipe during each stroke of the piston.

(c) *Multi-cylinder pump*: Pumps having more than one cylinder are known as multi-cylinder pumps.

5.16 CENTRIFUGAL PUMP

A centrifugal pump is a rotodynamic or dynamic pressure pump where the working fluid or liquid is subjected to whirling motion by means of backward curved blades mounted on a wheel called *impeller*. A centrifugal pump is named so, because the energy added by the impeller to the fluid is largely due to centrifugal effects. The liquid enters the impeller at its centre called the *eye of the pump* and the impeller discharges the liquid into the casing surrounding the impeller. The developed pressure head is purely due to the whirling motion of the liquid imparted by the rotating impeller and is not due to any displace-ment or impact.

A layout of a centrifugal pump is shown in Fig. 21.

The main components of a centrifugal pump are:

1. Strainer and foot valve
2. Suction pipe
3. Pump (a) Impeller (b) Casing
4. Delivery valve
5. Delivery pipe

1. Strainer and foot valve: It is fitted at one end of the suction pipe and is submerged in water in such a way that it is always a few meters above the surface of water in sump. The water from the sump enters the suction pipe through the strainer and foot valve.

Foot valve is a non return valve *i.e.* it does not allow the water to go back to the sump.

2. Suction pipe: A pipe whose one end is connected to the inlet of the pump and the other end dips into the water in a sump is known as suction pipe. Pipe fitting should be air tight because a pump cannot run if it contains air pockets.

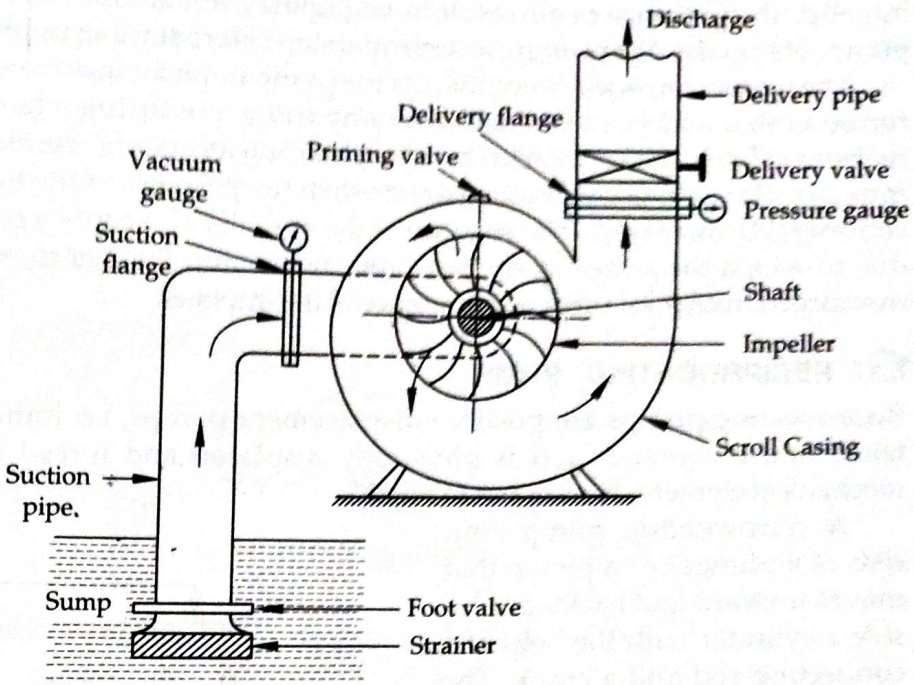

Fig. 21 Centrifugal Pump

3. Pump: The pump mainly consists of an impeller and casing. The water enters the impeller at its centre, called the eye of the pump and impeller discharge water into the casing.

(a) *Impeller*: The rotating wheel of a centrifugal pump is called the impeller. It has a number of forward curved or backward curved blades, depending upon whether it is a slow speed or a high speed impeller. When the impeller rotates, a negative pressure (lower than the atmospheric pressure) is created near the eye of the pump and water enters the impeller. The pressure head created by the centrifugal action is entirely due to the velocity imparted to water by the rotating impeller, and not due to any displacement or impact.

(b) *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 K.E 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.

Volute casing is used for single stage pump and diffuser casing for multistage pumps.

4. Delivery valve: The delivery valve connects the pump outlet and the delivery pipe. It remains closed before the pump is switched on. When the pump builds up its pressure, it is opened and can be used to control or vary the discharge.

The delivery valve is closed again before the pump is switched off so that the delivery pressure is not transmitted to the suction pipe.

5. 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 is known as delivery pipe.

Working of a Centrifugal Pump

To start the pump priming is the *first* step for the working of pump. The priming is the operation of filling the suction pipe, casing of the pump, and the portion of the delivery pipe up to the delivery valve, so that no air pocket is left. The presence of a small air pocket may hamper the working of pump as the density of air is usually very low compared to liquid being pumped.

The centrifugal action developed is directly proportional to the density of fluid in contact with

impeller, the presence of air result in negligible pressure rise, so no liquid will be lifted up by the pump. This makes the priming an essential step before starting pump.

The *second* step is the revolution of the pump impeller inside a casing full of water to produced a forced vortex which is responsible for imparting a centrifugal head to water. For this purpose the delivery valve is still kept closed to reduce starting torque and the electric motor is started to rotate the impeller. The delivery valve is opened when the pressure of the liquid surrounding the impeller is considerably increased. The rotation of the impeller also cause a reduction of pressure at the centre, due to which the water in suction pipe rushes into the eye to replace the liquid which is being discharged from the entire circumference of the impeller.

5.17 RECIPROCATING PUMP

Reciprocating pumps are positive displacement pumps, *i.e.* initially, a small quantity of liquid is taken into a chamber and is physically displaced and forced out with pressure by a moving mechanical element. It is shown in Fig. 22.

A reciprocating pump consists of a plunger or a piston that moves forward and backward inside a cylinder with the help of a connecting rod and a crank. The crank is rotated by an external source of power. The cylinder is connected to the sump by a suction pipe and to the delivery tank by a delivery pipe. At the cylinder ends of these pipes non-return valves air provided. A non-return valves allows the liquid to pass in only one direction. Through suction valve liquid can only be admitted into the cylinder and through the delivery valve, liquid can only be discharged into the delivery pipe.

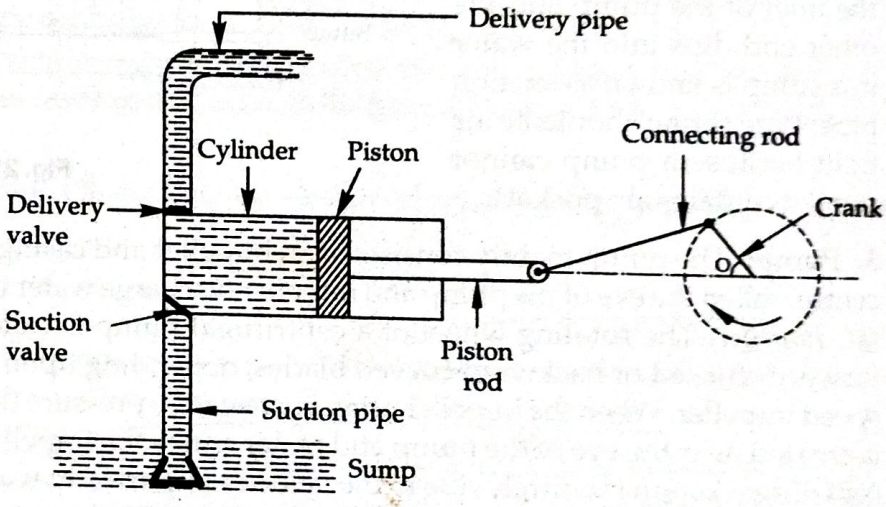

Fig. 22 Reciprocating Pump

Working of a reciprocating pump

The working of a simple reciprocating pump is depend on the movement of piston or plunger in the close fitting cylinder. The cylinder is connected to suction and delivery pipe, each of which is provided with a non-return valves.

When the piston moves from left to the right or towards outer dead center, a suction pressure is produced in the cylinder and is called as suction stroke. If the pump is started for the first time or after a long period, air from the suction pipe is sucked during the suction stroke, while the delivery valve is closed. Liquid rises into the suction pipe by a small height due to atmospheric pressure on the sump liquid. In the return motion of piston from right to left or towards inner dead centre the suction valve get closed while the delivery valve get opened. During the delivery stroke, air in the cylinder is pushed out into the delivery pipe by the thrust of the piston, while the suction valve is closed so this stroke is called as delivery stroke.

When all the air from the suction pipe has been exhausted, the liquid from the sump is able to rise and enter the cylinder. During the delivery stroke, it is displaced into the delivery pipe. Thus, the liquid is delivered into the delivery tank intermittently *i.e.* during the delivery stroke only. Later on, it will be observed that the pressure and velocity inside the cylinder are not uniform throughout a stroke of the piston.