gradually increasing area is used for discharging water from the exist of the turbine to the tail race. This tube of increasing area is called draft tube. The free end of the draft tube is submerged deep into the tail race.

(5) Runner: The runner of Francis turbine is a circular wheel on which a series of radial curved vanes are fixed. The radial curved vanes are so shaped that the water enters and leaves the runner without shock. The number of runner blades varies between 16 to 24. The runner is keyed to the shaft which is coupled to the generator shaft. A runner with the scroll casing is shown in Fig. 5.

Working of a Francis Turbine: The working of a Francis turbine is shown in Fig. 4. A Francis turbine is a mixed flow turbine in which the water enters at the circumference of the runner and travels towards the axis of the runner. Finally it comes out axially along the shaft.

It operates under medium heads and requires medium quantity of flow. The water first passes through the guide vanes and then through runner vanes. Finally the water is discharged into the tail race through a draft tube. There is a difference of pressure between guide vanes and runner which is called as reaction pressure. This reaction pressure is responsible for the motion of the runner.

5.6 KAPLAN TURBINE

It is a high discharge *low head turbine*

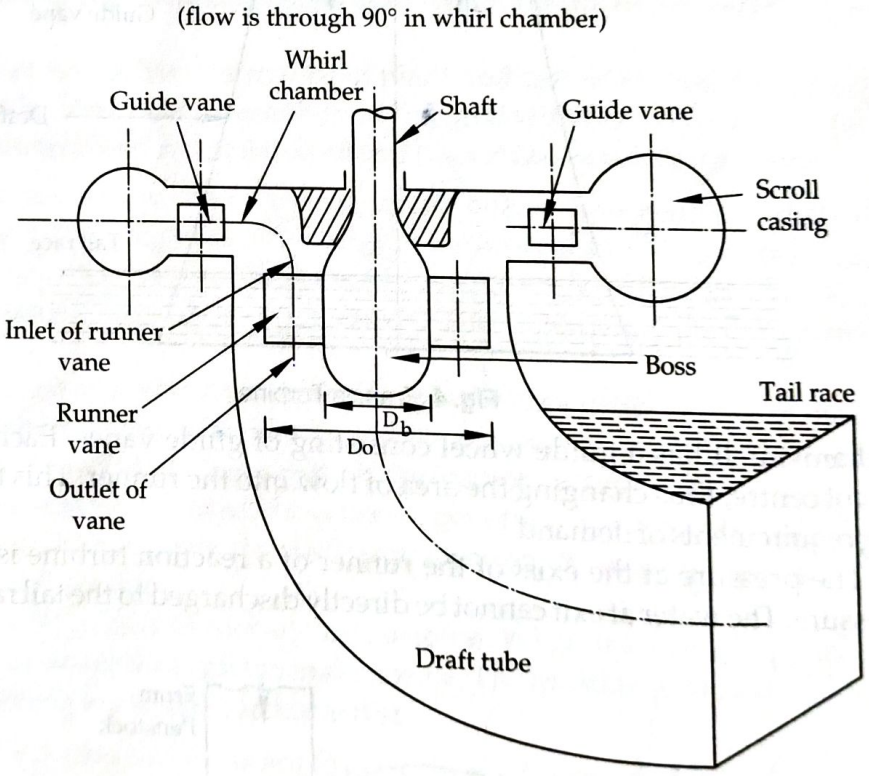

Fig. 6 Kaplan Turbine

A Kaplan turbine is shown in Fig. 6. Kaplan Turbine has the following main component:

(1) Runner: In Kaplan turbine the runner blades are adjustable and can be rotated about pivot fixed to the boss of the runner.

The runner blades are automatically adjusted with the help of a servomechanism. It is made up of stainless steel. A runner with scroll casing is shown in Fig. 7.

(2) Guide Vanes: They impart a tangential and a radial inward velocity to the liquid.

(3) Scroll Casing: The Kaplan turbine is high discharge low head turbine. So it needs a scroll casing in order to increase the velocity and keep it constant for a fixed load. The water first enters the spiral casing in which area of cross-section decreases continuously.

The reduction in area is proportional to the decreasing volume of water to be handled. It maintains a constant velocity of water along its path. It is made up of cast iron or rolled steel.

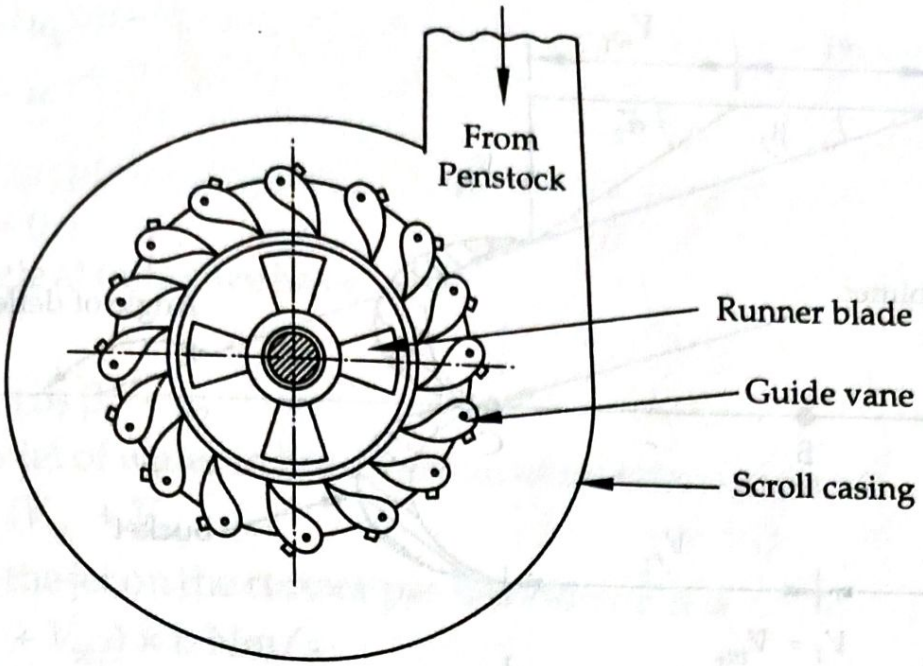

Fig. 7 Runner with scroll casing

(4) **Whirl Chamber:** A space is provided between the guide vanes and the runner, it is called as whirl chamber. In this chamber the flow is turned through 90° and moves as free vortex. The radial component of velocity is changed into axial component due to the guidance from fixed housing.

(5) **Draft Tube:** It performs the same function as in the *Francis Turbine*.

Working of Kaplan Turbine

The high discharge of low head water is allowed to enter the scroll casing. It enters axially into the runner and leaves axially. The water first passes through guide vanes and the guide vanes direct the water at proper angle to avoid the shock waves formation.

The movement of guide vanes and rotation of runner blades are controlled by means of servomechanism.

There is a difference of pressure between guide vanes and the runner which is responsible for the motion of the runner. After passing through the runner the water is discharged to tail race through draft tube.

out of the runner possesses a large amount of kinetic energy and the pressure at the runner outlet is less than the atmospheric pressure. This kinetic energy of water is converted into potential energy by allowing it to flow through a gradually diverging tube called draft tube.

The draft tube employed in reaction turbines have different shapes and a few of them have been illustrated in Fig. 14.

5.14 PUMPS

The hydraulic machines which convert the mechanical energy into hydraulic energy are called pumps.

Pump is a mechanical device which is used to increase the pressure of a liquid. It is also used for raising fluid from a lower level to a higher level. Pump is used to increase the pressure energy of a liquid. The pressure energy is increased by creating a region of low pressure (usually lower than the atmospheric pressure) near the inlet of the pump and a higher pressure at the outlet of the pump. Due to this low inlet pressure, the liquid rises to the pump from a low level reservoir (sump) and the high pressure created inside the pump forces the liquid out of the pump to be delivered to the reservoir.

5.15 CLASSIFICATION OF PUMP

Pumps can be broadly classified into two categories, i.e.

1. Rotodynamic or dynamic pressure pump.
2. Positive displacement pump.

1. Rotodynamic or dynamic pressure pump

In rotodynamic or dynamic pressure pumps the liquid is subjected to whirling motion by an impeller (a rotating disc having a finite number of blades similar to the runner of a turbine) and gain in the kinetic energy of the liquid is converted into the pressure energy inside the pump.

In these pumps the dynamic pressure is developed to lift the liquids from a lower to a higher level. The basic principle is based on centrifugal force developed during rotation of a liquid by an external force. Since, these pumps perform the lifting of the liquid mainly due to centrifugal force. These are also called as centrifugal pumps.

2. Positive displacement pump

In a positive displacement pumps the liquid is sucked or taken inside the pump and displaced or forced out of the pump under pressure.

The liquid inside a positive displacement pump may be subjected either to a reciprocating motion (a reciprocating pump) or to a rotary/circular motion (gear pump, screw pump etc.)

Rotodynamic pumps (centrifugal pumps) may be classified as:

1. On the basis of working head
2. On the basis of type of casing
3. On the basis of direction of flow of water through impeller.
4. On the basis of specific speed
5. On the basis of entrance of the impeller
6. On the basis of shaft position
7. On the basis of number of stages
8. On the basis of Impeller.

1. On the basis of working head: On the basis of working head, pumps may be classified as:

(a) Low lift pump (b) Medium lift pump (c) High lift pump

(a) *Low lift pump*: These pumps are capable of working upto 15 m of total head. These are generally single stage pumps. Such pumps use volute casing without guide vanes.

(b) *Medium lift pump*: These pumps are capable of working between 15 to 45 m of total head. These pumps are generally provided with guide vanes.