fixed to the periphery of the wheel. Each bucket has a sharp edge at the centre called the splitter. The jet strikes each bucket at this splitter and is divided into two sides, thus avoiding any unbalanced thrust on the shaft. It is shown in Fig. 3.

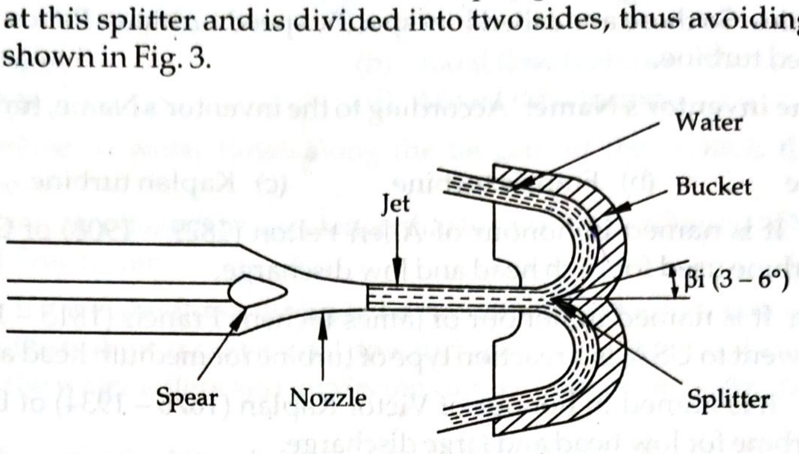

Fig. 3 Bucket

To get full reaction of the jet, it has to be turned through 180° by the bucket. But then, the jet may strike the incoming bucket retarding the speed of the runner. Therefore, the angle through which the jet is turned is kept between 160° to 170°. Average value is taken as 165°.

The bottom portion of the buckets is usually cut which also facilitates the jet to pass through the succeeding bucket.

Material for bucket is cast Iron for low head plant and cast steel, stainless steel and bronze for medium and high heads. The buckets are either cast integral with the wheel or bolted to the rim.

Bolted arrangement is preferred as the damaged bucket can be easily replaced.

(2) *Nozzle with guide mechanism:* The function of the nozzle of a pelton wheel is to convert the available pressure energy into high velocity energy in the form of jet. The quantity of water required is proportional to the load on the turbine. Therefore, to control the flow through the nozzle, some sort of a regulating or a governing mechanism is necessary. This is generally done by using a spear inside the nozzle.

The movement of spear inside the nozzle changes the area of flow through it, thus varying the discharge. The movement of the spear is affected by a governor through a servomechanism. The governor itself is operated by the turbine shaft. If the load on turbine reduces and the runner tries to speed up, the governor will be activated, the action of governor is to move the spear into the nozzle to reduce the area of flow. This reduces the discharge through the nozzle. Reverse will happen if the load increases on the turbine shaft.

A small brake nozzle is used in case of large turbine. When the wheel is to be stopped, besides cutting off the supply of water through the main nozzle. The brake nozzle also directs the water on to the back of buckets to bring the wheel quickly to rest.

(3) *Casing*: Casing of a pelton turbine is not to perform any hydraulic function. However, a casing is necessary to avoid accidents, splashing of water, to lead the water to the tail race and to support the housing for the bearing and the nozzle.

5.5 REACTION TURBINE

Reaction turbine is a pressure turbine *i.e.* the water enters the wheel under pressure after passing through the guide vanes. At the outlet of turbine, the pressure is atmospheric or below atmospheric if the discharge is taken through a draft tube into the tail race. Owing to this difference of pressure, the water flows through the vanes of the turbine towards the outlet. The difference of pressure between guide vanes and runner called reaction pressure is responsible for the motion of the runner. Therefore, such a turbine is called reaction turbine.

A reaction turbine operates under pressure and has more pressure at the inlet than at the outlet.

Francis Turbine

A Francis turbine has the following main components:

(1) **Penstock:** It is the water ways used to carry the water from the reservoir to the turbine.

(2) **Scroll casing:** It is the casing around the turbine wheel and it evenly distributes the water around the circumference of the wheel. Area of cross-section of a scroll casing reduces uniformly from maximum at the entrance to zero at the exit. Since the quantity of water reduces from maximum to zero correspondingly otherwise, velocity will vary all around the circumference of the wheel and water will not enter the runner with constant velocity. Material used for the casing is generally concrete for low head rolled steel for medium heads and cast steel for high heads.

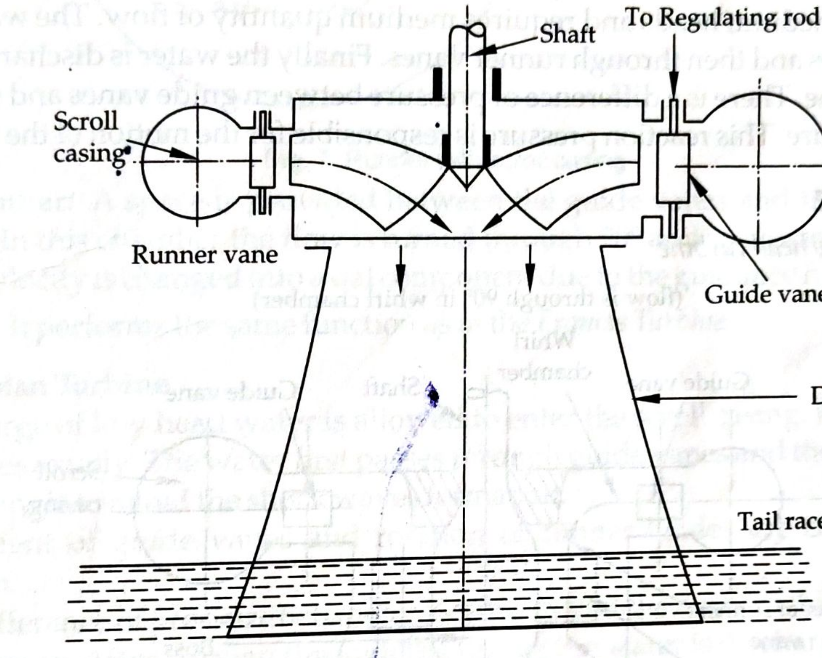

Fig. 4 Francis Turbine

(3) **Guide Mechanism:** It has a guide wheel consisting of guide vanes. Each guide vane can be moved on its pivot centre, thus changing the area of flow into the runner. This regulates the flow to meet the varying requirements of demand.

(4) **Draft tube:** The pressure at the exist of the runner of a 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

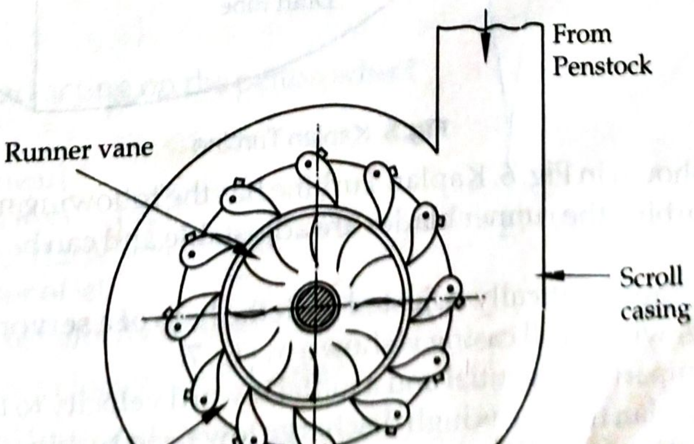

Fig. 5 Runner with scroll casing

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*

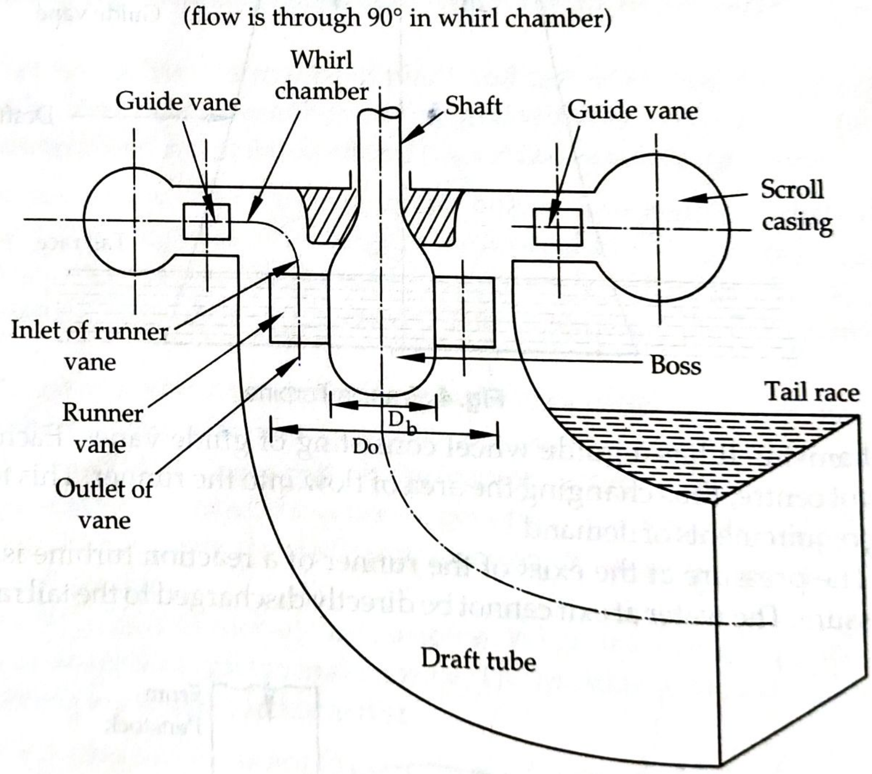

Fig. 6 Kaplan Turbine

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.