KAPLAN TURBINE

AXIAL FLOW TURBINE

If the water flows parallel to the axis of the rotation of the shaft, the turbine is known as axial flow turbine. And if the head at the inlet of the turbine is the sum of pressure energy and kinetic energy and during the flow of water through runner a part of pressure energy is converted into kinetic energy, the turbine is known as reaction turbine.

For the axial flow reaction turbine, the shaft of the turbine is vertical. The lower end of the shaft is made larger which is known as 'hub' or 'boss'. The vanes are fixed on the hub and hence hub acts as a runner for axial flow reaction turbine. The following are the important type of axial flow reaction turbines :

1. Propeller Turbine 2. Kaplan Turbine

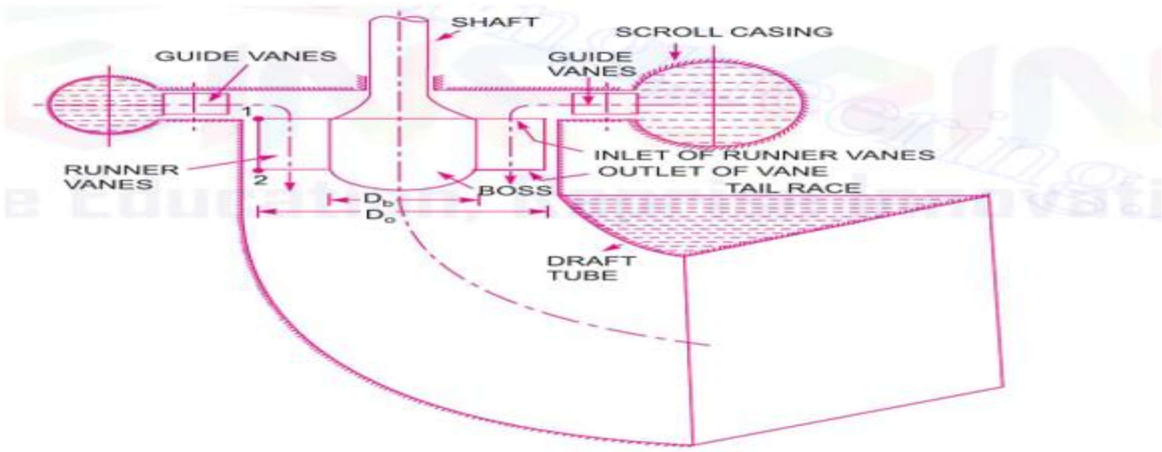
When the vanes are fixed to the hub and they are not adjustable, the turbine is known as propeller turbine. But if the vanes on the hub are adjustable, the turbine is known as a *Kaplan Turbine*, after the name of V Kaplan, an Austrian Engineer. This turbine is suitable where a large quantity of water at low head is available. Fig. 18.25 shows the runner of a Kaplan turbine, which consists of a hub fixed to the shaft. On the hub, the adjustable vanes are fixed as shown in Fig.

The main parts of a Kaplan turbine are :

1. Scroll casing,
2. Guide vanes mechanism,
3. Hub with vanes or runner of the turbine,
4. Draft tube.

The water from penstock enters the scrool

casing and then moves to the guide vanes. From the guide vanes, the water turns through 90° and flows axially through the runner as shown in Fig. 18.26. The discharge through the runner is obtained as



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$$Q = \frac{\pi}{4}\left(D_o^2 - D_b^3\right) \times V_{f_1}$$

where D_o = Outer diameter of the runner,

D_b = Diameter of hub, and

V_{f_1} = Velocity of flow at inlet.

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1. The peripheral velocity at inlet and outlet are equal

$$\therefore \quad u_1 = u_2 = \frac{\pi D_o N}{60}, \text{ where } D_o = \text{Outer dia. of runner}$$

2. Velocity of flow at inlet and outlet are equal

$$\therefore \quad V_{f_1} = V_{f_2}.$$

3. Area of flow at inlet = Area of flow at outlet

$$= \frac{\pi}{4}\left(D_o^2 - D_b^2\right).$$

PROBLEMS:

A Kaplan turbine develops 24647.6 kW power at an average head of 39 metres.

Assuming a speed ratio of 2, flow ratio of 0.6, diameter of the boss equal to 0.35 times the diameter of the runner and an overall efficiency of 90%, calculate the diameter, speed and specific speed of the turbine.

Solution. Given :

Shaft power, S.P. = 24647.6 kW

Head, $H = 39$ m

Speed ratio, $u_1 \sqrt{2gH} = 2.0$

$$\therefore \quad u_1 = 2.0 \times \sqrt{2gH} = 2.0 \times \sqrt{2 \times 9.81 \times 39} = 55.32 \text{ m/s}$$

Flow ratio, $\dfrac{V_{f_1}}{\sqrt{2gH}} = 0.6$

$$\therefore \quad V_{f_1} = 0.6 \times \sqrt{2gH} = 0.6 \times \sqrt{2 \times 9.81 \times 39} = 16.59 \text{ m/s}$$

Diameter of boss = 0.35 × Diameter of runner

$$\therefore \quad D_b = 0.35 \times D_o$$

Overall efficiency, $\eta_o = 90\% = 0.90$

Using the relation, $\eta_o = \dfrac{\text{S.P.}}{\text{W.P.}}$, where $\text{W.P.} = \dfrac{\rho \times g \times Q \times H}{1000}$

$$\therefore \quad 0.90 = \frac{24647.6}{\dfrac{\rho \times g \times Q \times H}{1000}} = \frac{24647.6 \times 1000}{1000 \times 9.81 \times Q \times 39}$$

$$\therefore \quad Q = \frac{24647.6 \times 1000}{0.9 \times 1000 \times 9.81 \times 39} = 71.58 \text{ m}^3\text{/s.}$$

But from equation (18.25), we have

$$Q = \frac{\pi}{4}\left(D_o^2 - D_b^2\right) \times V_{f_1}$$

$$\therefore \quad 71.58 = \frac{\pi}{4}\left[D_o^2 - (.35\,D_o)^2\right] \times 16.59 \qquad \left(\because \quad D_b = 0.35\,D_o,\ V_{f_1} = 16.59\right)$$

$$= \frac{\pi}{4}\left[D_o^2 - .1225\,D_o^2\right] \times 16.59$$

$$= \frac{\pi}{4} \times .8775\,D_o^2 \times 16.59 = 11.433\,D_o^2$$

(*i*) $\therefore \quad D_o = \sqrt{\frac{71.58}{11.433}} =$ **2.5 m. Ans.**

$\therefore \quad D_b = 0.35 \times D_o = 0.35 \times 2.5 =$ **0.875 m. Ans.**

(*ii*) Speed of the turbine is given by $u_1 = \frac{\pi D_o N}{60}$

$$\therefore \quad 55.32 = \frac{\pi \times 2.5 \times N}{60}$$

$\therefore \quad N = \frac{60 \times 55.32}{\pi \times 2.5} =$ **422.61 r.p.m. Ans.**

(*iii*) Specific speed * is given by $N_s = \frac{N\sqrt{P}}{H^{5/4}}$, where P = Shaft power in kW

$\therefore \quad N_s = \frac{422.61 \times \sqrt{24647.6}}{(39)^{5/4}} = \frac{422.61 \times 156.99}{97.461} =$ **680.76 r.p.m. Ans.**