

DRAFT TUBE

The draft-tube is a pipe of gradually increasing area which connects the outlet of the runner to the tail race. It is used for discharging water from the exit of the turbine to the tail race. This pipe of gradually increasing area is called a draft-tube. One end of the draft-tube is connected to the outlet of the runner while the other end is sub-merged below the level of water in the tail race. The draft-tube, in addition to serve a passage for water discharge, has the following two purposes also :

1. It permits a negative head to be established at the outlet of the runner and thereby increase the net head on the turbine. The turbine may be placed above the tail race without any loss of net head and hence turbine may be inspected properly.

2. It converts a large proportion of the kinetic energy ($V_2^2/2g$) rejected at the outlet of the turbine into useful pressure energy. Without the draft tube, the kinetic energy rejected at the outlet of the turbine will go waste to the tail race.

Hence by using draft-tube, the net head on the turbine increases. The turbine develops more power and also the efficiency of the turbine increases.

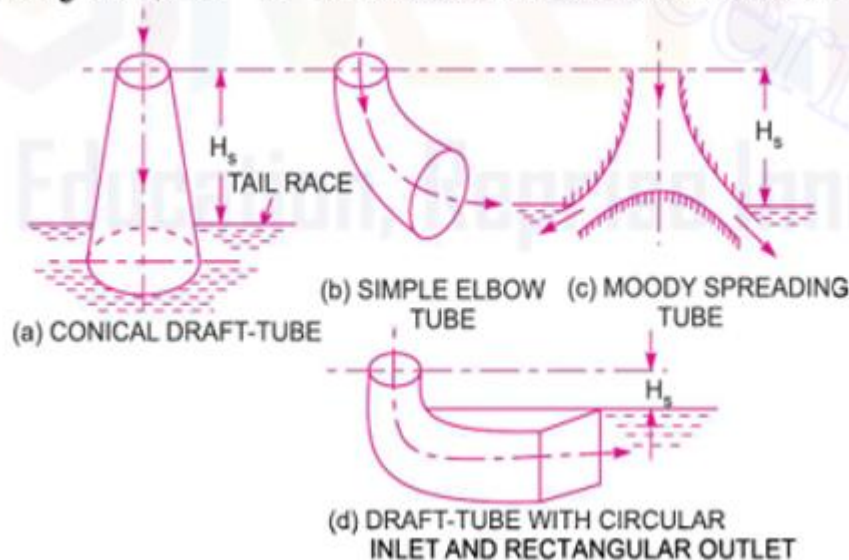
If a reaction turbine is not fitted with a draft-tube, the pressure at the outlet of the runner will be equal to atmospheric pressure. The water from the outlet of the runner will discharge freely into the tail race. The net head on the turbine will be less than that of a reaction turbine fitted with a draft-tube.

Also without a draft-tube, the kinetic energy ($\frac{V_2^2}{2g}$) rejected at the outlet of the runner will go waste to the tail race.

Types of draft tubes: The following are the important types of draft tubes which are commonly used:

Types of draft tubes

1. Conical draft-tubes,
2. Simple elbow tubes,
3. Moody spreading tubes, and
4. Elbow draft-tubes with circular inlet and rectangular outlet.



Types of draft tubes

Draft tube theory: Consider a capital draft tube as shown in fig

Let H_s = Vertical height of draft-tube above the tail race,
 y = Distance of bottom of draft-tube from tail race.

Applying Bernoulli's equation to inlet (section 1-1) and outlet (section 2-2) of the draft-tube and taking section 2-2 as the datum line, we get

$$\frac{p_1}{\rho g} + \frac{V_1^2}{2g} + (H_s + y) = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + 0 + h_f \quad \dots(i)$$

where h_f = loss of energy between sections 1-1 and 2-2.

But $\frac{p_2}{\rho g}$ = Atmospheric pressure head + y
 $= \frac{p_a}{\rho g} + y.$

Substituting this value of $\frac{p_2}{\rho g}$ in equation (i), we get

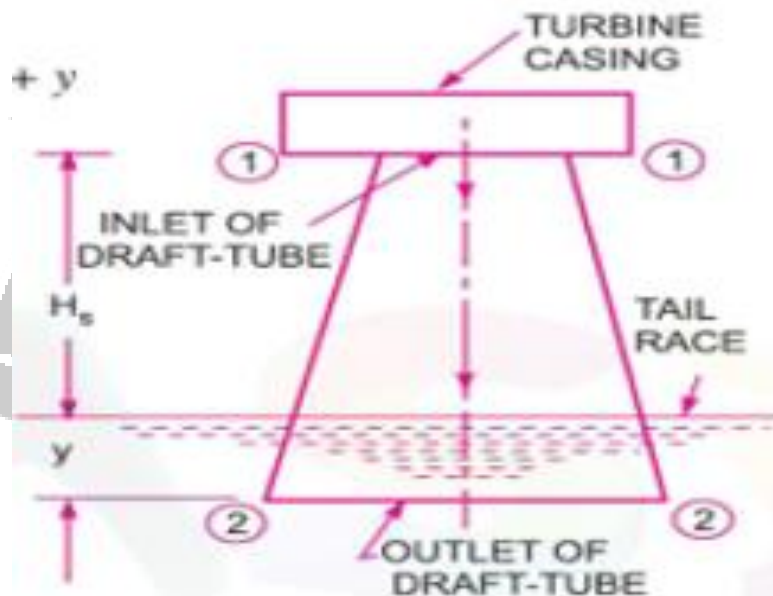
$$\frac{p_1}{\rho g} + \frac{V_1^2}{2g} + (H_s + y) = \frac{p_a}{\rho g} + y + \frac{V_2^2}{2g} + h_f$$

$$\frac{p_1}{\rho g} + \frac{V_1^2}{2g} + H_s = \frac{p_a}{\rho g} + \frac{V_2^2}{2g} + h_f$$

$$\therefore \frac{p_1}{\rho g} = \frac{p_a}{\rho g} + \frac{V_2^2}{2g} + h_f - \frac{V_1^2}{2g} - H_s$$

$$= \frac{p_a}{\rho g} - H_s - \left(\frac{V_1^2}{2g} - \frac{V_2^2}{2g} - h_f \right)$$

In equation (18.26), $\frac{p_1}{\rho g}$ is less than atmospheric pressure.



Efficiency of Draft tube: The efficiency of a draft tube is defined as the ratio of

actual conversion of kinetic head into pressure head in the draft-tube to the kinetic head at the inlet of the draft-tube. Mathematically, it is written as

$$\eta_d = \frac{\text{Actual conversion of kinetic head into pressure head}}{\text{Kinetic head at the inlet of draft-tube}}$$

Let

V_1 = Velocity of water at inlet of draft-tube,

V_2 = Velocity of water at outlet of draft-tube, and

h_f = Loss of head in the draft-tube.

$$\text{Theoretical conversion of kinetic head into pressure head in draft-tube} = \left(\frac{V_1^2}{2g} - \frac{V_2^2}{2g} \right).$$

$$\text{Actual conversion of kinetic head into pressure head} = \left(\frac{V_1^2}{2g} - \frac{V_2^2}{2g} \right) - h_f$$

$$\eta_d = \frac{\left(\frac{V_1^2}{2g} - \frac{V_2^2}{2g} \right) - h_f}{\left(\frac{V_1^2}{2g} \right)}$$

PROBLEMS:

A water turbine has a velocity of 6 m/s at the entrance to the draft-tube and a velocity of 1.2 m/s at the exit. For friction losses of 0.1 m and a tail water 5 m below the entrance to the draft-tube, find the pressure head at the entrance.

Solution. Given :

Velocity at inlet, $V_1 = 6 \text{ m/s}$

Velocity at outlet, $V_2 = 1.2 \text{ m/s}$

Friction loss, $h_f = 0.1 \text{ m}$

Vertical height between tail race and inlet of draft-tube = 5 m

Let y = Vertical height between tail race and outlet of draft-tube.

Applying Bernoulli's equation at the inlet and outlet of draft-tube and taking reference line passing through section (2-2), we get

$$\frac{p_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + h_f$$

$$\text{where } Z_1 = (5 + y); V_1 = 6 \text{ m/s}; V_2 = 1.2 \text{ m/s}, \\ h_f = 0.1$$

$$\frac{p_2}{\rho g} = \text{Atmospheric pressure head} + y = \frac{p_a}{\rho g} + y$$

$$Z_2 = 0$$

Substituting the values, we get

$$\frac{p_1}{\rho g} + \frac{6^2}{2 \times 9.81} + (5 + y) = \left(\frac{p_a}{\rho g} + y \right) + \frac{1.2^2}{2 \times 9.81} + 0 + 0.1$$

$$\text{or } \frac{p_1}{\rho g} + 1.835 + 5 + y = \frac{p_a}{\rho g} + y + 0.0734 + 0.1$$

$$\text{or } \frac{p_1}{\rho g} + 6.835 = \frac{p_a}{\rho g} + 0.1734$$

P_0 P_1

If $\frac{P_a}{\rho g}$ (i.e., atmospheric pressure head) is taken zero, then we will get $\frac{P_1}{\rho g}$ as vacuum pressure head at inlet of draft-tube.

But if $\frac{P_a}{\rho g} = 10.3$ m of water, then we will get $\frac{P_1}{\rho g}$ as absolute pressure head at inlet of draft-tube.

Taking $\frac{P_a}{\rho g} = 0$ and substituting this value in equation (i), we get

$$\frac{P_1}{\rho g} + 6.835 = 0 + 0.1734$$

$$\therefore \frac{P_1}{\rho g} = -6.835 + 0.1734 = -6.6616 \text{ m. Ans.}$$

Negative sign means vacuum pressure head.

