CHAPTER
2

Hydraulic Turbines

2.1 INTRODUCTION

Hydraulic turbines are the hydromachines to generate electricity in hydro-electrical power plants. Hydro or water power is a conventional renewable source of energy. In hydraulic or water turbines, the kinetic or potential energy of water is converted into rotary type mechanical energy which is further converted into electric energy by using electric generators. This conversion of hydro energy is clean and free from pollution and it has good environmental effects. Hydraulic turbines are used where appreciable heads of water are available. Water is discharged from high-level reservoirs through pipes to hydraulic turbines to harness mechanical work.

2.2 HYDRAULIC TURBINES

• What do you understand from hydraulic turbines? What are their uses?

A hydraulic turbine is a device that uses kinetic or potential energy of water and converts the same into mechanical energy. The mechanical energy is used to run (i) millstones, (ii) machinery, and (iii) electric generators.

2.2.1 Classification of Hydraulic Turbines

• How are fluid machines classified? Write a brief note an each.

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or

• Why are impulse and reaction turbines named as such?

The fluid machines or hydraulic turbines are classified according to (i) head and quantity of water; (ii) name of the originator; (iii) action of water on moving blades; (iv) direction of flow of water in the runner; (v) positioning of turbine shaft with respect to ground and (vi) specific speed.

1. **Head and quantity of water:** As per the requirement of head and quantity of water for proper functioning, hydraulic turbines can be:

runner. In axial flow, water flows parallel to the axis of the turbine shaft. In radial flow, the water flows inwardly or outwardly along the radius of the wheel. In mixed flow, water enters the blade radially and exits axially which is the direction parallel to the turbine shaft.

5. **Position of the shaft:** The turbine shaft can be either vertical or horizontal. Pelton turbines have horizontal shafts while other turbines have vertical shafts.
6. **Specific speed:** The turbines can have different heads and discharge conditions. In order to compare these different turbines, the concept of specific speed is used. Specific speed is defined as the speed of a geometrical similar turbines which would develop 1 kW of power when it is given water having 1 m head. All geometrical similar turbines having different sizes can have the same specific speed when they operate under the same head. The specific speed is given by the relation $N_s = \frac{N\sqrt{P}}{H^{5/4}}$ where N = rpm, P = power and H = head. The relation indicates that turbines with high heads and low discharges will have low specific speeds such as in impulse turbines while turbines with low heads and high discharges will have high specific speeds such as in reaction turbines.

- **Why are impulse and reaction turbines named as such?**

1. **Impulse:** In impulse turbine, impulse is the motive force to rotate the wheel of the turbine. Impulse is created by changing the momentum of water flow. Impulse is equal to the change of momentum as per Newton's law. The jet from nozzle strikes on the buckets where its direction is changed to create impulse.
2. **Reaction:** A force can accelerate or decelerate a body. In reaction turbine, water is made to accelerate in nozzle-like space between two runner vanes. A force is generated on this account in water. As per Newton's third law, a reaction force equal to this force (of water) acts on the vanes which starts rotating rotor with vanes. Hence, reaction force is the motive force to rotate the wheel.

2.3 HYDROSTATIONS

- **How does a hydrostation work?**

or

- **Draw a hydrostation and explain its main elements.**

A layout of a hydrostation with its main elements are as shown in Fig. 2.2. Hydrostations supplying electric supply have (i) dams or reservoirs to store water; (ii) pipelines or penstocks to discharge water from high-level reservoirs;

(iii) hydraulic turbines to use the potential energy of water and (iv) electric generators coupled with turbines to generate electricity. The main elements of hydrostations are:

(a) **Reservoirs:** They can be (i) natural or (ii) artificial. Natural reservoirs are naturally formed in mountains and these reservoirs get water from natural springs. Artificial reservoirs are created by building dams across rivers. There has to be appreciable gradient or slope available to provide sufficient potential energy of water wherever dams are constructed.

(b) **Penstocks:** These are pipelines to discharge water from the reservoirs to the hydraulic turbines to harness high potential energy of water. The reservoirs are located at appreciable height from the hydraulic turbines. Generally, penstocks are constructed using either cast iron pipes of large diameter or RCC pipes. Penstocks are provided with (i) valves to control discharge of water to turbines and (ii) surge tanks to minimize inertia effect of water column (water hammering effect).

(c) **Hydraulic turbines:** Hydraulic turbines are meant to convert potential energy into mechanical energy.

(d) **Electricity generators:** Electricity generators are directly coupled to the hydraulic turbines which generate power while rotating with hydraulic turbines.

(e) **Transmission of power supply:** The generated electricity is transmitted to distant places with the help of a power transmission system.

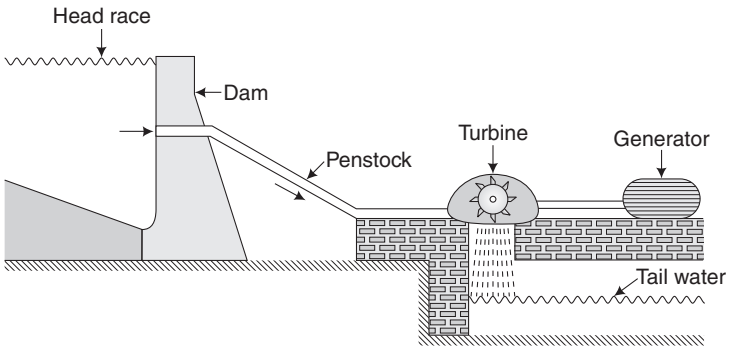

Fig. 2.2 Layout of a hydrostation.

2.3.1 Requirements of a Hydrostation

• **What are the primary requirements of a hydrostation?**

The primary requirements of a hydrostation are:

(a) **Availability:** Adequate quantity of water or discharge.

(b) **Regularity:** Supply of water must be regular and continuous throughout the year.

(c) **Gradient:** Steep gradient or slope to provide high potential energy of water.

2.3.2 Problems in Setting Hydrostations

• **What are the problems associated in setting up a hydrostation?**

The problems associated in setting up hydrostations are:

(a) **Cost:** The cost of construction of dam, reservoir and irrigation canals is very high.

(b) **Submerging:** A large area is submerged while constructing a dam or reservoir. Thousands of people are to be displaced from the areas which get submerged.

(c) **Deposition:** Silt gets deposited in the reservoir with time and this reduces storage capacity of the reservoir. Desilting is necessitated from time to time which involves huge expenditure.

(d) **Risk:** Any damage to the dam due to any natural calamity can lead to a high risk to areas located at the downstream of the dam.

2.3.3 Site Selection for a Hydrostation

What are criteria considered while selecting the site for hydrosta-tion:

The criteria considered during site selection are:

(a) **Head of water:** It determines the power which can be generated. A high head is essential for hydrostations.

(b) **Size of reservoir:** The storage requirement of a reservoir and area available for its construction as per the topography of the site.

(c) **Type of soil:** Loose soil is not preferred from the stability point of view of the dam.

(d) **Accessibility of site:** Heavy machinery and materials are to be taken to the site which require road or nearby rail link to the site.

(e) **Distance from load centre:** Power transmission for long distance is costly.

2.3.4 Merits and Demerits of a Hydrostation

The merits of a hydrostation are:

(a) It is a clean and pollution-free means of power generation.

(b) It has low running cost.

(c) It requires lesser number of manpower to operate.

(d) It can meet varying load requirements.

(e) It does not require any inputs such as costly fuel.

(c) Impulse turbine with tangential flow
(d) None of these

3. The flow of water in a Peloton turbine is:
   (a) Axial (b) Radial
   (c) Tangential (d) None of these
4. The flow of water in a Kaplan turbine is:
   (a) Axial (b) Radial
   (c) Tangential (d) None of these
5. Hydrostations are located where we have:
   (a) Adequate quantity of water (b) Regularity of supply
   (c) A steep gradient (d) All the above
6. Pipelines to take water from reservoir to turbine are called
   (a) Head race (b) Draft tube
   (c) Tail race (d) Penstock

FILL IN THE BLANKS

1. Cost of construction of a dam, reservoir or irrigation system is _____ .
2. Large land is _____ while making reservoir.
3. Turbines are coupled with _____ to produce electricity.
4. Pipeline to discharge water from a reservoir to a turbine is called _____ .
5. Running cost of a hydrostation is very _____ .

ANSWERS

State True or False:

1. True	2. False	3. True	4. True
5. True	6. True	7. True	8. False
9. False	10. True	11. True	

Multiple Choice Questions:

1. (a)	2. (b)	3. (c)	4. (a)
5. (d)	6. (d)		

Fill in the Blanks:

1. High	2. Submerged	3. generator
4. penstock	5. low.	