7th lecture

Hydro-electric Power Station

Constituents of Hydro-electric Plant

The constituents of a hydro-electric plant are

(1) hydraulic structures

(2) water turbines and

(3) electrical equipment.

We shall discuss these items in turn.

2. Water turbines.

Water turbines are used to convert the energy of falling water into mechanical energy. The principal types of water turbines are :

(*i*) Impulse turbines **(*ii*)** Reaction turbines

(*i*) *Impulse turbines*. Such turbines are used for high heads. In an impulse turbine, the entire pressure of water is converted into kinetic energy in a nozzle and the velocity of the jet drives the wheel. The example of this type of turbine is the Pelton wheel (See Fig. 2.4).

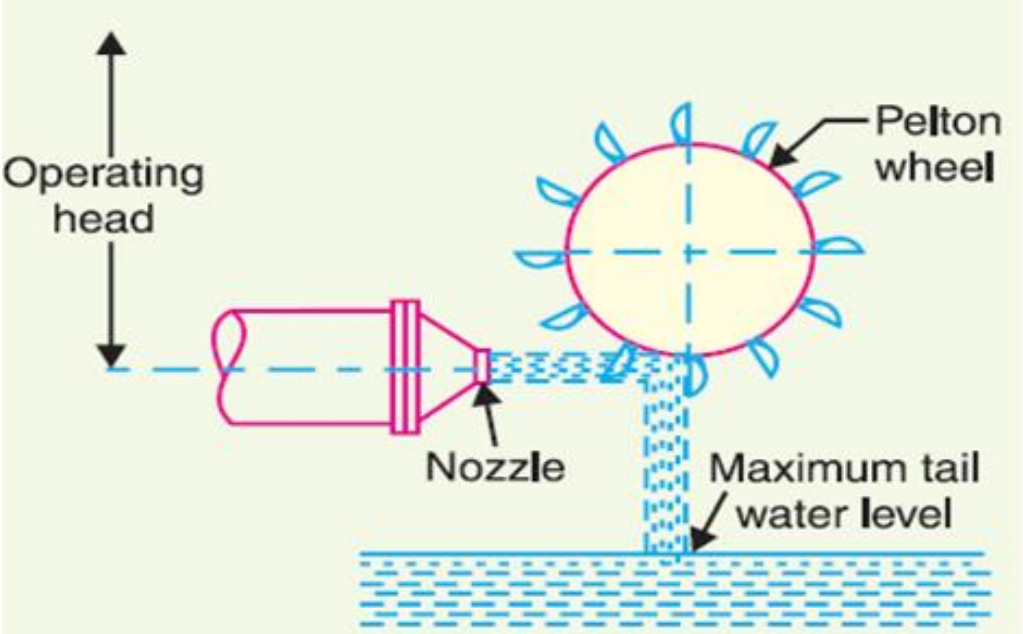

Fig. 2.4 Pelton Wheel

It consists of a wheel fitted with elliptical buckets along its periphery. The force of water jet striking the buckets on the wheel drives the turbine. The quantity of water jet falling on the turbine is controlled by means of a *needle* or *spear* (not shown in the figure) placed in the tip of the nozzle. The movement of the needle is controlled by the governor. If the load on the turbine decreases, the governor pushes the needle into the nozzle, thereby reducing the quantity of water striking the buckets. Reverse action takes place if the load on the turbine increases.

(*ii*) *Reaction turbines*. Reaction turbines are used for low and medium heads. In a reaction turbine, water enters the runner partly with pressure energy and partly with velocity head. The important types of reaction turbines are :

(*a*) Francis turbines

(*b*) Kaplan turbines

A Francis turbine is used for low to medium heads. It consists of an outer ring of stationary guide blades fixed to the turbine casing and an inner ring of rotating blades forming

the runner. The guide blades control the flow of water to the turbine. Water flows radially inwards and changes to a downward direction while passing through the runner. As the water passes over the "rotating blades" of the runner, both pressure and velocity of water are reduced. This causes a reaction force which drives the turbine. A Kaplan turbine is used for low heads and large quantities of water. It is similar to Francis turbine except that the runner of Kaplan turbine receives water axially. Water flows radially inwards through regulating gates all around the sides, changing direction in the runner to axial flow. This causes a reaction force which drives the turbine.

3. Electrical equipment.

The electrical equipment of a hydro-electric power station includes alternators, transformers, circuit breakers and other switching and protective devices.

Example 1.

A hydro-electric generating station is supplied from a reservoir of capacity 5×10^6 cubic metres at a head of 200 metres. Find the total energy available in kWh if the overall efficiency is 75%.

Example 2.

It has been estimated that a minimum run off of approximately 94 m^3/sec will be available at a hydraulic project with a head of 39 m. Determine (i) firm capacity (ii) yearly gross output. Assume the efficiency of the plant to be 80%.

Example 3.

Water for a hydro-electric station is obtained from a reservoir with a head of 100 metres. Calculate the electrical energy generated per hour per cubic metre of water if the hydraulic efficiency be 0·86 and electrical efficiency 0·92

Example 4.

Calculate the average power in kW that can be generated in a hydro-electric project from the following data

Catchment area = 5×10^9 m^2 ; Mean head, H = 30 m

Annual rainfall, F = 1·25 m ; Yield factor, K = 80 %

Overall efficiency, $\eta_{overall}$ = 70 %

If the load factor is 40% , what is the rating of generators installed ?

Example 5.

A hydro-electric power station has a reservoir of area 2·4 square kilometres and capacity 5×10^6 m^3. The effective head of water is 100 metres. The penstock, turbine and generation efficiencies are respectively 95%, 90% and 85%.

(*i*) *Calculate the total electrical energy that can be generated from the power station.*

(*ii*) *If a load of 15,000 kW has been supplied for 3 hours, find the fall in reservoir level.*