Heads

(**a) Gross Head:** Gross or total head is the difference between the headrace level and the tail race level when there is no flow.

(**b) Net Head:** Net head or the effective head is the head available at the turbine inlet. This is less than the gross head, by an amount, equal to the friction losses occurring in the flow passage, from the reservoir to the turbine inlet.

Losses

Various types of losses in Hydroelectric power plant are given below:

(a) Head loss in the penstock: This is the friction loss in the pipe of a penstock.

(b) Head loss in the nozzle: In case of impulse turbines, there is head loss due to nozzle friction.

(c) Hydraulic losses: In case of impulse turbines, these losses occur due to blade friction, eddy formation and kinetic energy of the leaving water.

In a reaction turbine, apart from above losses, losses due to friction in the draft tube and disc friction also occur.

d) Leakage losses: In case of impulse turbines, whole of the water may not be striking the buckets and therefore some of the water power may go waste.

In a reaction turbine, some of the water may be passing through the clearance between the casing and the runner without striking the blades and thus not doing any work. These losses are called leakage losses.

(e) Mechanical losses: The power produced by the runner is not available as useful work of the shaft because some power may be lost in bearing friction as mechanical losses.

f) Generator losses: Due to generator loss, power produced by the generator is still lesser than the power obtained at the shaft output.

Net Head

$$H = H_g - H_f$$

H_g = Gross head

$H_f = Head\ loss\ due\ to\ friction$

$$h_f = \frac{4 \times f \times L \times V^2}{D \times 2g},$$

V = Velocity of flow in penstock,

L = Length of penstock,

D = Diameter of penstock.

Efficiencies

(a) Hydraulic efficiency : It is the ratio of the power delivered to the runner to the power supplied by water at the inlet of turbine .

$$\eta_h = \frac{\text{power delivered to the runner}}{\text{power supplied at the inlet}}$$

$$= \frac{RP}{WP} = \frac{\text{runner } power}{water\ power}$$

$$= \frac{\text{power given by water to the runner}}{\text{power supplied by water at the inlet of turbine}}$$

R.P. = Power delivered to runner

$$= \frac{W}{g}\frac{\left[V_{w_1} \pm V_{w_2}\right] \times u}{1000} \text{ kW} \quad \text{Pelton Turbine}$$

$$= \frac{W}{g}\frac{\left[V_{w_1} u_1 \pm V_{w_2} u_2\right]}{1000} \text{ kW} \quad \text{radial flow turbine}$$

W.P. = Power supplied at inlet of turbine

$$= \frac{W \times H}{1000} \text{ kW}$$

W = Weight of water striking the vanes of the turbine per second

$= \rho g \times Q$ in which Q = Volume of water/s,

V_{w_1} = Velocity of whirl at inlet,

V_{w_2} = Velocity of whirl at outlet,

u = Tangential velocity of vane,

u_1 = Tangential velocity of vane at inlet for radial vane,

u_2 = Tangential velocity of vane at outlet for radial vane,

H = Net head on the turbine.

(b) Mechanical efficiency : The ratio of the shaft output to the runner output is called the mechanical efficiency

$$\eta_h = \frac{\text{power available at the shaft of turbine}}{\text{power given by water to the runner}}$$

$$= \frac{SP}{RP} = \frac{\text{shaft}\ power}{Runner\ \ power}$$

(c) Volumetric efficiency: It is the ratio of the actual volume of water striking the runner to the volume of water supplied to the turbine

$$\eta_v = \frac{\text{actual volume of water striking the runner}}{\text{volume of water supplied to the turbine}}$$

$$= \frac{Q_a}{Q}$$

(d) Overall efficiency: Ratio of shaft output to the net power available at the turbine inlet gives overall efficiency of the turbine

$$\eta_o = \frac{\text{power available at the shaft of turbine}}{\text{power given by water at the inlet of turbine}}$$

$$= \frac{SP}{WP} = \frac{\text{shaft } power}{Water \ \ power}$$

$$= \frac{SP}{WP} \text{ x } \frac{RP}{RP} = \frac{SP}{RP} \text{ x } \frac{RP}{WP}$$

$\eta_o = \eta_m$ x η_h = η_m x η_h x η_g

η_g = efficiency of generator