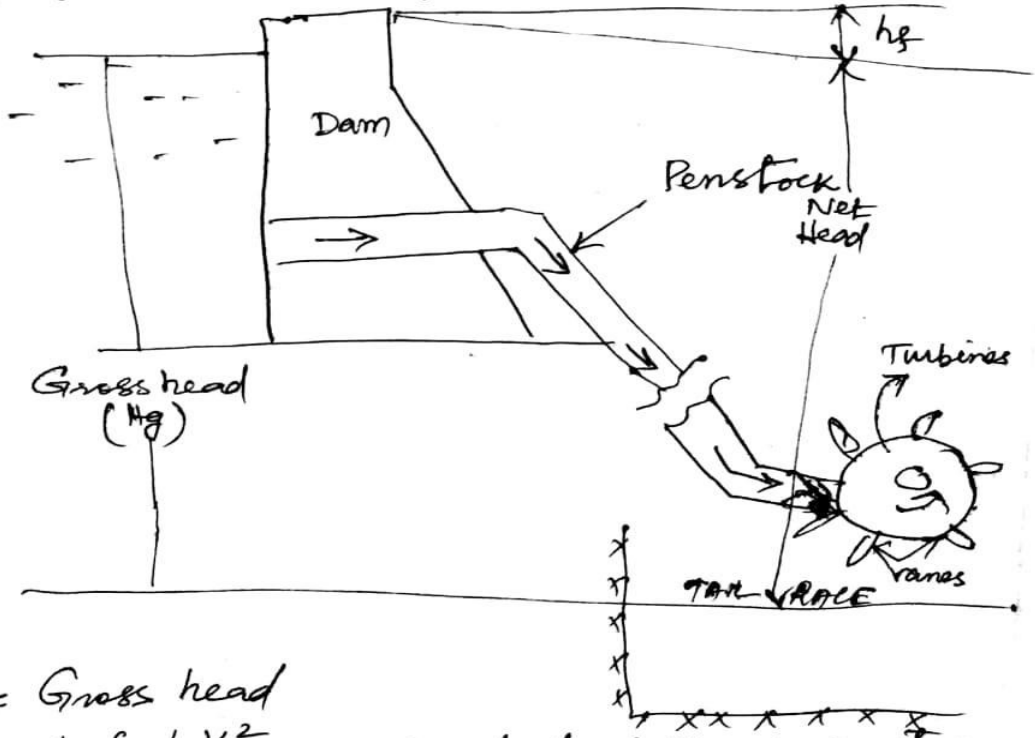
Definitions of Heads and Efficiencies of A Turbine:

1. **Gross Head:**
The difference between the head race level and tail race level when no water is flowing is known as Gross head. It is denoted by Hg

2. **Net Head:**
It is also called effective head and is defined as the head available at the inlet of the turbine $H = Hg - hf$



Hg = Gross head

$hf = \frac{4 f L V^2}{D 2g}$

V – Velocity of flow in penstock
L – Length of penstock
D – Diameter of penstock.

Efficiencies

(i) $\eta_h = \dfrac{\text{Power delivered to runner}}{\text{Power supplied at inlet}} = \dfrac{RP}{W.P} = \dfrac{\text{Runner power}}{\text{(water power)}}$

$WP = \dfrac{1000 \times g \times Q \times H}{1000} = g.Q.H \text{ KW}$

(ii) $\eta_m = \dfrac{\text{Power at the shaft of the turbine}}{\text{power delivered by water to the runner}} = \dfrac{SP}{RP}$

(iii) $\eta_r = \dfrac{\text{Volume of water actually striking the runner}}{\text{Volume of water supplied to the turbine.}}$

(iv) $\eta_o = \dfrac{\text{Volume available at the shaft of the turbine}}{\text{Power supplied at the inlet of the turbine}}$

$\eta_o = \dfrac{\text{Shaft power}}{\text{water power}}$

$\eta_o = \dfrac{\text{Shaft power in KW}}{\text{water power in KW}} = \dfrac{P\ (\text{Shaft Power})}{\left(\dfrac{\rho.g.Q.H}{1000}\right)}$

Turbine	Pump
1. Turbine Converts hydraulic energy into mechanical energy	Pump Converts mechanical energy into hydraulic energy
2. It is a Energy Prodng m/c	It is energy absorbing m/c
3. Flow takes place from high Pressure side to the low-Pressure side	Flow takes place from low-Pressure side to the high-Pressure side
4. Flow is decelerated	Flow is accelerated.

ALSO

Heads

EFFECTIVE HEAD (Net Head)

The effective head is the net head available to the turbine unit for power production.

This head is the static gross head, the difference between the level of water in the Forebay/impoundment and the tailrace water level at the outlet, less the hydraulic losses of the water passage as shown in Figure.

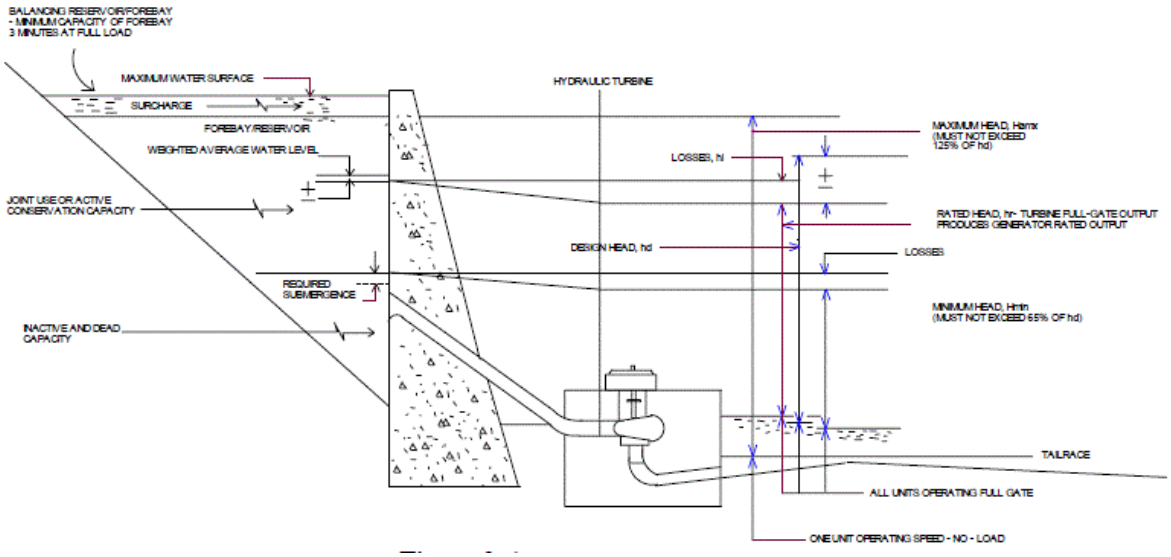
The effective head must be used for all power calculations.

The hydraulic losses can vary from essentially zero for flume-type turbine installations to amounts so significant for undersized outlet conduit that the energy potential of the site is seriously restricted.

The hydraulic losses in closed conduit can be calculated using the principles set out in general hydraulic textbooks. In addition to conduit losses, an allowance for a loss through the intake structure should also be included.

In general a hydraulic loss of one velocity head (velocity squared divided by 2 x acceleration due to gravity) or greater would not be uncommon.

The hydraulic losses through the turbine and draft tube are accounted for in the turbine efficiency.



Gross Head (Hg) – is the difference in elevation between the water levels of the forebay and the tailrace.

Maximum Head (Hmax.) – is the gross head difference in elevation between the maximum forebay (head water) level without surcharge and the tailrace level without spillway discharge, and with one unit operating at speed no-load (turbine discharge of approximately 5% of rated flow). Under this condition, hydraulic losses are negligible and may be disregarded.

Minimum Head (Hmin.) – is the net head resulting from the difference in elevation between the minimum forebay (head water) level and the tailrace level minus losses with all turbines operating at full specified gate opening.

HEADS FOR VAROUS TURBINES

Type of turbine	Maximum head (percent h_d)	Minimum head (percent h_d)
Francis	125	65
Propeller – fixed blade turbine	110	90
Kaplan – Adjustable blade propeller turbine	125	65

Weighted Average Head - is the net head determined from reservoir operation calculations which will produce the same amount of energy in kilowatt-hours between that head and maximum head as is developed between that same head and minimum head.

Design Head (hd) – is the net head at which peak efficiency is desired. This head should preferably approximate the weighted average head, but must be so selected that the maximum and minimum heads are not beyond the permissible operating range of the turbine. This is the head which determines the basic dimensions of the turbine and therefore of the power plant.

Explain (i) Hydraulic efficiency (ii) Mechanical efficiency (iii) Overall efficiency of turbines.

Ans. (i) Hydraulic Efficiency-It is the ratio of work done on the wheel to the head of rater (or energy) actually supplied to the turbine i.e.

$$\eta_h = \frac{\text{work done per kN of water}}{H}$$

(ii) Mechanical Efficiency—it is the ratio of actual work available at the turbine to e energy imparted to the wheel.

(iii) Overall Efficiency—it is a measure f the performance of a turbine and is the 120 of power produced by the turbine to the energy actually supplied to the turbine.