LECTURE NOTES – III

« HYDROELECTRIC POWER PLANTS »

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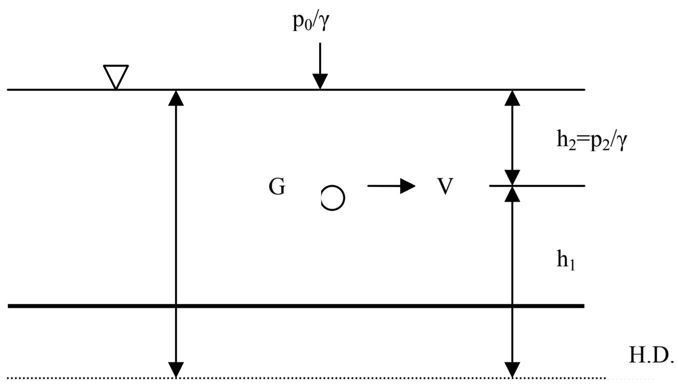
CHAPTER 3

Power in Flowing Water

Power is the proportion of performed work in unit time. N = Power, E = Energy,

$$N = \frac{dE}{dt}$$



The total energy of any water particle of weight G, under pressure p, and moving at a velocity V, at an elevation h_1 above a horizontal datum is, according to Bernoulli theorem,

$$E = G\left(h_1 + \frac{V^2}{2g} + \frac{p}{\gamma}\right) \quad \text{(kgm, Nm, Joule)}$$

With the substitution,

$$\frac{p}{\gamma} = \frac{p_0}{\gamma} + h_2$$

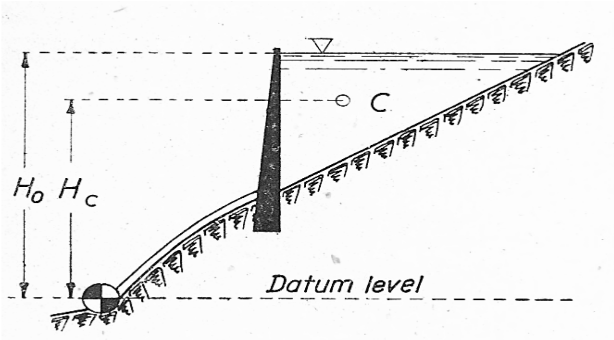
$$E = G\left(h + \frac{V^2}{2g} + \frac{p_0}{\gamma}\right)$$

Working with gage pressure,

$$E = G\left(h + \frac{V^2}{2g}\right)$$

Total mechanical energy of any water mass of 1 kg in weight amounts to,

$$h + \frac{V^2}{2g} \text{ (m)}$$



The total potential energy of the volume of water V stored in the reservoir is,

$$E = \gamma V H_0$$

While it's inherent energy is,

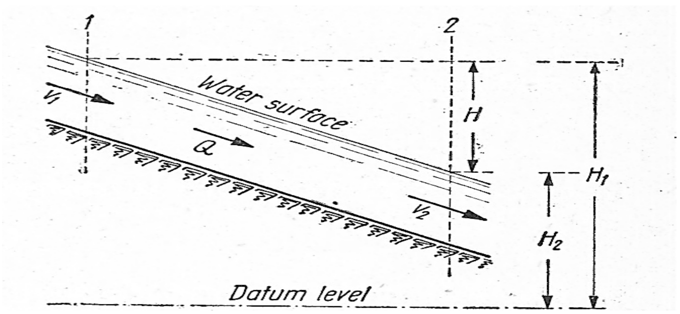
$$E_i = \gamma V H_C$$

H_C = the height of the center of gravity of the volume of stored water above the chosen datum.

The energy consumed in emptying the reservoir is exactly equal to inherent energy of the entire mass as imagined to be in the center of gravity. The total energy of water discharging from the reservoir is subject to constant change and equals the inherent energy pertaining to the momentary water surface. Accordingly, the work performed during emptying the reservoir is not the sum of the total energy of water particles stored in the full reservoir, but is the inherent potential energy of the water mass.

If the surface of water in the reservoir is kept constant level by balanced inflow and outflow, both total energy and inherent energy in any volume of effluent water of weight G are equal for any arbitrary time.

$$E_i = E = \gamma V H_0 = G H_0 \text{ (kgm, Nm, Joule)}$$



If the discharge at a velocity V_1 through any section of a stream amounts to Q (m^3/sec), the power of the flowing mass per second, with reference to any datum at a depth H_1 below the surface,

$$\frac{dE_1}{dt} = \gamma Q\left(H_1 + \frac{V_1^2}{2g}\right) \quad \text{(kgm/sec, watt)}$$

The energy per second of the body of water flowing through section 2 located downstream from section 1 and having a height of water level H_2 above the datum is,

$$\frac{dE_2}{dt} = \gamma Q\left(H_2 + \frac{V_2^2}{2g}\right)$$

Accordingly, with any discharge Q flowing steadily between constant levels by a difference in elevation $H = H_1 - H_2$, the energy dissipated in section 1-2 in every second,

$$\gamma Q\left(H_1 + \frac{V_1^2}{2g}\right) - \gamma Q\left(H_2 + \frac{V_2^2}{2g}\right) = \gamma Q\left(H + \frac{V_1^2 - V_2^2}{2g}\right)$$

The overall potential power for the considered stretch is,

$$N_p = \gamma Q\left(H + \frac{V_1^2 - V_2^2}{2g}\right) \quad \text{(kgm/sec, watt)}$$

The portion of power that originates from changes in velocity is generally negligible as against the potential power from the differences in elevation.

The theoretical potential power in any river stretch with a difference in elevation H is,

$$N_p = \gamma QH \quad \text{(kgm/sec, watt)}$$