Design of pelton wheel

Following data is to be determined

(i) Diameter of the Jet (d)

(ii) Diameter of the wheel (D)

(iii) width of the buckets which is 5×d

(iv) depth of the buckets which is 1.2×d

(v) Number of buckets on the wheel

Size of buckets means the width and depth of the buckets.

A pelton wheel has a mean bucket speed of 10 metres per second with a jet of water flowing at the rate of 700 litres/second under a head of 30 metres. The bucket deflect the Jet through an angle of 160°. Calculate the power given by water to the runner and the hydraulic efficiency of the turbine. Assume co-efficient of velocity as 0.98

Given:

Speed of bucket $u = u_1 = 10\ m/s$

Discharge $Q = 700$ litres/s $= 0.7\ m^3/s$

Head of water $H = 30m$

Angle of deflection $= 160°$

$\therefore$ Angle $\phi = 180° - 160° = 20°$

Co efficient of velocity $C_v = 0.98$

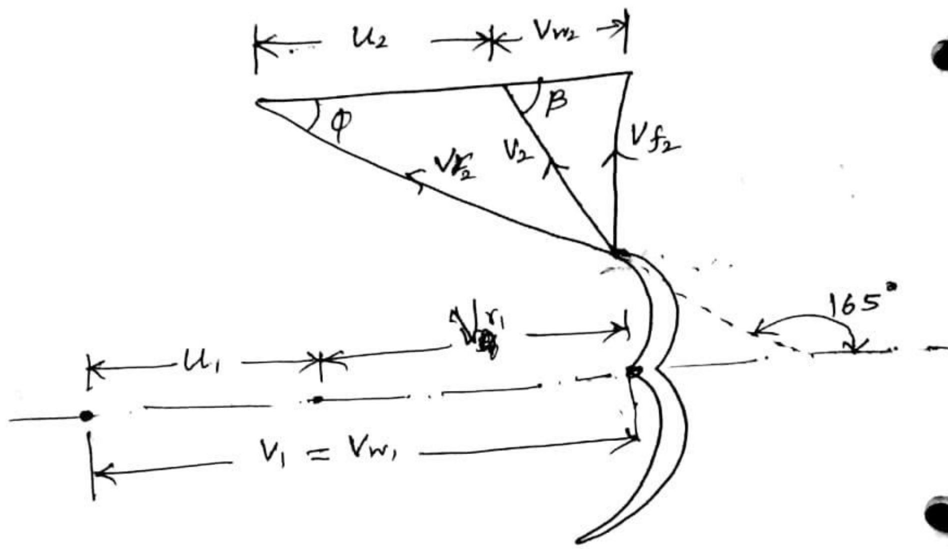
The velocity of Jet $V_1 = C_v \sqrt{2gH} = 0.98\sqrt{2 \times 9.81 \times 30}$

$$V_1 = 23.77 \text{ m/s}$$

$$V_{r_1} = V_1 - u_1 = 23.77 - 10$$

$$V_{r_1} = 13.77 \text{ m/s}$$

$$V_{w_1} = V_1 = 23.77 \text{ m/s}$$



From outlet velocity triangle

$$V_{r_2} = V_{r_1} = 13.77 \text{ m/s}$$

$$V_{w_2} = V_{r_2}\cos\phi - u_2 = 13.77\cos 20° - 10$$

$$V_{w_2} = 2.49 \text{ m/s}$$

work done by the jet per second on the runner is given by equation $= \rho a V_1 [V_{w_1} + V_{w_2}] \times u$

$$= 1000 \times 0.7 \times [23.77 + 2.94] \times 10$$

$$[\because aV_1 = Q = 0.7 \text{ m}^3/\text{s}]$$

$$= 186970 \text{ Nm/s}$$

Power given to turbine $= \frac{186970}{1000} \frac{Nm}{s} = J/s = W \rightarrow KW.$

$= 186.97\ KW$

The hydraulic efficiency of the turbine is given by equation $\eta_h = \frac{2(V_{w_1} + V_{w_2}) \times u}{V_1^2}$

$$= \frac{2[23.77 + 2.94] \times 10}{23.77 \times 23.77}$$

$$\eta_h = 0.9454$$

$$\boxed{\eta_h = 94.54\%}$$

(2) A pelton wheel is to be designed for the following specifications:

Shaft power = 11.772 KW
Head = 380 metres
Speed = 750 rpm
$\eta_0 = 86\%$

Jet diameter is not to exceed one sixth of the wheel diameter, Determine.

(i) The wheel diameter (ii) The number of Jets required
(iii) Diameter of Jet.

Take $K_{v_1} = 0.985$ and $K_{u_1} = 0.45$.

Given Data

Shaft Power $S_p = 11.772$ KW

Head $H = 380m$

Speed $N = 750$ rpm

Overall efficiency $\eta_0 = 86\%$ or 0.86

Ratio of Jet dia to wheel dia $= \frac{d}{D} = \frac{1}{6}$ $d = \frac{1}{6}D$

Co-efficient of velocity $K_{V_1} = C_V = 0.985$

Co efficient of wheel velocity } Speed ratio $K_{u_1} = 0.45$

Velocity of Jet $V_1 = C_V\sqrt{2gH}$

$V_1 = 0.985\sqrt{2\times9.81\times380}$

$V_1 = 85.85$ m/s

The velocity of the wheel $u = u_1 = u_2$

= Speed ratio (or Coefficient of wheel velocity) $\times \sqrt{2gH}$

$= 0.45 \times \sqrt{2\times9.81\times380}$

$= 38.85$ m/s

But $u = \frac{\pi DN}{60}$ $\therefore 38.85 = \frac{\pi DN}{60}$

$D = \frac{60\times38.85}{\pi\times N} = \frac{60\times38.85}{\pi\times750} = 0.989m.$

But ~~Dia of~~ $\frac{d}{D} = \frac{1}{6}$

Dia of Jet $d = \frac{1}{6}\times D = \frac{0.989}{6} = 0.165m$

Discharge of one Jet q = Area of Jet × Velocity of Jet

$= \frac{\pi}{4}d^2\times V_1$

$$= \frac{\pi}{4}(0.165) \times 85.05 \ m^3/s$$

$$\boxed{q = 1.818 \ m^3/s} \quad \text{——— (1)}$$

Now $\eta_o = \frac{SP}{WP} = \frac{11772}{\frac{\rho g \times Q \times H}{1000}}$ $\quad \frac{kg}{m^3} \times \frac{m}{s^2} \times \frac{m^3}{s} \times m = \frac{kg\,m}{s^2} \times \frac{m}{s}$

$$0.86 = \frac{11772 \times 1000}{1000 \times 9.81 \times Q \times 380}$$

where Q = total discharge

$$\therefore \text{Total discharge } Q = \frac{11772 \times 1000}{1000 \times 9.81 \times 380 \times 0.86}$$

$$= 3.672 \ m^3/s$$

$$\therefore \text{Number of Jets} = \frac{\text{Total discharge}}{\text{Discharge of one Jet}}$$

$$= \frac{Q}{q}$$

$$= \frac{3.672}{1.818}$$

$$\boxed{\text{Number of Jets} = 2 \text{ Jets}}$$