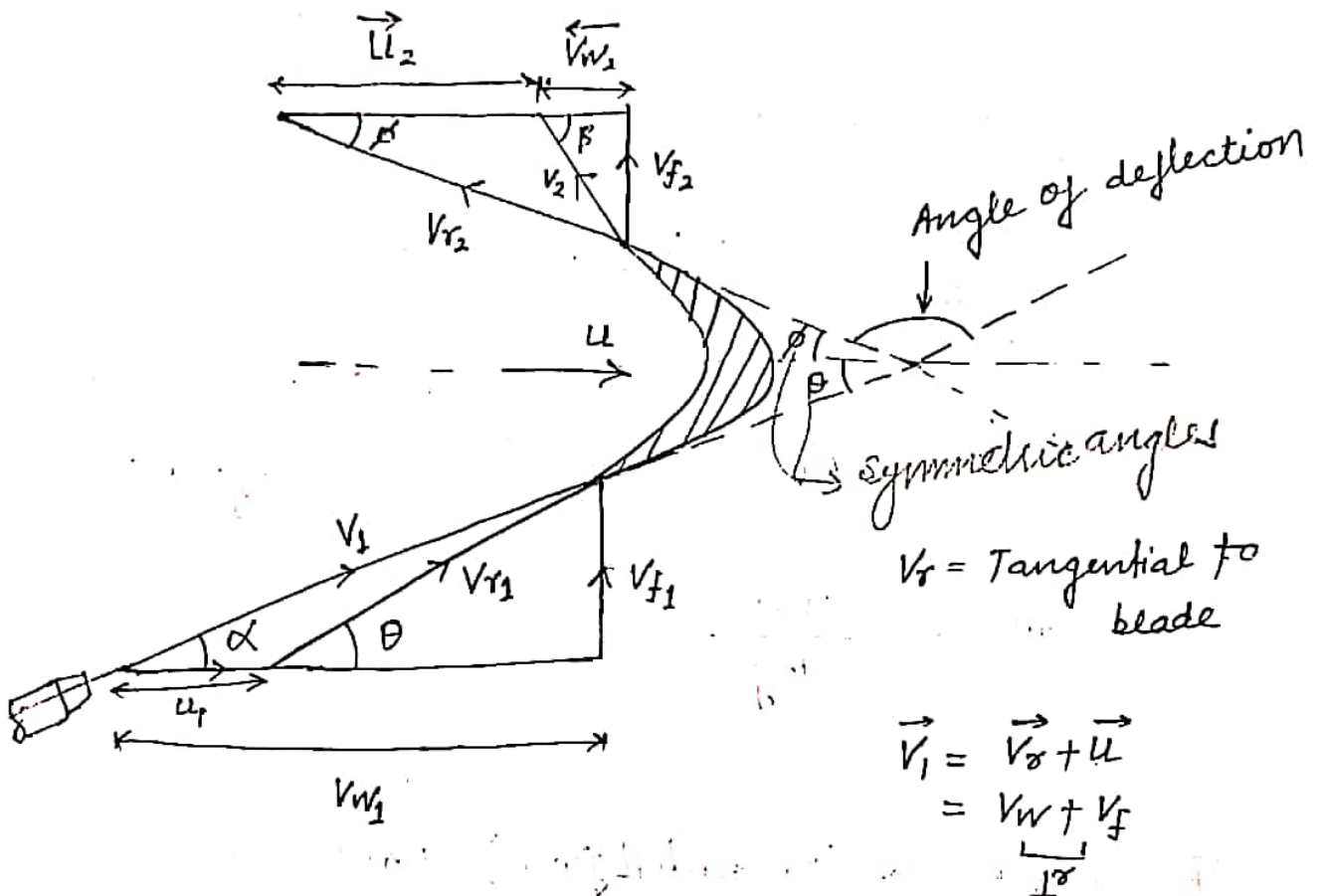


[TURBINE]

convert pressure en. into mechanical en.
(in the form of rotation of runner)



α = nozzle angle (OR) guide vane angle (OR) absolute velocity angle at inlet (OR) fixed blade outlet angle

β = diffuser angle

θ & ϕ = blade angle (OR) vane-angle

$$F_x = (\rho a V_{r1}) [V_{w1} + V_{w2}] \quad \left[\text{when } \beta \text{ is acute angle} \right]$$

→ 2.11.17 को 1.4

$$F_x = (\rho a V_{r1}) [V_{w1}] \quad \left[\text{when } \beta = 90^\circ \right]$$

$$F_x = (\rho a V_{r1}) [V_{w1} - V_{w2}] \quad \left[\text{when } \beta \text{ is obtuse angle} \right]$$

→ 2.11.17 को 1.4

$$\boxed{\text{W.D.} = F_x \times U}$$

$$\frac{\text{W.D.}}{\rho a U} = (\rho a V_{r1}) [V_{w1} \pm V_{w2}] \times U$$

$$\eta = \frac{\text{W.D.}}{\text{K.E.}} = \frac{(\rho a V_{r1}) [V_{w1} \pm V_{w2}] \times U}{\frac{1}{2} (\rho a V_{r1}) V_1^2}$$

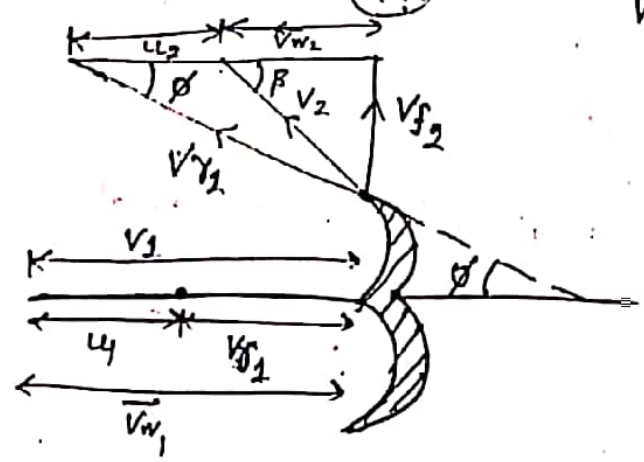
$$\text{W.D. / wt.} = \frac{\text{W.D.}}{mg}$$

PELTON WHEEL → (Tangential flow) L.A. PELTON

$$\boxed{V_{r2} = K V_{r1}} \quad (K < 1)$$

$$u_1 = u_2 = \frac{\pi D N}{60}$$

$$V_{r2} = K V_{r1}$$



$\alpha = 0$
 $\theta = 0$

- For slow speed runner — $\beta = \text{acute angle}$
- Medium " — $\beta = 90^\circ$ ($V_2 = V_{f2}$) ($V_{w2} = 0$)
- High — $\beta = \text{obtuse angle}$

$$F = (\rho a v_1) (v_{w1} + v_{w2})$$

W.D. per second = power = $F \times U$

Blade efficiency (η_b) = $\frac{\text{power developed by blade}}{\text{power given to blade}}$



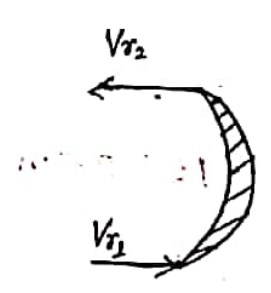
$$\eta_b = \frac{(\rho a v_1) (v_{w1} + v_{w2}) \cdot U}{\frac{1}{2} \dot{m} v_1^2}$$

$\dot{m} = (\rho a v_1)$

$$U = \frac{v_1}{2}$$

$$\eta_b = \frac{1 + K \cos \phi}{2}$$

for best design of bucket the blade should be smooth $K=1$ if $\phi=0$



$$\eta_b = \frac{1+1}{2} = 100\%$$

Hydraulic eff. \rightarrow

$$\eta_H = \frac{\text{O.P.}}{\text{W.P.}} = \frac{(\rho a v_1) (v_{w1} + v_{w2}) \times U}{\rho g Q H}$$

Mechanical eff \rightarrow

$$\eta_m = \frac{\text{S.P.}}{\text{O.P.}} = \frac{P}{(\rho a v_1) (v_{w1} + v_{w2}) \times U}$$

Overall eff. \rightarrow

$$\eta_o = \frac{\text{S.P.}}{\text{W.P.}} = \frac{P}{\rho g Q H}$$

$$\boxed{\eta_o = \eta_H \times \eta_m \times \eta_w}$$

$$\text{Head loss in nozzle} = \frac{V_1^2}{2g} = \frac{V_1^2}{2g}$$

$$V_1 = C_v V_{th}$$

$$= \frac{V_1^2}{2g} \left[\frac{1}{C_v^2} - 1 \right]$$

$$\text{Jet Ratio (m)} = \frac{\text{dia of wheel}}{\text{jet dia}}$$

$$\text{No. of buckets} = 15 + \frac{D}{2d} = 15 + 0.5 m$$

$$\text{blade to jet speed ratio} = \frac{u}{V_j}$$

$$U = \frac{\pi D N}{60} \quad \text{conceal dia.}$$

$\frac{\pi}{4} d^2$ Jet dia

specific speed \rightarrow (Ns)

$$\eta_0 = \frac{\text{S.P.}}{\text{W.P.}} = \frac{P}{\frac{\rho g Q H}{1000}}$$

$$P = \eta_0 \times \frac{\rho g Q H}{1000}$$

$$\boxed{P \propto Q H} \quad \left\{ \eta_0 \text{ \& } \rho \text{ are const.} \right\}$$

$$U = \frac{\pi D N}{60}$$

$$U \propto \sqrt{H}$$

$$U \propto D N$$

$$\sqrt{H} \propto D N$$

$$D \propto \frac{\sqrt{H}}{N}$$

$$Q = \text{Area} \times \text{velocity}$$

$$Q = (\pi B D) \times \sqrt{2gH}$$

$$Q \propto B D \times H^{1/2}$$

$$B = D$$

$$Q \propto D^2 H^{1/2}$$

$$Q \propto \left(\frac{H}{N}\right)^3 \times H$$

$$Q \propto \frac{H^{3/2}}{N^2}$$

$$P \propto Q H$$

$$P \propto \frac{H^{3/2}}{N^2} \cdot H$$

$$P \propto \frac{H^{5/2}}{N^2}$$

$$P = K \frac{H^{5/2}}{N^2} \quad \left[\text{where } K \text{ is const} \right]$$

if $P=1$, $H=1$, the speed $N =$ specific speed N_s

$$1 = K \times \frac{1^{5/2}}{N_s^2}$$

$$N_s^2 = K$$

$$P = N_s^2 \frac{H^{5/2}}{N^2}$$

$$N_s^2 = N^2 \frac{P}{H^{5/2}}$$

$$N_s = N \frac{\sqrt{P}}{H^{5/4}}$$

$$Q = \text{Area} \times \text{Velocity} = A \times V_1$$

Unit Quantities \rightarrow Turbine working under unit head

$$N_u = \frac{N}{\sqrt{H}}$$

$$Q_u = \frac{Q}{\sqrt{H}}$$

$$P_u = \frac{P}{H^{3/2}}$$

These formula used when dia is not given

Model \rightarrow

$$\frac{H}{N^2 D^2} = C$$

$$\frac{D_m}{D_p} = D_r$$

$$\frac{Q}{ND^3} = C$$

$$\frac{P}{N^3 D^5} = C$$

FRANCIS TURBINE \rightarrow Mixed flow

degree of R^m !

$$R = \frac{\text{change in pressure en. inside the runner}}{\text{change of total en. inside the runner}}$$

$$= \frac{\text{contribution of moving part}}{\text{Total energy}}$$

$$= \frac{T.E. - K.E.}{T.E.}$$

$$R = 1 - \frac{K \cdot E}{T \cdot E}$$

$$R = 1 - \frac{(V_1^2 - V_2^2)}{(V_1^2 - V_2^2) + (U_1^2 - U_2^2) + (V_{r2}^2 - V_{r1}^2)}$$

$$R = 1 - \frac{\cot \alpha}{2 (\cot \alpha - \cot \theta)}$$

for pelton wheel

$$U_1 = U_2$$

$$V_{r1} = V_{r2}$$

$$R = 1 - \frac{(V_1^2 - V_2^2)}{(V_1^2 - V_2^2) + 0 + 0}$$

$$R = 0$$

$$\text{Head } (H) = \frac{w \cdot D / \text{sec}}{wt}$$

$$H = \frac{(\cancel{\rho a V_1}) (V_{w1} + V_{w2}) U}{(\cancel{\rho a V_1}) g}$$

$$H = \frac{1}{g} (V_{w1} + V_{w2}) U$$

Speed Ratio $\phi = \frac{U_1}{\sqrt{2gH}} = 0.6 \text{ to } 0.9$

flow ratio

$$K_f = \frac{V_{f1}}{\sqrt{2gH}}$$

(0.15 to 0.3)

$Q = \text{Area} \times \text{velocity of flow}$

$$Q = \pi D_1 B_1 \times V_{f1}$$

or
 V_{radial}

$$Q = K_f \pi D_1 B_1 V_{f1}$$

$K_f = \frac{\text{blade thickness factor (or) blade thickness coefficient}}{\text{blade thickness coefficient}}$

$$Q = \frac{(\pi D_1 B_1 - \eta f B_1) V_{f1}}{\text{Area}}$$

$\eta = \text{no. of blades}$

KAPLAN TURBINE \rightarrow Axial flow { Vanes on the hub are adjustable }

Propeller turbine \rightarrow similar to Kaplan but vanes are fixed on hub.

$$A = \frac{\pi}{4} (D_o^2 - D_b^2)$$

$$Q = A \times V_f$$

$$\begin{array}{l} u_1 = u_2 = u \\ V_{f1} = V_{f2} = V_f \end{array}$$