

Fluid Machinery & Steam Generator

Francis turbine

- Area of flow $A_{f1} = K \pi d_1 b_1$
- Discharge through the runner $Q = A_{f1} V_{f1}$
- Hydraulic power $[HP = \rho g Q H]_{\text{hy}}$
- Runner power when v_{w1} is in direction of u_1
 $R.P = \frac{\rho g Q}{\rho} [v_{w1} u_1 - v_{w2} u_2]$
- Runner power when v_{w1} is in opposite direction of u_2
 $R.P = \frac{\rho g Q}{\rho} [v_{w1} u_1 + v_{w2} u_2]$
- Hydraulic efficiency $\eta_h = \frac{R.P}{HP} = \frac{v_{w1} u_1}{gH}$ L-R-L-R
- Mechanical efficiency $\eta_{mech} = \frac{S.P}{R.P}$ M-S-P
- Overall efficiency $\eta_o = \eta_h \times \eta_{mech}$ O-S-L-R
- Volumetric efficiency $\eta_{vol} = \frac{Q}{Q + \Delta Q}$
 where ΔQ = leakage loss
 Q = discharge entering the turbine
- Degree of reaction (R) : $R = 1 - \frac{v_2^2 - v_1^2}{2 v_{w1} u_1}$
- Efficiency of draft tube $\eta_d = \frac{\frac{v_1^2 - v_2^2}{2g}}{\frac{v_1^2 - v_2^2}{2g} + h_f}$
- Pelton wheel**
- Power available at inlet of vanes = $\frac{\rho Q v^2}{2}$
- Runner power $R.P = \frac{\rho g Q}{\rho} [v_{w1} - v_{w2}] u$
- $(\eta_h)_{max} = \frac{1 - k \cos \alpha}{2}$
- Blade efficiency $\eta_{b, max} = \frac{v_1^2 - v_2^2}{v_1^2}$
- Specific speed of Turbine $N_s = \frac{N \sqrt{P}}{H^{5/4}}$

Model relationships for turbine / Cp

Capacity or flow Q rotational speed ω

$$\left[\frac{Q}{ND^3} \right]_1 = \left[\frac{Q}{ND^3} \right]_2 \quad \left[\frac{\omega}{ND^2} \right]_1 = \left[\frac{\omega}{ND^2} \right]_2$$

Power P

$$\left[\frac{P}{N^3 D^5} \right]_1 = \left[\frac{P}{N^3 D^5} \right]_2$$

Brayton cycle or Joule cycle:- [G.M.P.P]

$$\eta = 1 - \frac{1}{(r_p)^{\gamma}}$$

$$T_2 = T_4 = \sqrt{T_{max} \cdot T_{min}}$$

$$(r_p)_{optimum} = \left(\frac{T_{max}}{T_{min}} \right)^{\frac{1}{\gamma-1}}$$

$$(r_p)_{optimum} = \sqrt{(r_p)_{max}} \quad (r_p)_{max} = \left(\frac{T_{max}}{T_{min}} \right)^{\frac{1}{\gamma-1}}$$

$$\text{Back work Ratio} = \frac{W_c}{W_T}$$

$$\text{Work Ratio} = \frac{W_{net}}{W_T} = \frac{W_T - W_c}{W_T} = 1 - \frac{W_c}{W_T}$$

Rankine vapour power cycle (or) steam power cycle

$$\text{Specific steam consumption } SSC = \frac{3600}{W_{net}} \frac{\text{kg}}{\text{kwhr}}$$

$$\eta_{Rankine} = 1 - \frac{Q_{out}}{Q_{in}} = 1 - \frac{T_c}{T_h} = \frac{W_{net}}{Q_c} = \frac{Q_2 - Q_1}{Q_1} = 1 - \frac{Q_2}{Q_1}$$

For regeneration in Rankine cycle

$$W_1 = (1-x)(h_1 - h_f) + (1-y)(h_1 - h_2)$$

$$W_2 = (1-x)(h_1 - h_2) + 1(h_1 - h_3)$$

$$W_{net} = W_1 - W_2$$

$$Q_2 = 1(h_2 - h_3)$$

Applying conservation of energy

Mechanical Engineering Formula

Michael Brown



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Mechanical Engineering American Society of Mechanical Engineers, 1919 History of the American society of mechanical engineers Preliminary report of the committee on Society history issued from time to time beginning with v 30 Feb 1908

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careful 1 hes always talking about himself 4 properly 2 im always spending

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