Velocity diagram for velocity compounded impulse turbine

Total work of velocity compounded impulse turbine is the summation of the work for every row. In the same manner, the total power output is the sum of the power produced from the first and second rows of moving blades, and so on for thrust.

5.9.1. Driving Force:

$$total\ whirl\ velocity = (whirl\ velocity)_{1st\ row} + (whirl\ velocity)_{2nd\ row}$$

$$total\ whirl\ velocity = (V_{w1} + V_{w2})_{1st} + (V_{w3} + V_{w4})_{2nd}$$

$$total\ driving\ force = (driving\ force)_{1st\ row} + (driving\ force)_{2nd\ row}$$

$$total\ driving\ force = m^{o} \times [(V_{w1} + V_{w2})_{1st} + (V_{w3} + V_{w4})_{2nd}]$$

$$total\ Driving\ force = m^{o} \times [(\Delta V_{w})_{1st} + (\Delta V_{w})_{2nd}]$$

$$total\ work = work_{1st\ row} + work_{2nd\ row}$$

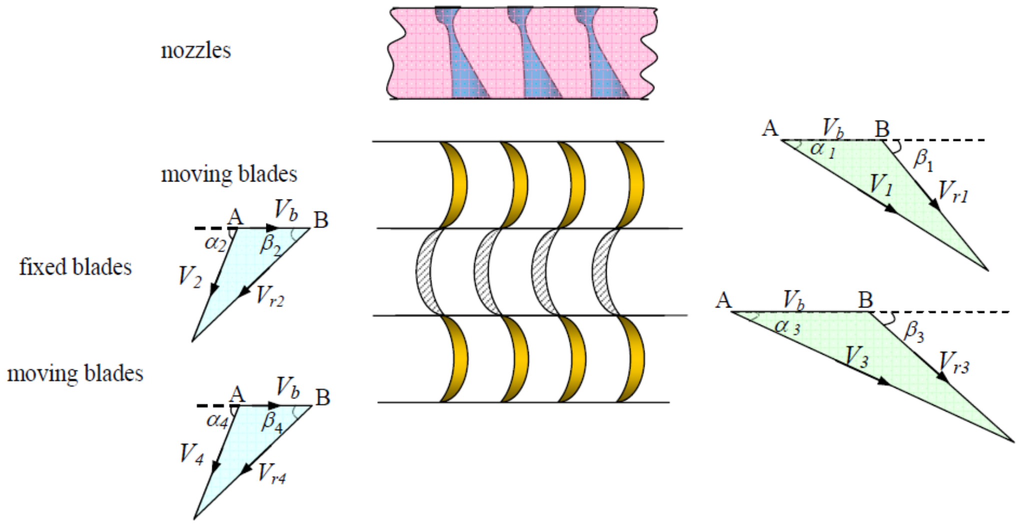

Figure (5.8): velocity triangles for velocity compound impulse turbine.

5.9.2. Power

$$total\ power = power_{1st\ row} + power_{2nd\ row}$$

$$\text{total Power} = W^{o} = m^{o} \times V_{b} \times [(V_{w1} + V_{w2})_{1st} + (V_{w3} + V_{w4})_{2nd}]$$

$$\text{total Power} = W^{o} = m^{o} \times V_{b} \times [(\Delta V_{w})_{1st} + (\Delta V_{w})_{2nd}]$$

5.9.3. Axial Thrust

$$total\ axial\ force\ (thrust) = (thrust)_{1st\ row} + (thrust)_{2nd\ row}$$

$$total\ axial\ force\ (thrust) = m^o \times \left[\left(V_{f2} - V_{f1}\right)_{1st} + \left(V_{f4} - V_{f3}\right)_{2nd}\right]$$

$$total\ thrust\ = m^o \times \left[\left(\Delta V_f\right)_{1st} + \left(\Delta V_f\right)_{2nd}\right]$$

5.9.4. Blades velocity coefficient

$$K_{1st\ row,moving\ blade} = \frac{Vr_2}{V_{r1}}$$

$$K_{fixed\ blade} = \frac{V_3}{V_2}$$

$$K_{2nd\ row,moving\ blade} = \frac{Vr_4}{V_{r3}}$$

5.10. Blade Height

The blade height for impulse and reaction turbine can be calculated with the aid of mass flow rate as follows:

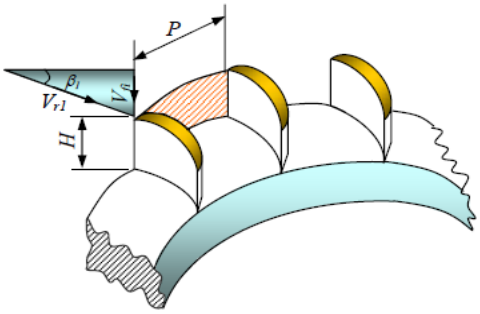

Figure (5.9): Blade height.

$$m^o = \frac{flow\ area \times flow\ velocity}{specific\ volume\ of\ stam\ flow}$$

$$flow\ area = H \times N_{blade} \times P = \pi \times D_{mean} \times H$$

$$flow\ velocity = axial\ component\ of\ flow\ at\ which\ steam\ enters\ the\ blade$$

$$flow\ velocity = V_{f1}$$

$$m^o = \frac{(H \times N_{blade} \times P\ ) \times V_{f1}}{v}$$

$$H = \frac{m^o \times v}{N_{blade} \times P \times V_{f1}}$$

Or,

$$H = \frac{m^o \times v}{\pi \times D_{mean} \times V_{f1}}$$

Where:

H: blade height in m.
N_b: number of blades.
P: pitch of blade in m.
D_{mean}: mean diameter in m.

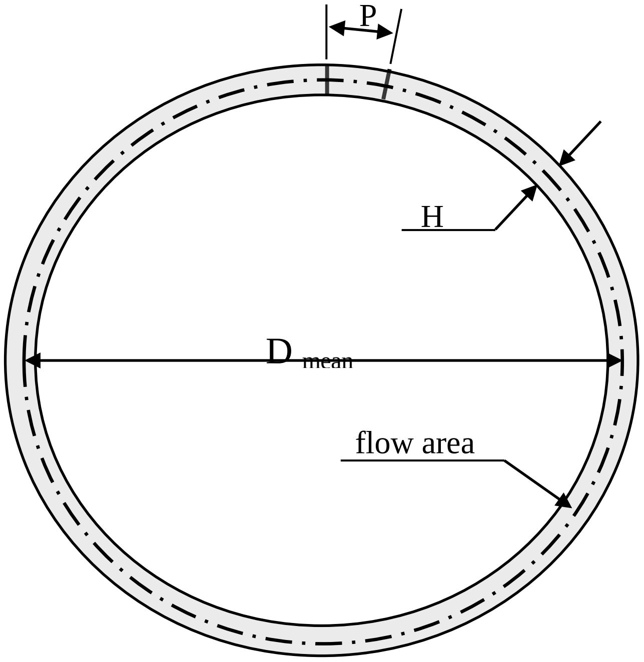

Figure (5.10): Turbine Blading annulus

5.11. Reaction Turbine.

$$Degree\ of\ Reaction = \frac{Heat\ Drop\ in\ Rotor\ Blades}{Heat\ Drop\ in\ the\ stage}$$

Is can be noticed from figure (5.11),

$$Degree\ of\ Reaction = \frac{h_1 - h_2}{h_0 - h_2}$$

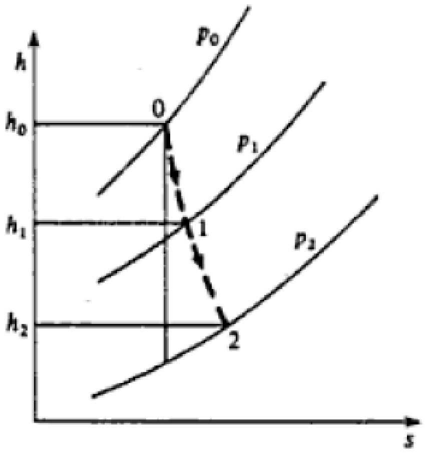

Figure (5.11): Enthalpy drop across reaction turbine stage.

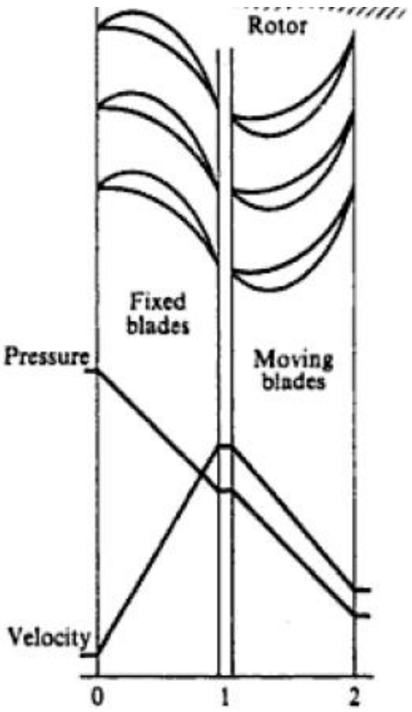

Figure (5.10): Pressure and Velocity profile for Reaction Turbine

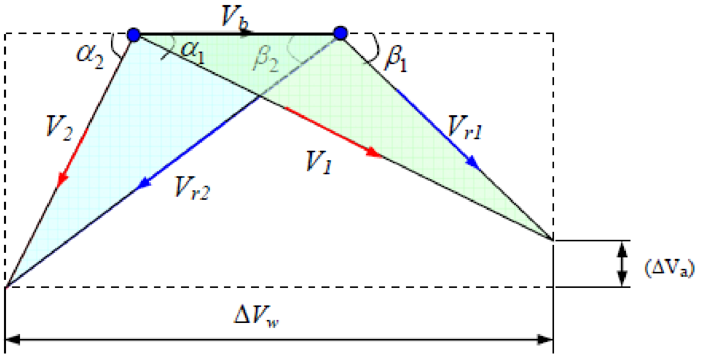

Figure (5.12): Velocity Diagram for Reaction Turbine.