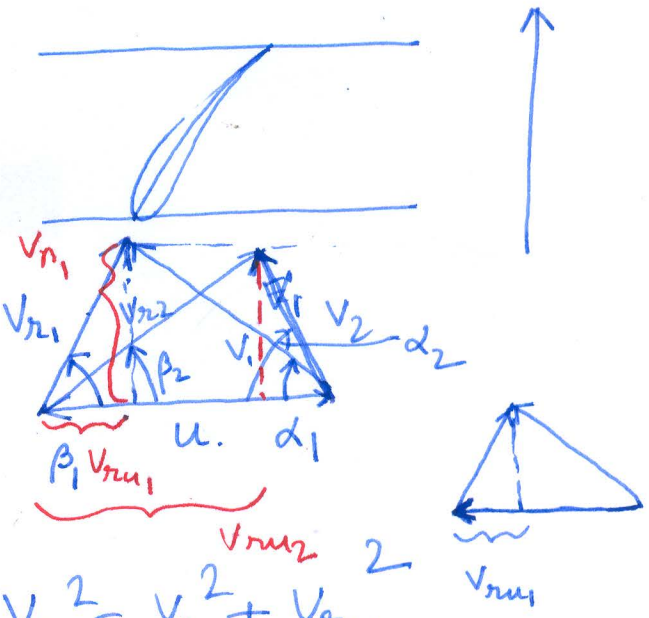
Degree of reaction

Axial flow m/c

$$W = u(V_{u1} - V_{u2})$$

$$R = \frac{(u_1^2 - u_2^2) - (V_{r1}^2 - V_{r2}^2)}{2W}$$



$u_1 = u_2$

$$R = \frac{-(V_{r1}^2 - V_{r2}^2)}{2W}$$

$$V_{r_1}^2 = V_{r_1}^2 + V_{ru_1}$$

$$= \frac{-\{V_{r_1}^2 + V_{ru_1}^2 - V_{r_2}^2 - V_{ru_2}^2\}}{2W}$$

$$V_{ru_1} = -(u - V_{u_1})$$

$$V_{ru_2} = -(u - V_{u_2})$$

$$= \frac{-(V_{ru_1}^2 - V_{ru_2}^2)}{2W}$$

$$= \frac{-(V_{ru_1} - V_{ru_2})(V_{ru_1} + V_{ru_2})}{2W}$$

$$V_{ru_1} - V_{ru_2} = -(u - V_{u_1}) + (u - V_{u_2})$$

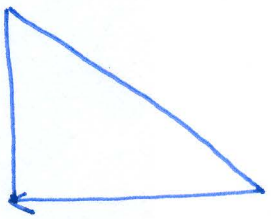
$$= +(V_{u_1} - V_{u_2})$$

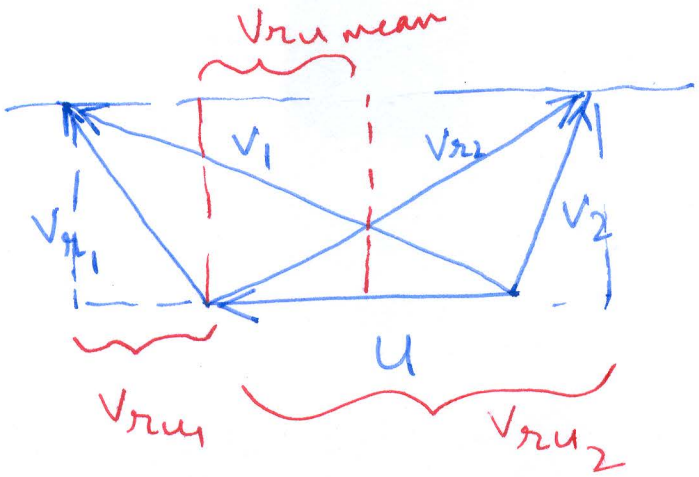
$$R = \frac{-\phi\,(V_{u_1} - V_{u_2})\,(V_{ru_1} + V_{ru_2})}{2u\,(V_{u_1} - V_{u_2})}$$

$$= -\frac{(V_{ru_1} + V_{ru_2})}{2u}$$

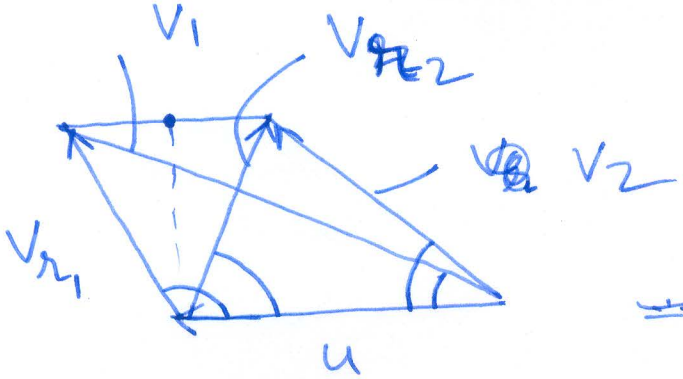
$$= \frac{-V_{ru\ mean}}{u}$$

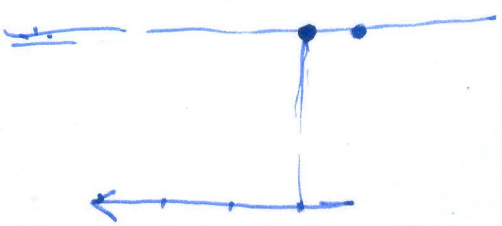
$R = 0$





$$R = -\frac{(-\frac{u}{2})}{u} = \frac{1}{2}$$





2/ Pai Chap 4

$D_1 = 6.5$ cm

$D_2 = 15$ cm

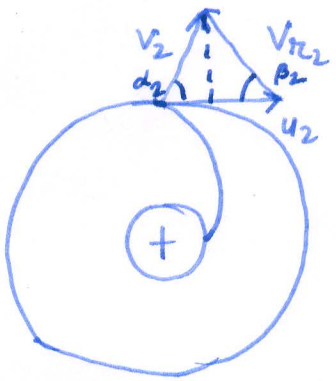
$N = 1440$ rpm

$u_1 = \frac{2\pi N}{60} \times \frac{D_1}{2}$

$= \frac{2 \times \pi \times 1440}{60} \times \frac{6.5}{200}$ m/s

$= 4.9$ m/s

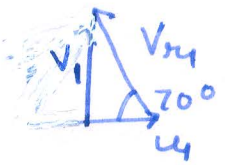
$u_2 = 11.3$



$\beta_1 = 70^\circ$

$V_{n_2} = 0.9 V_{n_1}$

$\beta_2 = 85^\circ$



$\frac{V_1}{u_1} = \tan 70 \Rightarrow V_1 = V_{n_1} = 13.5$ m/s

$V_{n_2} = 0.9 \times V_{n_1} = 0.9 \times 13.5 = 12.15$ m/s

$V_{r_2} \sin\beta_2 = V_{n_2} \Rightarrow V_{r_2} = \frac{V_{n_2}}{\sin\beta_2} = \frac{12.15}{\sin 85} = 12.2$ m/s.

~~$\sin\beta_2 = \frac{V_{n_2}}{}$~~

$V_{u_2} = u_2 - V_{r_2}\cos\beta_2 = 11.3 - 12.2 \cos 85 = 10.2$ m/s

$\omega = u_2 V_{u_2} - u_1 V_{u_1}$

$= 11.3 \times 10.2$ J/kg

$= 115.3$ J/kg

$\tan\alpha_2 = \frac{V_{n_2}}{V_{u_2}} = \frac{12.15}{10.2} = \frac{81}{68}$

$\alpha_2 = 50^\circ$

$\frac{V_{n_2}}{V_2} = \sin\alpha_2 \Rightarrow u_2 = \frac{V_{n_2}}{\sin\alpha_2} = \frac{12.15}{\sin 50}$

$= 15.9$ m/s

$R = \frac{\omega - \frac{V_2^2 - V_1^2}{2}}{\omega} = \frac{115.3 - \frac{15.9^2 - 13.5^2}{2}}{115.3}$

$= 0.694$

CASE II

$\mu = 0.95$

$\omega = 0.95 \times 115.3 = 109.5$ J/kg

$V_{u_2} = 0.95 \times 10.2 = 9.69$ m/s

$V_2 = \sqrt{V_{u_2}^2 + V_{n_2}^2} = \sqrt{9.69^2 + 12.15^2} = 15.54$ m/s

$R = \frac{109.5 - \frac{15.54^2 - 13.5^2}{2}}{109.5} = 0.729$

$R = \frac{\omega - \frac{V_1^2 - V_2^2}{2}}{\omega}$

$= \frac{(u_1 V_{u_1} - u_2 V_{u_2}) - \frac{V_1^2 - V_2^2}{2}}{(u_1 V_{u_1} - u_2 V_{u_2})}$

$= \frac{u_2 V_{u_2} - \frac{V_2^2 - V_1^2}{2}}{u_2 V_{u_2}}$

3 Pair Chap 4

$D_1 = 75\text{ cm}$

$\alpha_1 = 28^\circ$

$V_{n_2} = 0.75 V_{n_1}$

$V_{u_2} = 0$ as $\alpha_2 = 90^\circ$

$D_2 = 30\text{ cm}$

$\beta_2 = 55^\circ$

$N = 500\text{ rpm}$

$$u_1 = \frac{2\pi N}{60} \times \frac{D_1}{2}$$

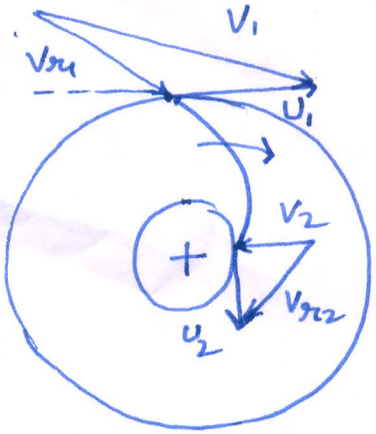
$$= \frac{2 \times \pi \times 500}{60} \times \frac{75}{200}$$

$$= 19.6\text{ m/s}$$

$$u_2 = \frac{2\pi N}{60} \times \frac{D_2}{2}$$

$$= \frac{2 \times \pi \times 500}{60} \times \frac{30}{200}$$

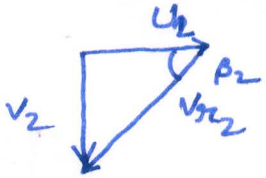
$$= 7.8\text{ m/s}$$



$V_{n_2} = 0.75 \times V_1 \times \sin\alpha_1 = V_2$ | $\frac{V_2}{u_2} = \tan 55^\circ$

$V_2 = 11.1\text{ m/s}$.

$$\frac{V_2}{u_2} = \tan\beta_2$$



$0.75 \times V_1 \times \sin 28 = 7.8 \times \tan 55$

$V_1 = 31.6\text{ m/s}$

$V_{w_1} = V_1 \cos\alpha_1 = 31.6 \times \cos 28 = 27.9\text{ m/s}$

$V_{n_2} = 0.75 \times V_{n_1}$ ~~$= 0.75 \times 7.8 \times \tan 55 = 0.75 \times 11.1 = 8.3\text{ m/s}$~~ $V_{n_1} = 14.8\text{ m/s}$

$$\tan\beta_1 = \left(\frac{u_1 - V_1\cos\alpha_1}{V_{n_1}}\right)^{-1} = \left(\frac{19.6 - 31.6 \times \cos 28}{14.8}\right)^{-1} = -0.56 \text{ ~~-1.8~~}$$

$\beta_1 = 119.1^\circ - 60.9^\circ$ or, 119.1°.

$$\omega = (u_1 V_{w_1} - u_2 V_{w_2}) \times 0.85$$

$$= 19.6 \times 27.9 \times 0.85$$

$$= 465\text{ J/kg}$$

$$R = \frac{\omega - \frac{V_1^2 - V_2^2}{2}}{\omega} = \frac{465 - \frac{31.6^2 - 11.1^2}{2}}{465} = 0.059$$

$$\epsilon = \frac{\omega}{\omega + \frac{V_2^2}{2}} = \frac{465}{465 + \frac{11.1^2}{2}} = 0.883$$

4

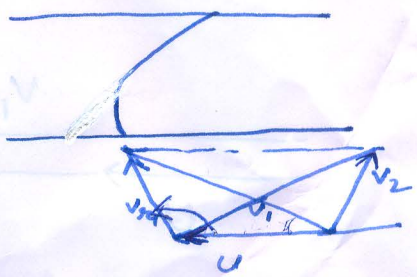
Pari Chatterjee

$N = 1500$ rpm

$V_1 = 180$ m/s

$\alpha_1 = 30^\circ$

$\beta_1 = 60^\circ$



$V_1 \sin\alpha_1 = V_{r1} \sin\beta_1$

$$V_{r1} = \frac{V_1 \sin\alpha_1}{\sin\beta_1} = \frac{180 \times \sin 30}{\sin 60} = 60\sqrt{3} \text{ m/s}$$

$U = V_1 \cos\alpha_1 + V_{r1} \cos\beta_1$

$= 180 \cos 30 - 60\sqrt{3} \cos 60$

$= 60\sqrt{3}$

$$U = \frac{2\pi N}{60} \times \frac{D}{2} = \frac{2 \times \pi \times 1500}{60} \times \frac{D}{2} = 60\sqrt{3}$$

$D = 1.323$ m

(i) $R = 0.5$, i.e. $\dfrac{V_{ru_1} + V_{ru_2}}{2} = 0.5 \times U = 0.5 \times 60\sqrt{3} = 30\sqrt{3}$

$V_{ru_1} = V_{r1} \cos 60 = 60\sqrt{3} \times \cos 60 = 30\sqrt{3}$

$\dfrac{V_{ru\,mean}}{U} = R$

$-30\sqrt{3} + V_{ru_2} = 2 \times 30\sqrt{3}$

$V_{ru_2} = 90\sqrt{3}$

$V_{r_2} \cos\beta_2 = 90\sqrt{3}$

$V_{r_2} \sin\beta_2 = V_1 \sin\alpha_1 = 180 \times \sin 30 = 90$

$V_{r_2} = \sqrt{90^2 + (90\sqrt{3})^2} = 180$ m/s

$\omega = U\left(V_1 \cos\alpha_1 - V_2 \cos\alpha_2\right) = 60\sqrt{3}\left(180 \times \cos 30 + 60\sqrt{3} \cos 60\right) = 21600$ J/kg

$$\epsilon = \frac{\omega}{\omega + \frac{V_2^2}{2}} = \frac{21600}{21600 + \frac{(60\sqrt{3})^2}{2}} = 0.8$$