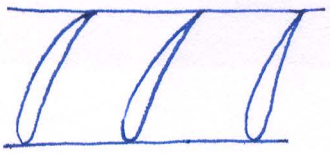


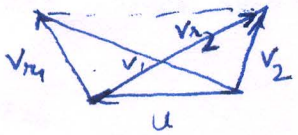
$u = 125$ m/s

$\beta_1 = 140°$

$\beta_2 = 25°$

$V_1 = 220$ m/s

$V_{r_2} = 1.5\, V_{r_1}$



$$V_1^2 = u^2 + V_{r_1}^2 - 2uV_{r_1}\cos 140$$

$$220^2 = 125^2 + V_{r_1}^2 - 2\times 125 \times V_{r_1} \times (-0.766)$$

$$V_{r_1}^2 + 191.5\, V_{r_1} - 32775 = 0$$

$$V_{r_1} = \frac{-191.5 \pm \sqrt{191.5^2 + 4\times 32775}}{2}$$

$$= \frac{-191.5 + 409.6}{2}$$

$$= 109 \text{ m/s}$$

$V_{r_2} = 163.5$ m/s

$$V_2^2 = u^2 + V_{r_2}^2 - 2uV_{r_2}\cos\beta_2$$

$$= 125^2 + 163.5^2 - 2\times 125 \times 163.5 \times \cos 25$$

$$= 5311.9$$

$V_2 = 72.9$ m/s

$$\sin\alpha_1 = \frac{V_{r_1}\sin 40}{V_1} = \frac{70.06}{220} = 0.318$$

$\alpha_1 = 18.54°$.

Specific work $= u(V_{u_1} - V_{u_2})$

$= 125\,(220 \times \cos 18.54 + 163.5\cos 25 - 125)$

$= 28.970$ kJ/kg

①

$$R = \frac{28.970 - \frac{220^2 - 72.9^2}{2000}}{28.97}$$

$$= 0.26$$

$$\epsilon = \frac{28.97}{28.97 + \frac{72.9^2}{2000}}$$

$$= 0.92$$

Axial thrust $= (V_1 \sin\alpha_1 \quad V_{s_2} \sin\beta_2)\dot{m}\ N$

$$= 0.855 \times 1\ N/(kg/s)$$

2. $V_1 = 50\ m/s$

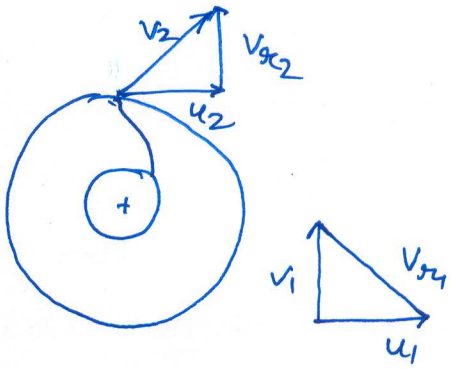
$V_{u_1} = 0$

$D_1 = 30\ cm$

$D_2 = 60\ cm$

$\beta_2 = 90^\circ$

$\alpha_1 = 90^\circ$



$$\omega = \left| u_1 v_{u_1} - u_2 v_{u_2} \right|$$

$$30 = u_2 \times u_2 \times 10^{-3}$$

$$u_2 = \sqrt{30 \times 10^3}$$

$$= 173.2\ m/s$$

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

$$173.2 = \frac{\pi \times 0.6 \times N}{60}$$

$$N = \frac{173.2 \times 60}{\pi \times 0.6}$$

$$= 5513\ rpm$$

$$u_1 = \frac{u_2}{2} = \frac{173.2}{2} = 86.6\ m/s$$

$$\tan\beta_1 = \frac{V_1}{u_1} = \frac{50}{86.6} = 0.577$$

$$\beta_1 = 30^\circ$$

$$V_{r_2} = V_1$$

$$\tan\alpha_2 = \frac{V_{r_2}}{u_2} = \frac{50}{173.2} = 0.289$$

$$\alpha_2 = 16.1^\circ$$

$$V_2 = \sqrt{u_2^2 + v_{r_2}^2}$$

$$= \sqrt{173.2^2 + 50^2}$$

$$= 180.3 \text{ m/s}$$

$$R = \frac{30 - \frac{180.3^2 - 50^2}{2000}}{30}$$

$$= 0.5$$

3. $D_1 = 75\text{ cm}$

$N = 500\text{ rpm}$

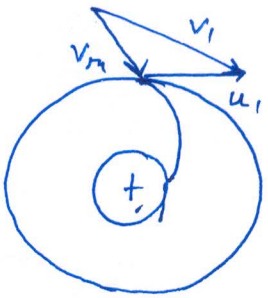
$\alpha_1 = 28^0$

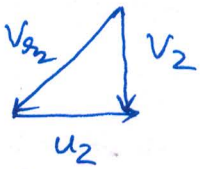
$V_{n_2} = 0.75 \times V_{n_1}$

$V_{u_2} = 0$

$D_2 = 30\text{ cm}$

$\beta_2 = 55^0$





$$u_1 = \frac{\pi D_1 N}{60} = \frac{\pi \times 0.75 \times 500}{60}\ \text{m/s}$$

$$= 19.63\ \text{m/s}$$

$$\tan 55 = \frac{V_2}{u_2}$$

$$V_2 = u_2 \tan 55$$

$$u_2 = \frac{\pi D_2 N}{60} = \frac{\pi \times 0.3 \times 500}{60}$$

$$= 7.85\ \text{m/s}$$

$$V_2 = 7.85 \times \tan 55$$

$$= 11.21\ \text{m/s}$$

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

$$11.21 = 0.75 \times V_{n_1}$$

$$V_{n_1} = 14.95\ \text{m/s}$$

$$V_1 \sin\alpha_1 = V_{n_1}$$

$$V_1 = \frac{V_{n_1}}{\sin\alpha_1} = \frac{14.95}{\sin 28} = 31.84\ \text{m/s}$$

Tangential component at inlet

$= V_1 \cos\alpha_1$

$= 31.84 \times \cos 28$

$= 28.11 \text{ m/s}$

Blade angle β_1 at inlet

$$\tan\beta_1 = \frac{V_{n_1}}{u_1 - V_1 \cos\alpha_1}$$

$$= \frac{14.95}{19.63 - 28.11}$$

$$= -1.763$$

$\beta_1 = -60.44$

$= 119.56^\circ$

specific work output

$= u_1 v_{u_1} \times (1 - 0.15)$

$= 19.63 \times 28.11 \times 0.85$

$= 469 \text{ J/kg}$

$$R = \left[469 - \frac{V_1^2 - V_2^2}{2}\right] / 469$$

$$= \left[469 - \frac{31.84^2 - 11.21^2}{2}\right] / 469$$

$= 0.053$

$$\epsilon = \frac{\omega}{\omega + \frac{V_2^2}{2}} = \frac{469}{469 + \frac{11.21^2}{2}}$$

$= 0.88$