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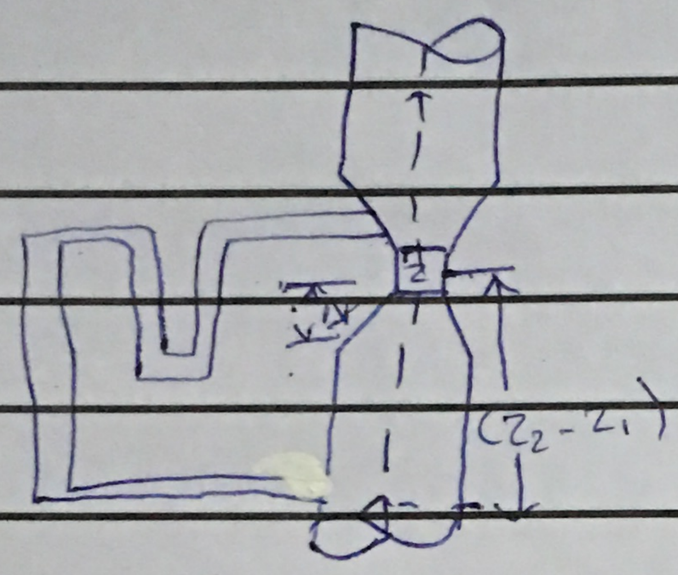
18/engos/041

Mechatronics Engr

Eng 214

11.



Data given : Sp gravity = 0.8, D_1 = 150mm = 0.15m, D_2 = 75mm = 0.075m, $Z_2 - Z_1$ = 150mm = 0.15m, Q_{act} = 40 Litre/sec = $0.04 m^3/s$, cd = 0.96 Pressure difference $(P_1 - P_2)$:

$$A_1 = \frac{\pi}{4} D_1^2 = \frac{\pi}{4} \times 0.15^2 = 0.01767 m^2$$

$$A_2 = \frac{\pi}{4} D_2^2 = \frac{\pi}{4} \times 0.075^2 = 0.00442 m^2$$

$$Q_{act} = cd \times \frac{A_2 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$$

$$0.04 = 0.96 \times \frac{0.01767 \times 0.00442}{\sqrt{0.01767^2 - 0.00442^2}} \times \sqrt{2 \times 9.81 \times h}$$

OR

$$0.04 = 0.96 \times 0.004565 \times 4.429 \sqrt{h}$$

$$h = \left(\frac{0.04}{0.96 \times 0.004565 \times 4.429} \right)^2 = 4.297m$$

Also, $h = \left(\frac{P_1}{\omega} + Z_1 \right) - \left(\frac{P_2}{\omega} + Z_2 \right)$

$$\text{or } 4.247 = \left(\frac{P_1}{\omega} - \frac{P_2}{\omega}\right) + (z_1 - z_2)$$

$$= \left(\frac{P_1 - P_2}{\rho g}\right) - 0.15$$

$$\text{or } P_1 - P_2 = \rho g (4.247 + 0.15)$$

$$= (0.8 \times 1000 \times 9.81)(4.247 + 0.15) \text{ N/m}^2$$

$$= 34.51 \text{ kN/m}^2$$

2. Data given = Diameter at inlet $D_1 = 30\text{mm} = 0.3\text{m}$

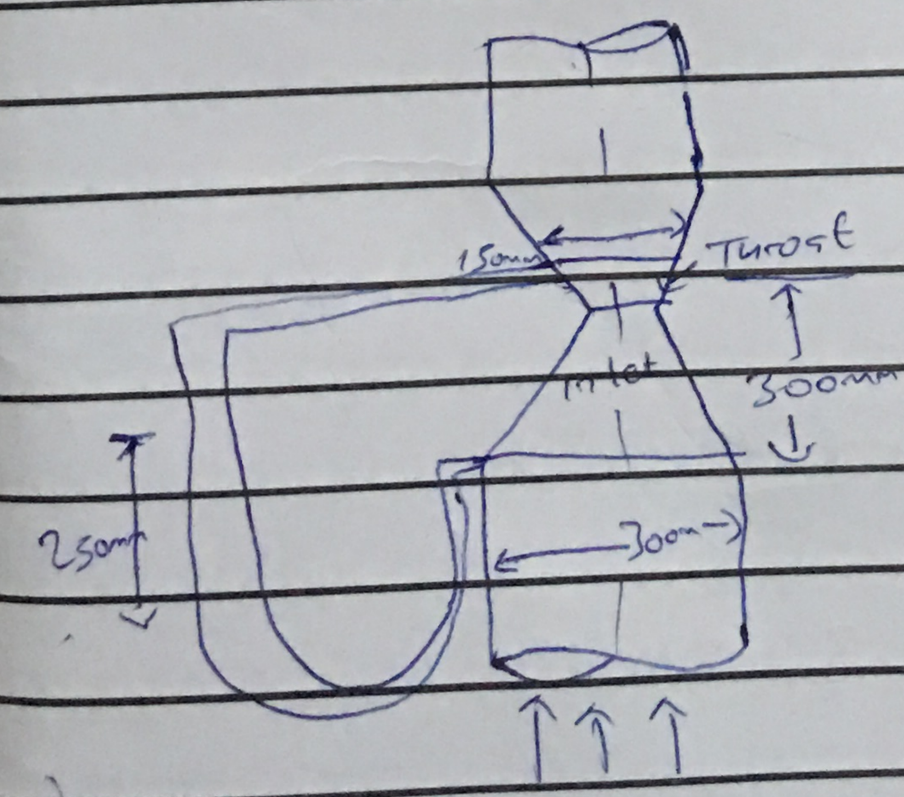
$$A_1 = \frac{\pi}{4} \times 0.3^2 = 0.07\text{m}^2$$

Diameter of throat $D_2 = 150\text{mm} = 0.15\text{m}$

Area of throat $A_2 = \frac{\pi}{4} \times 0.15^2 = 0.01767\ \text{m}^2$

Specific gravity of heavy liquid (mercury) in U-tube manometer $S = 13.6$ Specific gravity of liquid (oil) flowing through pipe, $S_p = 0.9$

differential manometer - $y = 250\text{mm} = 0.25\text{m}$



The differential 'h' is given by:

$$h = \left(\frac{P_1}{\omega} + z_1\right) - \left(\frac{P_2}{\omega} + z_2\right)$$

$$= y\left(\frac{S_M - 1}{S_f}\right) = 0.25\left(\frac{13.6}{0.9} + 1\right)$$

$$= 3.53m \text{ of oil}$$

i. Discharge of oil Q:

Using the relation

$$Q = \frac{Cd \times A_1 A_2 \times \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$$

$$\therefore Q = \frac{0.98 \times 0.07^2 \times 0.01767 \times \sqrt{2 \times 9.81 \times 3.53}}{\sqrt{(0.07)^2 - 0.01767^2}}$$

$$= \frac{0.001212 \times 8.32}{0.0677} = 0.1489 m^3/s$$

$$\therefore Q = 0.1489 m^3/s //$$

ii. Pressure difference between entrance and throat section $P_1 - P_2$:

Recall: $h = \left(\frac{P_1}{\omega} + z_1\right) - \left(\frac{P_2}{\omega} + z_2\right) = 3.53$

$$\Rightarrow \left(\frac{P_1}{\omega} - \frac{P_2}{\omega}\right) + (z_1 - z_2) = 3.53$$

$$z_2 - z_1 = 300mm = 0.3m$$

$$\therefore \left(\frac{P_1}{\omega} - \frac{P_2}{\omega}\right) - 0.3 = 0.35 \Rightarrow \frac{P_1 - P_2}{\omega} = 3.83$$

$$P_1 - P_2 = (9.81 \times 09) \times 3.83 = 33.8 kN/m^2 //$$