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MECHATRONICS ENGINEERING

FLUID MECHANICS

(1) Diameter of inlet at P_1 = 300mm = 0.3m

Area of inlet $A_1 = \pi/4 \times 0.3^2 = 0.07m^2$

Diameter of throat D_2 = 150mm = 0.15m

Area of throat $A_2 = \pi/4 \times 0.15^2 = 0.01767m^2$

Specific gravity of heavy liquid (mercury in U-tube manometer) S_h = 13.6

Specific gravity of liquid (oil) flowing through pipe S_p = 0.9

Reading of differential manometer, y = 250mm = 0.25m

=) The differential 'h' is given by:

$h = \left[\frac{P_1}{\rho g} + z_1\right] - \left[\frac{P_2}{\rho g} + z_2\right] = y\left[\frac{S_h}{S_p} - 1\right] = 0.25\left[\frac{13.6}{0.9} - 1\right]$

= 3.53m of oil

(iii) Discharge of oil, Q_o

using the relation

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

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

$$= \frac{0.001212}{0.0677} \times 8.62$$

$$= 0.1489 m^3/s$$ // entrance.

(iv) Pressure difference between the throat Section $P_1 - P_2$

$$h = \left(\frac{Pt}{m} - t_1\right)\left(\frac{P_2}{w} - t_2\right) = 3.53$$

But $Z_2 \cdot 2t = 300mm$ or $0.3m$

$$\left[\frac{Pt}{m} - \frac{P_2}{w} = 0.3 = 3.53\right.$$

$$P_1 - P_2 = (9.81) \times 0.9) \times 3.83$$

$$= 33.8 kN/m^2$$ //

2. Pressure difference $(P_1 - P_2)$:

$$A_1 = \pi/4\, D_1^2 = \pi/4 \times 0.15^2 = 0.01767 m^2$$

$$A_2 = \pi/4\, D_2^2 = \pi/4\, (0.075)^2 = 0.0012 m^2$$

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

$$0.04 = 0.94 \times \frac{0.01767 \times 0.00442}{\sqrt{0.01767} \times \sqrt{0.00442}}$$

$$\therefore h = \left(\frac{0.04}{0.96 \times 0.00465 \times 4.429}\right) = 4.247 m$$

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

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

$$(P_1 - P_2) = \rho g (4.247 + 0.15)$$

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

$$= 34.51 kN/m^2$$