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18/Eng06/045
Mechanical Engineering
ENG 214 (Assignment Solutions)

1) Question 1

Diameter of Inlet (D_1) = 300mm = 300×10^{-3} m = 0.3m

Area (A_1) = $\frac{\pi d^2}{4} = \frac{\pi (0.3)^2}{4} = 0.070695 \simeq 0.07 m^2$

Diameter at throat (D_2) = 150mm = 150×10^{-3} m = 0.15m

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

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

$S_m = 13.6$

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

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

$$h = \left(\frac{P_a}{\omega} + Z_1\right) - \left(\frac{P_a}{\omega} + Z_2\right)$$

$$= y\left(\frac{S_m}{S_p} - 1\right) = 0.25\left[\frac{13.6}{0.9} - 1\right]$$

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

i) Discharge of oil Q:

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

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

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

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

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

$$\text{or } \left(\frac{P_1}{w} - \frac{P_2}{w}\right) + (z_1 - z_2) = 3.53$$

But $z_2 - z_1 = 300\text{mm or } 0.3\text{m}$

$$\therefore \left(\frac{P_1}{w} - \frac{P_2}{w}\right) - 0.3 = 3.53$$

$$\therefore \text{or } P_1 - P_2 = (9.81 \times 0.9) \times 3.83$$

$$= 33.8\text{kN/m}^2$$

Question 2 (Solution)

Given Sp. gravity = 0.8, D_1 = 150mm = 0.15m, ~~D_2 = 75mm = 0.075~~

$z_2 - z_1$ = 150mm = 0.15m, D_2 = 75mm = 0.075m

Q_{act} = 40 litres/sec = 0.04 m^3/s, C_d = 0.96

Pressure difference $(P_1 - P_2)$:

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

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

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

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

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

$$\therefore h = \left(\frac{0.04}{0.96 \times 0.004565 \times 4.429} \right)^2 = 4.247\text{m}$$

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

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

$4.247 = \left(\frac{P_1 - P_2}{\rho g} \right) - 0.15$

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

$P_1 - P_2 = (0.8 \times 1000 \times 9.81)(4.247 + 0.15)$

$= 34.51\ kN/m^2$