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18/ENG 06/064
MECHANICAL ENGINEERING
FLUID MECHANICS (ENG 214)

① solution:

Diameter at inlet, $D_1 = 300mm = 0.3m$

$\therefore$ Area of inlet, $A_1 = \frac{\pi}{4} \times 0.3^2 = 0.07m^2$

Diameter at throat, D_2

$= 150mm = 0.15m$

$\therefore$ Area at throat, $A_2 =$

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

specific gravity of heavy liquid (mercury) in u-tube manometer, $S_{hl} = 13.6$

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

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

$$= y\left(\frac{S_{hl}}{S_p} - 1\right) = 0.25\left(\frac{13.6}{0.9} - 1\right)$$

$= 3.5m$ of

i) Discharge of oil, Q:

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

$$Q = 0.98 \times \frac{0.07 \times 0.01767}{\sqrt{0.07^2 - 0.01767^2}} \times \sqrt{2 \times 9.81 \times 7.53}$$

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

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

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

But, $z_2 - z_1 = 300mm$ or $0.3m$

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

or $\frac{P_1 - P_2}{w} = 3.83$

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

$= 33.8 \, kN/m^2$

(2) Solution:

Given Sp. gravity = 0.8, D_1 = 150 mm = 0.15 m;
D_2 = 75 mm = 0.075 m; $z_2 - z_1$ =
150 mm = 0.15 m, Q_{act} = 40 litres/sec
= $0.04 m^3 s^{-1}$; C_d = 0.96.

Pressure difference $(P_1 - P_2)$:

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

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

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

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

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

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

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

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

or, $(P_1 - P_2) = \rho g (4.247 + 0.15)$ $(4.247 + 0.15) N/m^2$

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

$= 34.51 kN/m^2$ Ans.