OJANWEMEN JANE
MECHANICAL ENGG
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Question Two

Solution

Given: Sp. gravity = 0.8, D_1 = 150mm = 0.15m, D_2 = 75mm = 0.075m, [illegible]
150mm = 0.15m, Q_{act} = 40 litres/sec = 0.04 m^3/s, C_d = 0.96

Pressure difference $(P_1 - P_2)$:

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

$A_2 = \frac{\pi}{4} D_2^2 = \frac{\pi}{4} \times (0.075)^2 = 0.004420 m^2$

$Q_{act} = C_d \times \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$, 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 $0.04 = 0.96 \times 0.004565 \times 4.429\sqrt{h}$

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

Also, $h = \left[\frac{P_1}{w} + z_1 \right] - \left[\frac{P_2}{w} + z_2 \right]$

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

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

$= 34.51 kN/m^2$

Diameter at inlet, D_1 = 300mm = 0.3m

Area of inlet, $A_1 = \pi/4 \times 0.3^2$ = 0.0707m^2

Diameter at throat, D_2 = 150mm = 0.15m

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

Specific gravity of heavy liquid (mercury) in the 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

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

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

$= 3.53m$ of oil

Discharge of oil, Q:

Using the relation:

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

$Q = 0.98 \times \frac{0.0707 \times 0.01767}{\sqrt{0.0707^2 - 0.01767^2}} \times \sqrt{2 \times 9.81 \times 3.53}$

$= \frac{0.001717}{0.0685} \times 8.32 = 0.1464 m^3/s$

(ii) Pressure difference between entrance & throat section, $P_1 - P_2$

We know that, $h = \left[\frac{P_1}{w} + z_1 \right] - \left[\frac{P_2}{w} + z_2 \right] = 3.53$

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

$z_2 - z_1$ = 300mm = 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 $P_1 - P_2 = (9.81 \times 0.9) \times 3.83 = 33.8 kN/m^2$