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Civil Eng Fluid Mech.

1) Given: Sp of gravity 0.8, $D_1 = 150mm = 0.15m$, $D_2 = 75mm = 0.075m$

$z_2 - z_1 = 150mm = 0.15m$, $Q = 40 lit/sec = 0.04 m^3/s$, $C_d = 0.96$

Pressure difference $(P_1 - P_2)$ $A_1 = \frac{\pi D_1^2}{4} = \frac{\pi \times 0.15^2}{4} = 0.01767 m^2$

$A_2 = \frac{\pi D_2^2}{4} = \frac{\pi \times 0.075^2}{4} = 0.00442 m^2$, $Q = \frac{C_d \times A_1 A_2 \times \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

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

$0.04 = 0.96 \times 0.004565 \times 4.427\sqrt{h}$

$h = \left(\frac{0.04}{0.96 \times 0.004565 \times 4.425}\right)^2 = 4.247 m$

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

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

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

$P_1 - P_2 = (0.8 \times 1000 \times 9.81)(4.247 + 0.15) \Rightarrow P_1 - P_2 = 34.51 kN/m^2$

2) Diameter of Inlet $(D_1) = 300mm = \frac{300}{1000} = 0.3m$

Area of Inlet $(A_1) = \frac{\pi \times D_1^2}{4} = \frac{\pi \times 0.3^2}{4} = 0.07 m^2$

Diameter of throat $(D_2) = 150mm = \frac{150mm}{1000} = 0.15m$

Area of inlet 2 $(A_2) = \frac{\pi D_2^2}{4} = \frac{\pi \times 0.15^2}{4} = 0.07767 m^2$

Specific gravity of mecury in U tube manometer, $S_{hg} = 13.6$

Specific gravity of oil flowing in pipe, $S_p = 0.9$

Value of differential manometer, $y = 250mm = 0.25m$

The differential 'h' is given by $h = \left(\frac{P_1}{\omega} + z_1\right) - \left(\frac{P_2}{\omega} + z_2\right)$

$= y\left[\frac{S_{hg}}{S_p} - 1\right] = 0.25\left[\frac{13.6}{0.9} - 1\right] = 3.53m$ of oil

a) Discharge of oil Q using the relation, $Q = \frac{C_d \times A_1 A_2 \times \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$Q = \frac{0.98 \times 0.07 \times 0.07767 \times \sqrt{2 \times 9.81 \times 3.53}}{\sqrt{0.07^2 - 0.7764^2}} = 0.148 m^3/s$

$\therefore Q = 0.148 m^3/s$

b) Pressure difference at entrance to throat Section $P_1 - P_2$

$h = \left(\frac{P1}{\omega} + Z_1\right) - \left(\frac{P_2}{\omega} + Z_2\right) = 3.53$, also $h = \left(\frac{P_1}{\omega} - \frac{P_2}{\omega}\right) - (z_1 - z_2) = 3.53$

$z_2 - z_1 = 300mm = \frac{300}{1000} = 0.3m$, $\left(\frac{P_1 - P_2}{\omega}\right) - 0.3 = 3.53$

$\frac{P_1 - P_2}{\omega} = 3.53 + 0.3 \Rightarrow \frac{P_1 - P_2}{\omega} = 3.83 \Rightarrow P_1 - P_2 = 3.83\omega$

$\Rightarrow P_1 - P_2 = 3.82 \times 9.81 \times 0.9 \Rightarrow P_1 - P_2 = 33.8 \, kN/m^2$