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1) Diameter at Inlet $D_1 = 300mm = 0.3m$
Area of inlet $A_1 = \frac{\pi}{4} \times 0.3^2 = 0.07m^2$
Diameter at throat, $D_2 = 150mm = 0.15m$
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 $S_M = 13.6$
Specific gravity of liquid (oil) flowing through pipe $Sp = 0.7$
Reading of differential manometer $y = 250mm = 0.25m$
The differential 'h' is given by

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

$$= y\left[\frac{S_M}{S_f} - 1\right] = 0.25\left[\frac{13.6}{0.7} - 1\right]$$

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

2) Discharge of oil a using the relation

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

$$= \frac{0.78 \times 0.07 \times 0.01767}{\sqrt{0.07^2 - 0.01767^2}} \times \sqrt{2 \times 9.81 \times 3.53}$$

$$= \frac{0.001212}{0.0677} \times 8.32$$

$$= 0.1489 m^3/s$$

ii) Pressure difference between throat sections

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

If $z_2 - z_1 = 0.3m$

$$\left[\frac{P_1}{w} - \frac{P_2}{w}\right] - 0.3 = 3.53$$

2) Gravity = 0.8, $D_1 = 150mm = 0.15m$
$D_2 = 75mm = 0.075m$, $z_2 - z_1 = 150mm = 0.15m$
$Q_{act} = 40 \text{ litres/sec} = 0.04m^3/s$
$C_d = 0.96$
Pressure difference $(P_1 - P_2)$

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

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

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

$$0.04 = 0.96 \times \frac{0.01767 \times 0.0042}{\sqrt{0.01767^2 - 0.00442^2}} \times \sqrt{2 \times 9.81} \times \sqrt{h}$$

$$\therefore h = \left(\frac{0.04}{0.96 \times 0.0045 \times 4.429}\right)^2$$

$$= 4.247m$$

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

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

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

$$\text{or. } (P_1 - P_2) = P_g (4.247 + 0.15)$$

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

$$= 34.51 KN/m^2$$