

1 Diameter at inlet $D_1 = 300\text{mm} = 0.3\text{m}$

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

Diameter at throat, $D_2 = 150\text{mm} = 0.15\text{m}$

Area at throat, $A_2 = \frac{\pi}{4} \times 0.15^2 = 0.01767\text{m}^2$

Specific gravity of heavy liquid (mercury) in U-tube manometer, $S_H = 13.6$

Specific gravity of Liquid (oil) flowing through pipe, $S_P = 0.9$

Reading of differential manometer $y = 250\text{mm} = 0.25\text{m}$

The differential 'h' is given by:

$$h = \left(\frac{P_1}{\rho} + Z_1 \right) - \left(\frac{P_2}{\rho} + Z_2 \right)$$

$$= y \left[\frac{S_H \rho}{S_P} - 1 \right] = 0.25 \left[\frac{13.6}{0.9} - 1 \right]$$

= 3.53m of oil

i) Discharge of oil, Q : using the relation

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

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

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

ii) Pressure difference between entrance and throat sections, $P_1 - P_2$:

$$h = \left(\frac{P_1}{\rho} + Z_1 \right) - \left(\frac{P_2}{\rho} + Z_2 \right) = 3.53$$

$$\left(\frac{P_1}{\rho} - \frac{P_2}{\rho} \right) + (Z_1 - Z_2) = 3.53$$

$$Z_2 - Z_1 = 300 \text{ mm or } 0.3 \text{ m}$$

$$\therefore \left(\frac{P_1}{\rho} - \frac{P_2}{\rho} \right) - 0.3 = 3.53 \text{ or } \frac{P_1 - P_2}{\rho} = 3.83$$

$$P_1 - P_2 = (9.81 \times 0.9) \times 3.83 = 33.8 \text{ kN/m}^2$$

2) Pressure difference ($P_1 - P_2$):

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

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

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

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

OR

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

$$\text{Also, } h = \left(\frac{P_1}{\rho} + Z_1 \right) - \left(\frac{P_2}{\rho} + Z_2 \right)$$

$$\text{or, } 4.247 = \left(\frac{P_1}{\rho} - \frac{P_2}{\rho} \right) + (Z_1 - Z_2)$$

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

$$\text{or, } (P_1 - P_2) = \rho (4.247 + 0.15)$$

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

$$= 34.51 \text{ kN/m}^2$$