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1

Pressure difference $(P_1 - P_2)$

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

$$A_2 = \frac{\pi D_2^2}{4} = \frac{\pi \times 0.015^2}{4} = 0.000442 \text{ m}^2$$

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

$$0.04 = \frac{0.96 \times 0.01767 \times 0.000442 \times \sqrt{2 \times 9.81 \times h}}{\sqrt{0.01767^2 - 0.000442^2}}$$

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

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

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

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

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

$$4.247 + 0.15 = \frac{P_1 - P_2}{\rho}$$

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

$$P_1 - P_2 = (0.8 \times 1000 \times 9.81) (4.247 + 0.15)$$

$$P_1 - P_2 = 34.51 \text{ kN/m}^2$$

2

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

$$\text{Area of inlet } A_1 = \frac{\pi D_1^2}{4} = \frac{\pi \times 0.3^2}{4} = 0.07 \text{ m}^2$$

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

$$\text{Area of } A_2 = \frac{\pi D_2^2}{4} = \frac{\pi \times 0.15^2}{4} = 0.01767 \text{ m}^2$$

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, $y = 250 \text{ mm} = 0.25 \text{ m}$

The differential "h" is given by

$$h = \left(\frac{P_1}{\rho} + Z_1 \right) - \left(\frac{P_2}{\rho} + Z_2 \right)$$
$$= y \left[\frac{S_h}{S_p} - 1 \right] = 0.25 \left[\frac{13.6}{0.9} - 1 \right] = 3.53 \text{ m of oil}$$

a) Discharge of oil Q

using relation

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

$$Q = \frac{0.98 \times 0.07 \times 0.07767 \times \sqrt{2 \times 9.81 \times 3.53}}{\sqrt{0.07^2 - 0.07767^2}}$$

$$Q = 0.1489 \text{ m}^3/\text{s}$$

b) Pressure difference between entrance and throat section $P_1 - P_2$ we all know that

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

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

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

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

$$\frac{P_1 - P_2}{\rho} = 3.53 + 0.3$$

$$P_1 - P_2 = 3.83 \rho$$

$$P_1 - P_2 = 3.83 \times 9.81 \times 0.9$$

$$= 33.8 \text{ kN/m}^2$$