18/ENG03/026

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Civil Engineering

Fluid Mechanics

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 $(P_1 - P_2)$

$$A_1 = \frac{\pi D_1^2}{4} = \frac{\pi \times 0.15^2}{4} = 0.07767 m^2$$

$$A_2 = \frac{\pi D_2^2}{4} = \frac{\pi \times 0.075^2}{4} = 0.004442 m^2$$

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

$$0.04 = \frac{0.96 \times 0.01767 \times 0.004442 \times \sqrt{2 \times 9.81 h}}{\sqrt{0.07767^2 - 0.004442^2}}$$

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

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

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

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

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

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

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

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

$$P_1 - P_2 = 34.51 kN/m^2$$

(2) Diameter of Inlet $D_1 = 300mm = 0.3m$

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

Diameter of throat $D_2 = 150mm = 0.15m$

Area of inlet $A_2 = \frac{\pi D_2^2}{4} = \frac{\pi \times 0.15}{4} = 0.1767m^2$

Specific gravity of heavy liquid (mercury) in tube manometer $= 13.6$

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;

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

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

a) Discharge of Oil Q

Using the relation;

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

$$Q = \frac{0.98 \times 0.07 \times 0.07767 \times \sqrt{2 \times 9.81 \times 3.53}}{\sqrt{0.07^2 - 0.7767^2}}$$

$$Q = 0.1489m^3/s$$

b) Pressure difference between entrance and throat section $P_1 - P_2$

we all know that;

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

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

$$Z_2 - Z_1 = 300mm = 0.3m$$

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

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

$$\frac{P_1 - P_2}{w} = 3.83$$

$$P_1 - P_2 = 3.83w$$

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

$$= 33.8\,kN/m^2$$