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DEPT: CHEMICAL ENGINEERING

MAT No. 18/ENGG01/014

COURSE: FLUID MECHANICS

Q1) Given: Sp of gravity = 0.8, $D_1 = 150\text{mm} = 0.15\text{m}$, $D_2 = 75\text{mm} = 0.075\text{m}$
 $Z_2 - Z_1 = 150\text{mm} = 0.15\text{m}$, $Q_{act} = 40\text{lit/sec} = 0.04\text{m}^3/\text{s}$, $C_d = 0.96$

Pressure difference ($P_1 - P_2$):

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

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

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

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

$$0.04 = 0.96 \times 0.00465 \times 4.429 \sqrt{h}$$

$$h = \left(\frac{0.04}{0.96 \times 0.00465 \times 4.429} \right)^2 = 4.247\text{m}$$

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

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

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

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

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

$$P_1 - P_2 = 34$$

$$P_1 - P_2 = (0.8 \times 1000 \times 9.81)(4.247 + 0.13)$$

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

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

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

Diameter of throat $D_2 = 180 \text{ mm} = 0.18 \text{ m}$

$$\text{Area of inlet } A_2 = \frac{\pi \times D_2^2}{4} = \frac{\pi \times 0.18^2}{4} = 0.01767 \text{ m}^2$$

Specific gravity of heavy liquid (mercury) in U tube manometer,
 $S_{ac} = 13.6$

Specific gravity of liquid (oil) flowing through pipe $S_p = 0.9$

Reading of differential manometer, $y = 80 \text{ mm} = 0.25 \text{ m}$

The differential 'h' is given by:

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

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

(a) Discharge of oil (Q):

Using the relation,

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

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

$$Q = 0.48 \text{ m}^3/\text{s}$$

Q17 Pressure difference between entrance and throat section $P_1 - P_2$

We know that,

$$h = \left(\frac{P_1}{\rho} + z_1 \right) - \left(\frac{P_2}{\rho} + z_2 \right) = 3.53$$

$$h = \left(\frac{P_1}{\rho} - \frac{P_2}{\rho} \right) - (z_1 - z_2) = 3.53$$

$$z_2 - z_1 = 300 \text{ mm} = 0.3 \text{ m}$$

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

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

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

$$P_1 - P_2 = 3.83 \rho$$

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