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18/ENG01/008
CHEMICAL ENGINEERING
FLUID MECHANICS
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1) Given sp gr gravity $= 0.8$

$D_1 = 150mm = 0.15m$

$D_2 = 75mm = 0.075m$

$Z_2 - Z_1 = 150mm = 0.15m$

$Q = 40l/sec = 0.4 m^3/$

$cd = 0.96$

Pressure difference $(P_1 - P_2)$

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

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

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

$$0.04 = \frac{0.96 \times 0.1767 \times 0.00442 \times \sqrt{2 \times 9.81 \times h}}{\sqrt{0.01767^2 - 0.0042^2}}$$

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

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

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

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

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

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

$$(4.247 + 0.15) Pg = P_1 - P_2$$

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

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

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 throat, $A_2 = \frac{\pi \times D_2^2}{4} = \frac{\pi \times 0.15^2}{4} = 0.01767m^2$

Specific gravity of heavy liquid (mercury in u-tube manometer $S_H = 13.6$

Specific gravity of liquid (oil) flowing through pipe, $S_0 = 0.9$

Reading of differential manometer $y = 250mm = 0.25m$

The differential h is given by

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

$$= y\left[\frac{S_H}{S_0} - 1\right] = 0.25\left[\frac{13.6}{0.9} - 1\right] = 3.53m \text{ of oil}$$

i) Discharge of oil Q:

Using the relation

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

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

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

ii) Pressure difference between entrance and throat Sections

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

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

$Z_2 - Z_1 = 300mm = 0.3m$

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

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

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

$P_1 - P_2 = 3.83w$

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

$= 33.81 kN/m^2$