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Biomedical Engineering

1) $D_1 = 300mm = 0.3m$ $D_2 = 150mm = 0.15m$

$A_1 = \frac{\pi}{4} \times 0.3^2 = 0.07m^2$ $A_2 = \frac{\pi}{4} \times 0.15^2 = 0.01767m^2$

Specific gravity of Mercury $(S_{hl}) = 13.6$

Specific gravity of oil $(S_p) = 0.9$

Reading on manometer $(y) = 250mm = 0.25m$

$\therefore$ Differential head is given by

$$y\left(\frac{S_{hl}}{S_p} - 1\right) = 0.25\left(\frac{13.6}{0.9} - 1\right)$$

$h = \underline{\underline{3.53m \text{ of oil}}}$

i) Discharge of oil

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

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

$= 0.1489 m^3/s$

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

$$\frac{P_1 - P_2}{W} - 0.3 = 3.53$$

$P_1 - P_2 = 3.83 \times W$

$W = (9.81 \times 0.9) = 8.829$

$\therefore P_1 - P_2 = 3.83 \times 8.829 = 33.8 KN/m^2$

2) Sp. gravity $= 0.8$

$D_1 = 150\,mm = 0.15m$

$D_2 = 75mm = 0.075m$

$Z_1 - Z_2 = 150mm = 0.15m$

$Q = 40\,litres/sec = 0.04m^3/s$

$A_1 = \frac{\pi}{4} \times 0.15^2 = 0.1767m^2$

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

$Q = C_d \times \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$ (using this to find h)

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

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

$\sqrt{h} = 2.0608$

$h = 2.0608^2$ $\therefore h = 4.247m$

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

$\left(\frac{P_1 - P_2}{w}\right) = 4.247 + 0.15 = 4.397$

$\therefore (P_1 - P_2) = 4.397 \times w$

$= 4.397 \times (0.8 \times 1000 \times 9.81)$

$= 34.51 kN/m^2$