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18/ENG04/038
Mechanical Engineering

1) $D_1 = 150mm = 0.15m$ $\quad Z_1 - Z_2 = 0.15m$

$D_2 = 75mm = 0.075m$

$Q_{act} = 40 litres/sec = 0.04 m^3/sec$

$C_d = 0.96$

Relative density $= 0.8$

$$A_1 = \frac{3.142 \times (0.15)^2}{4} = 0.0177m^2$$

$$A_2 = \frac{3.142 \times (0.075)^2}{4} = 0.00442m^2$$

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

$$0.04 = \frac{0.96 \times 0.0177 \times 0.00442 \times \sqrt{2 \times 9.81 \times h}}{\sqrt{0.0177^2 - 0.00442^2}}$$

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

$h = 4.247m$

Pressure difference $= P_1 - P_2$

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

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

$$P_1 - P_2 = \rho g h + 0.15$$

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

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

2) $D_1 = 300mm = 0.3m$

$D_2 = 150mm = 0.15m$

i) $A_1 = \frac{3.142 \times (0.3)^2}{4} = 0.07m^2$

$A_2 = \frac{3.142 \times (0.15)^2}{4} = 0.01767m^2$

$h = 0.25\left(\frac{13.6}{0.9-1}\right) = 3.5m$ of oil

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

$Q = \frac{0.98 \times 0.07 \times 0.01767 \times \sqrt{2 \times 9.81 \times 3.5}}{\sqrt{0.07^2 - 0.01767^2}}$

$Q = 0.1489 m^3/s$

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

$Z_1 - Z_2 = 0.3m$

~~$P_1 - P_2 = 3.83 \times 0.9 A$~~

$P_1 - P_2 = (0.9 \times 9.81)(3.53 + 0.3)$

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

$P_1 - P_2 = 33.8 KN/m^2$