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COURSE: FLUID MECHANICS (ENG 214).
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1) • Relative density = 0.8.
Inlet diameter (D_1) = 150mm = 0.15m
Throat diameter (D_2) = 75mm = 0.075m.
$Z_2 - Z_1$ = 150mm = 0.15m.
Q = 40 lit/sec = $0.04 m^3/s$,
Cd = 0.96.
• $P_1 - P_2$ = ?

$$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi \times (0.15)^2}{4} = \frac{0.070685834 71}{4} = 0.018\ m^2.$$

$$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi \times (0.075)^2}{4} = \frac{0.01767}{4} = 4.42 \times 10^{-3}\ m^2.$$

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

$$0.04 = \frac{0.96 \times 0.018 \times 4.42 \times 10^{-3} \times \sqrt{2 \times 9.81 \times h}}{\sqrt{(0.018)^2 - (4.42 \times 10^{-3})^2}}$$

$$0.04 = \frac{7.63776 \times 10^{-5} \times \sqrt{2 \times 9.81 \times \sqrt{h}}}{\sqrt{(3.24 \times 10^{-4}) - (1.95364 \times 10^{-5})}}$$

$$0.04 = \frac{7.63776 \times 10^{-5} \times 4.429\sqrt{h}}{\sqrt{3.01 4636 \times 10^{-4}}}$$

$$0.04 = \frac{7.63776 \times 10^{-5} \times 4.429\sqrt{h}}{0.017}$$

$$0.04 \times 0.017 = 7.63776 \times 10^{-5} \times 4.429 \sqrt{h}$$

$$\sqrt{h} = \frac{0.04 \times 0.017}{7.63776 \times 10^{-5} \times 4.429}$$

$$\sqrt{h} = \frac{6.8 \times 10^{-4}}{3.38 \times 10^{-4}}$$

Square both sides

$$(\sqrt{h})^2 = \left(\frac{6.8}{3.38}\right)^2$$

$$h = (2.01)^2$$

$$h = 4.0401 \text{ m}.$$

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

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

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

$$4.0401 = \left(\frac{P_1 - P_2}{\rho g}\right) - 0.15$$

$$4.0401 + 0.15 = \frac{P_1 - P_2}{\rho g}$$

$$P_1 - P_2 = (4.0401 + 0.15)\rho g$$

$$P_1 - P_2 = (4.0401 + 0.15)(0.8 \times 1000 \times 9.81)$$

$$P_1 - P_2 = (4.1901)(7848)$$

$P_1 - P_2 = 32.8\ kN/m^2$

2) Diameter of inlet (d_1) = 300m = 0.3m.
Diameter of throat (d_2) = 150mm = 0.15m
Specific gravity of heavy liquid (mercury) (S_{hg}) = 13.6
Specific gravity of oil (S_p) = 0.9
Reading of differential manometer (y) = 250mm = 0.25m
Areas of inlet $(A_1) = \frac{\pi d_1^2}{4} = \frac{\pi \times (0.3)^2}{4} = \frac{0.2827}{4} = 0.07m^2$.

Area of throat $(A_2) = \frac{\pi d_2^2}{4} = \frac{\pi \times (0.15)^2}{4} = \frac{0.070685\pi}{4} = 0.01767m^2$

$h = \left(\frac{P_1}{w} + z_1\right) - \left(\frac{P_2}{w} + z_2\right) = y\left(\frac{S_{hg}}{S_p} - 1\right)$

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

$= 0.25(15.1 - 1)$

$h = 0.25 \times 14.1$

$h = 3.53m$ of oil

ii) Discharge of oil (Q)

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

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

$$Q = \frac{1.212162 \times 10^{-3} \times \sqrt{69.2586}}{\sqrt{(4.9 \times 10^{-3}) - (3.12 \times 10^{-4})}}$$

$$Q = \frac{1.212162 \times 10^{-3} \times 8.3}{\sqrt{4.587711 \times 10^{-3}}}$$

$$= \frac{0.01}{0.0677} = 0.148\ m^3/s.$$

ii) Pressure difference between the entrance section and the throat section. $(P_1 - P_2)$

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

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

$z_2 - z_1 = 300mm$

$z_1 - z_2 = -300mm = 0.3m.$

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

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

$$P_1 - P_2 = (3.53 + 0.3)w$$

$$P_1 - P_2 = (3.53 + 0.3)\,0.9 \times 9.8)$$

$$= 3.83 \times 0.9 \times 9.8$$

$$= 33.81 kN/m^2.$$