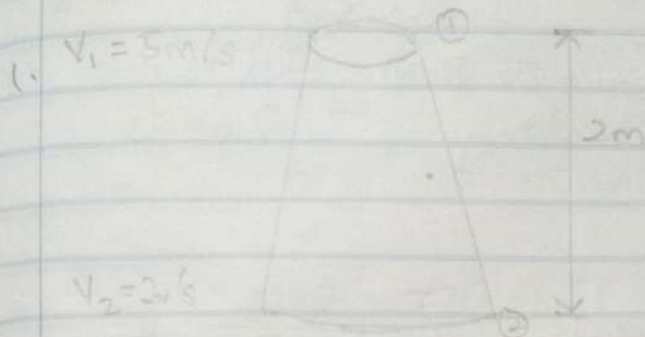


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CIVIL ENGINEERING

ENG214



$$\text{Loss of head } (h) = \frac{0.35(v_1 - v_2)^2}{2g}$$

$$h = \frac{0.35(5^2 - 2^2)}{2g} = \frac{3.15}{19.62}$$

$$h = 0.16 \text{ m}$$

$$h = h_1 - h_2$$

$$h_1 = \frac{P_1}{w} + \frac{v_1^2}{2g} + z_1$$

$$\frac{P_1}{w} = 2.5 \text{ m}, v_1 = 5 \text{ m/s}, z_1 = 2 \text{ m}$$

$$h_2 = \frac{P_2}{w} + \frac{v_2^2}{2g} + z_2$$

$$\frac{P_2}{w} = ?, v_2 = 2 \text{ m/s}, z_2 = 0 \text{ m}$$

$$\therefore h = \left[\frac{P_1}{w} + \frac{v_1^2}{2g} + z_1 \right] - \left[\frac{P_2}{w} + \frac{v_2^2}{2g} + z_2 \right]$$

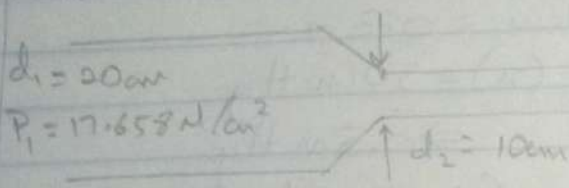
$$0.16 = (2.5 + 1.27 + 2) - \left(\frac{P_2}{w} + 0.204 + 0 \right)$$

$$0.16 = 5.77 - \frac{P_2}{w} - 0.204$$

$$\frac{P_2}{w} = 5.77 - 0.16 - 0.204$$

$$\frac{P_2}{w} = 5.406 \text{ m}$$

2. $d_1 = 20\text{cm} = 0.2$, Pressure head at throat = -30cmHg
 $C_d = 0.98$



$$d_1 = 20\text{cm} = 0.2\text{m}$$

$$A_1 = \frac{\pi \times 0.2^2}{4} = 0.0314\text{m}^2$$

$$d_2 = 10\text{cm} = 0.1\text{m}$$

$$A_2 = \frac{\pi \times 0.1^2}{4} = 0.00785\text{m}^2$$

$$P_1 = 17.658\text{ N/cm}^2 \Rightarrow 17.658 \times 10^4\text{ N/m}^2$$

$$\text{Pressure head at inlet} \Rightarrow \frac{P_1}{\rho g} = \frac{17.658 \times 10^4}{1000 \times 9.81}$$

$$= 18\text{m}$$

Pressure head at throat = manometer reading \times S.g of mercury

$$\text{Manometer reading} = -30\text{cmHg} = -0.3\text{mHg}$$

$$\text{S.g of mercury} = 13.6$$

$$\therefore \frac{P_2}{\rho} = -0.3 \times 13.6$$

$$= -4.08\text{m}$$

$$\text{Differential head (h)} = \frac{P_1}{\rho} - \frac{P_2}{\rho}$$

$$= 18 - (-4.08) = 22.08\text{m}$$

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

$$Q = 0.98 \times 0.0314 \times 0.00785 \times \sqrt{\frac{2 \times 9.81 \times 22.08}{0.0314^2 - 0.00785^2}}$$

$$= 2.416 \times 10^{-4} \times \sqrt{433.21}$$

$$= 2.416 \times 10^{-4} \times 684.72$$

$$Q = 0.165\text{ m}^3/\text{s}$$

3. diameter of orifice (d_o) = 15 cm = 0.15 m
 diameter of pipe (d_i) = 30 cm = 0.3 m
 pressure difference manometer (x) = 50 cm Hg

$\Rightarrow 0.5 \text{ m Hg}$
 $Q = ?$, S.g of oil = 0.9, $C_d = 0.64$

$$A_o = \frac{\pi \times 0.15^2}{4} = 0.0177 \text{ m}^2$$

$$A_i = \frac{\pi \times 0.3^2}{4} = 0.0707 \text{ m}^2$$

$$\text{Differential head (h)} = x \left[\frac{\text{S.g. mercury}}{\text{S.g. oil}} - 1 \right]$$

$$= 0.5 \left[\frac{13.6}{0.9} - 1 \right]$$

$$= 7.06 \text{ m}$$

Rate of flow through an orifice meter $Q = C_d A_o A_i \sqrt{\frac{2gh}{A_i^2 - A_o^2}}$
 $C_d = 0.64$

$$Q = 0.64 \times 0.0177 \times 0.0707 \times \sqrt{\frac{2 \times 9.81 \times 7.06}{0.0707^2 - 0.0177^2}}$$

$$= 8.009 \times 10^{-4} \times \sqrt{\frac{138.5172}{4.6952 \times 10^{-3}}}$$

$$= 8.009 \times 10^{-4} \times \sqrt{29564.84}$$

$$Q = 0.137 \text{ m}^3/\text{s}$$

4. Since no value for coefficient of velocity (C_v) is given, we use formula for theoretical velocity.

$$V = \sqrt{2gh}$$

(x) Difference of mercury level = 170 mm Hg = 0.17 m Hg

S.g of mercury = 13.6

S.g of sea water = 1.026

$$\text{Difference of seawater level (h)} = x \left[\frac{\text{S.g. mercury}}{\text{S.g. sea water}} - 1 \right]$$

$$= 0.17 \times \left[\frac{13.6}{1.026} - 1 \right] = 2.08 \text{ m of sea water}$$

$$\therefore v = \sqrt{2 \times 9.81 \times 2.08}$$

$$v = \sqrt{40.8096}$$

$$v = 6.39 \text{ m/s}$$

5. Actual flow rate (Q_A) = $0.05 \text{ m}^3/\text{min} \Rightarrow 8.33 \times 10^{-4} \text{ m}^3/\text{s}$

$$\Delta P = 15 \text{ bar} = 15 \times 10^5 \text{ N/m}^2$$

$$\text{Speed of rotation} = 1700 \text{ rev/min} \Rightarrow 28.33 \text{ rev/s}$$

$$\text{normal displacement} = 10 \text{ cm}^3/\text{rev} = 10^{-5} \text{ m}^3/\text{rev}$$

$$\text{Torque} = 15 \text{ Nm}$$

i. Volumetric Efficiency = $\frac{\text{Actual flow rate}}{\text{Theoretical flow rate}} \times 100$

$$\text{Theoretical flow rate } (Q_T) = \text{normal displacement} \times \text{speed of rotation.}$$

$$= 28.33 \times 10^{-5}$$

$$= 2.833 \times 10^{-4} \text{ m}^3/\text{s}$$

$$\therefore \text{Volumetric Efficiency} = \frac{8.33 \times 10^{-4}}{2.833 \times 10^{-4}} \times 100$$

$$= 294.03 \%$$

This value is obtained because actual flow rate \gg than theoretical flow rate.

ii Fluid Power (P_F) = $Q_A \Delta P$ (Actual flow rate \times change in pressure)

$$P_F = (8.33 \times 10^{-4}) \times (15 \times 10^5)$$

$$= 1249.5 \text{ Watts}$$

$$= 1.249 \text{ kW}$$

iii Shaft Power = $T \cdot \omega$ (Torque \times angular speed (rad/sec))

$$T = 15 \text{ Nm}$$

$$\omega = 2\pi N \quad \text{where } N \rightarrow \text{speed of rotation.}$$

$$\omega = 2 \times \pi \times 28.33 = 178 \text{ rad/sec}$$

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$$\begin{aligned} \text{Shaft power} &= 15 \times 178 \\ &= 2670 \text{ watts} \\ &= 2.67 \text{ kW} \end{aligned}$$

$$\begin{aligned} \text{Overall Efficiency} &= \frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100 \\ &= \frac{1.249 \times 10^3}{2.67 \times 10^3} \times 100 \\ &= 46.78\% \end{aligned}$$