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Fluid Mechanics Assignment

18/ENR05/011

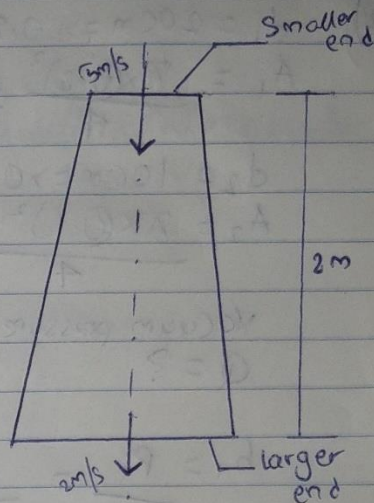
Mechatronics
Engineering

- 1) length of Conical tube = 2.0m
 $v_1 = 5 \text{ m/s}$
 $v_2 = 2 \text{ m/s}$
Pressure head of smaller end = 2.5m

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

$$\text{loss of head} \Rightarrow \frac{0.35 \times (5 - 2)^2}{2 \times 9.81} = \frac{0.35(3)^2}{19.62}$$

$$h_L = 0.160 \text{ m}$$



The pressure at Larger end $\Rightarrow \frac{P_2}{\rho}$

Applying Bernoulli's equation for conical tube

$$\frac{P_1}{\rho} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho} + \frac{v_2^2}{2g} + z_2 + h_L$$

$$z_1 = 2 \text{ m}, z_2 = 0$$

$$2.5 + \frac{5^2}{2 \times 9.81} + 2 = \frac{P_2}{\rho} + \frac{2^2}{2 \times 9.81} + 0 + 0.160$$

$$2.5 + 1.27 + 2 = \frac{P_2}{\rho} + 0.203 + 0.160$$

$$5.77 = \frac{P_2}{\rho} + 0.363$$

$$\frac{P_2}{\rho} = 5.77 - 0.363$$

head at Larger end $= \frac{P_2}{\rho} \Rightarrow 5.41 \text{ m}$

$$2) \quad d_1 = 20\text{cm} \Rightarrow 0.2\text{m (inlet)}$$

$$A_1 = \frac{\pi \times (0.2)^2}{4} = 0.03142\text{m}^2$$

$$c_d = 0.98$$

$$P_1 = 17.658\text{N/cm}^2$$

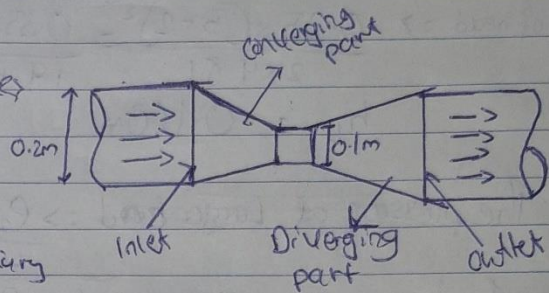
$$\Rightarrow \frac{17.658}{10^{-4}} = 176580\text{N/m}^2$$

$$d_2 = 10\text{cm} \Rightarrow 0.1\text{m (throat)}$$

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

Vacuum pressure = 30cm Hg \Rightarrow 0.3m Hg
 $Q = ?$

$$h_1 = \frac{P_1}{\rho g} = \frac{176580}{9.81 \times 1000} \Rightarrow 18\text{m}$$



$$h_2 = \frac{P_2}{\omega} = -0.3\text{m of mercury}$$

$$\Rightarrow -0.3 \times 13.6 = -4.08\text{m of water}$$

$$h = \frac{P_1}{\omega} - \frac{P_2}{\omega} \Rightarrow 18 - (-4.08) = 22.08\text{m}$$

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

$$Q = \frac{0.98 \times 0.03142 \times 0.00785 \sqrt{2 \times 9.81 \times 22.08}}{\sqrt{0.03142^2 - 0.00785^2}}$$

$$Q \Rightarrow \frac{2.42 \times 10^{-4}}{\sqrt{9.26 \times 10^{-4}}}$$

$$Q \Rightarrow \frac{5.037 \times 10^{-3}}{0.0304} = 0.166\text{m}^3/\text{s}$$

$$3) \quad d_0 = 15\text{cm} = 0.15\text{m}$$

$$d_1 = 30\text{cm} = 0.30\text{m}$$

$$A_0 = \frac{\pi \times 0.15^2}{4} = 0.0177\text{m}^2$$

$$A_1 = \frac{\pi \times 0.3^2}{4} = 0.07\text{m}^2$$

$$C_d = 0.64$$

$$\text{S.g. of oil} = 0.9$$

Reading of differential manometer

$$y = 50\text{cm Hg}$$

$$\Rightarrow 0.5\text{m Hg}$$

$$h = y \left[\frac{S_m}{S_o} - 1 \right] = 0.5 \left[\frac{13.6}{0.9} - 1 \right]$$

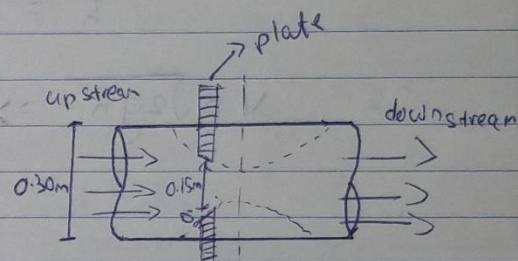
$$h = 7.05\text{m}$$

$$Q = C_d A_0 \times A_1 \sqrt{\frac{2gh}{A_1^2 - A_0^2}}$$

$$Q = \frac{0.64 \times 0.0177 \times 0.07 \times \sqrt{2 \times 9.81 \times 7.05}}{\sqrt{0.07^2 - 0.0177^2}}$$

$$Q \Rightarrow \frac{7.929 \times 10^{-4} \times 138.32}{\sqrt{4.59 \times 10^{-3}}}$$

$$Q \Rightarrow \frac{9.326 \times 10^{-3}}{0.068} \Rightarrow 0.137\text{m}^3/\text{s}$$



4) Reading from Differential manometer = ~~0.17~~ 170 mm Hg = 0.17 m Hg
Specific gravity of mercury is 13.6
Specific gravity of sea water = 1.026

$$h = y \left[\frac{s_m}{s_L} - 1 \right]$$

$$h = 0.17 \left[\frac{13.6}{1.026} - 1 \right]$$

$$h \Rightarrow 0.17 [12.26]$$

$$h = 2.084 \text{ m}$$

$$V = \sqrt{2gh} \Rightarrow \sqrt{2 \times 9.81 \times 2.084} = \sqrt{40.84}$$
$$\Rightarrow 6.39 \text{ m/s}$$

$$b) \text{ actual flow rate} = 5 \text{ dm}^3/\text{min} = 5 \text{ l/min}$$

cos

$$P = 15 \text{ bar} \quad \text{Speed} = 1700 \text{ rpm} \quad \text{Displacement} = 10 \text{ cc/rev}$$

$$\text{Torque} = 15 \text{ Nm}, \quad \text{volumetric Efficiency} = \frac{\text{Theoretical flow}}{\text{Actual flow}} \times 100$$

$$\text{Theoretical flow} \Rightarrow \text{Displacement} \times \text{Speed}$$

$$\text{but } 10 \text{ cm}^3/\text{rev} = 10 \times 10^{-3} = 0.01 \text{ l/rev}$$

$$\text{Theoretical flow} = 0.01 \times 1700 \Rightarrow 17 \text{ l/min}$$

$$\text{volumetric efficiency} = \frac{5}{17} \times 100 \Rightarrow 0.294 \times 100$$
$$\Rightarrow 29.4\%$$

$$b) \text{ Fluid power} \Rightarrow \frac{\overset{(P)}{\text{Pressure}} \times \overset{(Q)}{\text{Actual flow}}}{600} \quad \begin{array}{l} P \text{ in bar} \\ Q \text{ in l/min} \end{array}$$
$$= \frac{15 \times 5}{600} \Rightarrow 0.125 \text{ kW} \Rightarrow 125 \text{ W}$$

$$c) \text{ shaft power} = \frac{\text{fluid power}}{\text{efficiency of pump}} \Rightarrow \frac{125}{0.294} = 425.17 \text{ W}$$

General/Overall Efficiency

$$= \text{volumetric eff} \times \text{hydraulic/mechanical efficiency}$$

$$\text{Hydraulic efficiency} = \frac{\text{Theoretical torque} \times \cancel{20\pi}}{\text{Actual torque}}$$

$$\text{Theoretical torque} = \frac{\text{Displacement} \times \text{Pressure}}{20\pi}$$

$$\Rightarrow \frac{10 \times 15}{20 \times 3.142} \Rightarrow 2.39 \text{ Nm}$$

$$\text{Hydraulic/mechanical eff} \Rightarrow \frac{2.39}{15} = 0.16$$

$$\text{overall efficiency} = 0.294 \times 0.160 \times 100 \\ \Rightarrow \underline{\underline{4.7\%}}$$