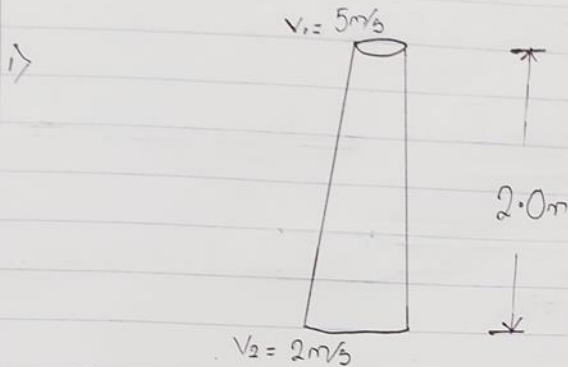


NAME - IZUCHUKWU CHIDERA VICTOR
~~18/ENG05/024~~ - 18/ENG05/024
 DEPT - MECHATRONICS
 COURSE TITLE - FLUID MECHANICS



Length $l = 2.0 \text{ m}$

v_1 (velocity of flow at smaller end) = 5 m/s

v_2 (at lower end) = 2 m/s

Pressure Head $\left(\frac{P_1}{\rho}\right) = 2.5 \text{ m}$ of liquid at smaller end

Pressure Head at $\left(\frac{P_2}{\rho}\right) = ?$ lower end

$$H_L = \text{Loss of Head} = \frac{0.35(v_1 - v_2)^2}{2 \times 9.81} = \frac{0.35(5 - 2)^2 \times 9.81}{2 \times 9.81} = 0.16 \text{ m}$$

Applying Bernoulli's Equation,

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

$z_1 = 2 \text{ m}$

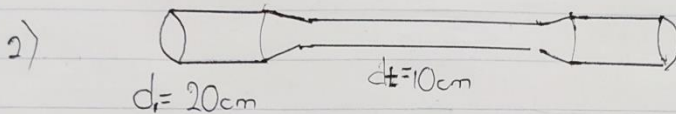
$z_2 = 0$

$$\Rightarrow 2.5 + 2 + \frac{5^2}{2(9.81)} = \frac{P_2}{\rho} + 0 + \frac{2^2}{2(9.81)} + 0.16$$

$$5.77 = \frac{P_2}{\omega} + 0.364$$

$$\frac{P_2}{\omega} = 5.77 - 0.364 = 5.406 \text{ m of liquid}$$

\therefore Pressure head at lower End = 5.406 m of liquid



Inlet diameter, $d_i = 20 \text{ cm} = 0.2 \text{ m}$

$$A_i = \frac{\pi d_i^2}{4} = \frac{\pi (0.2)^2}{4} = 0.0314 \text{ m}^2$$

Throat diameter, $d_t = 10 \text{ cm} = 0.1 \text{ m}$

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

$$P_i \text{ (Pressure at Inlet)} = 17.658 \text{ N/cm}^2 \\ = 176580 \text{ N/m}^2 = 17.658 \times 10^4 \text{ N/m}^2$$

$$P_t \text{ (Pressure at throat)} = +30 \text{ cm of mercury}$$

~~$= 0.3 \times 13.6$~~

$$C_d = 0.98$$

$$\Rightarrow \frac{P_i}{\omega} = \frac{17.658 \times 10^4}{1000 \times 9.81} = 18 \text{ m of water}$$

$$\Rightarrow \frac{P_t}{\omega} = -0.3 \times 13.6 = -4.08 \text{ of water}$$

where s.g. of mercury = 13.6
s.g. of water = 1

$$\begin{aligned} \text{Differential head, } h &= \frac{P_1}{\omega} - \frac{P_2}{\omega} \\ &= 18 - (-4.06) \\ &= 22.06 \text{ m} \end{aligned}$$

Discharge for a Venturimeter :

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

$$= \frac{0.98 \times 0.0314 \times 0.00785 \sqrt{2 \times 9.81 \times 22.06}}{\sqrt{0.0314^2 - 0.00785^2}}$$

$$= \frac{5.0278 \times 10^{-3}}{0.0304}$$

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

3) Orifice diameter, $d_o = 15 \text{ cm} = 0.15 \text{ m}$
 $A_o = \frac{\pi (0.15^2)}{4} = 0.01767 \text{ m}^2$

Diameter of pipe, $d_i = 30 \text{ cm} = 0.3 \text{ m}$
 $A_i = \frac{\pi (0.3^2)}{4} = 0.07068 \text{ m}^2$

Differential manometer reading = 50 cm of mercury
 S.g of oil = 0.9
 $C_d = 0.64$

$$\Rightarrow \text{Differential head, } h = x \left[\frac{s_g - 1}{s_{oil}} \right]$$

where s.g of mercury = 13.6

$$h = 0.50 \left[\frac{13.6 - 1}{0.9} \right] = 7.055 \text{ m of oil}$$

$$\Rightarrow \text{Rate of flow, } Q = \frac{C_d A_0 A_1 \sqrt{2gh}}{\sqrt{A_1^2 - A_0^2}}$$

$$Q = \frac{0.64 \times 0.01767 \times 0.07068 \sqrt{2 \times 9.81 \times 7.055}}{\sqrt{0.07068^2 - 0.01767^2}}$$

$$Q = \frac{9.404 \times 10^{-3}}{0.0684} = 0.137 \text{ m}^3/\text{s} = \underline{\text{Ans}}$$

4) Submarine is 15m below the surface of water
 Difference of mercury level, $x = 170 \text{ mm} = 0.17 \text{ m}$
 Speed of submarine = ?

$$S_g = \text{Sp.gr of mercury} = 13.6$$

$$S_o = \text{Sp.gr of sea water} = 1.026$$

$$\text{Differential head, } h = x \left[\frac{S_g - 1}{S_o} \right]$$

$$= 0.17 \left(\frac{13.6 - 1}{1.026} \right) = 2.0834 \text{ m of water}$$

Velocity / Speed of submarine

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

$$= \sqrt{2 \times 9.81 \times 2.0834}$$

$$= 6.393 \text{ m/s} = \underline{\text{Ans}}$$

$$5) \quad Q = 5 \text{ dm}^3/\text{min}$$

$$= \frac{5 \times 0.001}{60} = 8.33 \times 10^{-5} \text{ m}^3/\text{s}$$

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

$$\text{Speed of rotation} = 1700 \text{ rev/min} = 1700/60 = 28.33 \text{ rev/s}$$

$$\text{Normal displacement} = 10 \text{ cm}^3/\text{rev}$$

$$= 1 \times 10^{-5} \text{ m}^3/\text{rev}$$

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

$$1) \quad \text{Volumetric Efficiency} = \frac{Q}{\text{Ideal Flow Rate}}$$

$$\text{Ideal Flow rate} = \text{Normal displacement} \times \text{speed}$$

$$= (1 \times 10^{-5}) \times 28.33$$

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

$$\text{Volumetric Efficiency} = \frac{8.33 \times 10^{-5} \text{ m}^3/\text{s}}{2.833 \times 10^{-4} \text{ m}^3/\text{s}}$$

$$= 0.294$$

$$= 29.4\% \quad \underline{\underline{\text{Ans}}}$$

$$\begin{aligned}\text{ii) Fluid Power} &= Q \times \Delta P \\ &= (8.33 \times 10^{-5}) \times (15 \times 10^5) \\ &= 124.95 \text{ W} = \underline{\text{Ans}}\end{aligned}$$

$$\begin{aligned}\text{iii) Shaft Power} &= 2\pi T \times \text{speed of rotation} \\ &= 2\pi \times 15 \times 28.33 \\ &= 2670.04 \text{ W} = \underline{\text{Ans}}\end{aligned}$$

$$\begin{aligned}\text{iv) Overall Efficiency} &= \frac{\text{Fluid Power}}{\text{Shaft Power}} \\ &= \frac{124.95}{2670.04} \\ &= 0.0468 \\ &= 4.68\% = \underline{\text{Ans}}\end{aligned}$$