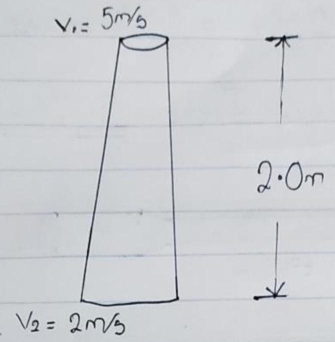
IZUCHUKWU CHIDERA VICTOR
18/ENGO5/024
MECHATRONICS

NAME - IZUCHUKWU CHIDERA VICTOR
[illegible] - 18/ENG05/024
DEPT - MECHATRONICS
COURSE TITLE - FLUID MECHANICS

i)



Length $L = 2{\cdot}0m$

V_1 (velocity of flow at smaller end) = 5m/s

V_2 (at lower end) = 2m/s

Pressure Head $\left(\frac{P_1}{\omega}\right)$ = 2·5m of liquid at smaller end

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

$$H_L = \text{Loss of Head} = \frac{0{\cdot}35(V_1 - V_2)^2}{2g}$$

$$= \frac{0{\cdot}35\,(5-2)^2}{2 \times 9{\cdot}81} = 0{\cdot}16m$$

Applying Bernoulli's Equation,

$$\frac{P_1}{\omega} + Z_1 + \frac{V_1^2}{2g} = \frac{P_2}{\omega} + Z_2 + \frac{V_2^2}{2g} + H_L$$

$Z_1 = 2m$

$Z_2 = 0$

$$\Rightarrow \quad 2{\cdot}5 + 2 + \frac{5^2}{2(9{\cdot}81)} = \frac{P_2}{\omega} + 0 + \frac{2^2}{2(9{\cdot}81)} + 0{\cdot}16$$

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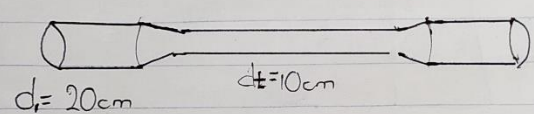
$$5.77 = \frac{P_2}{\omega} + 0.364$$

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

$\therefore$ Pressure Head at Lower End = **5.406m of Liquid**

2)



Inlet diameter, d_1 = 20cm = 0.2m

$$A_1 = \frac{\pi d^2}{4} = \frac{\pi (0.2)^2}{4} = 0.0314\text{ m}^2$$

Throat diameter, d_t = 10cm = 0.1m

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

P_1 (Pressure at Inlet) = 17.658 N/cm²
= 176580 N/m² = 17.658×10^4 N/m²

P_t (Pressure at throat) = + 30cm of mercury
~~= 0.3 × 13.6 =~~

$C_d = 0.98$

$$\Rightarrow \frac{P_1}{\omega} = \frac{17.658 \times 10^4}{1000 \times 9.81} = 18\text{m of water}$$

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

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

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Differential Head, $h = \frac{P_1}{\omega} - \frac{P_t}{\omega}$

$= 18 - (-4.08)$

$= 22.08\,m$

Discharge for a Venturimeter :

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

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

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

$$= 0.165\ m^3/s \quad = \underline{ANS}$$

3) Orifice diameter, $d_0 = 15cm = 0.15m$

$A_0 = \frac{\pi (0.15^2)}{4} = 0.01767\,m^2$

Diameter of pipe, $d_1 = 30cm = 0.3m$

$A_1 = \frac{\pi (0.3^2)}{4} = 0.07068\,m^2$

Differential manometer reading = 50cm of mercury

S.g of oil = 0.9

$C_d = 0.64$

$\Rightarrow$ Differential Head, $h = x \left[\frac{S_g}{S_{oil}} - 1 \right]$

where S.g of mercury = 13.6

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

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

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

$$Q = \frac{9.404 \times 10^{-3}}{0.0684}$$

$$= 0.137\ m^3/s = \underline{ANS}$$

4) Submarine is 15m below the surface of water
Difference of mercury level, $x =$ 170mm $= 0.17$m
Speed of submarine = ?
S_g = Sp.gr of mercury = 13.6
S_o = Sp.gr of sea water = 1.026

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

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

Velocity / Speed of submarine

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

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

$$= 6.393\ m/s = \underline{ANS}$$

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5) $Q = 5\,dm^3/min$

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

Pressure Charge, $\Delta P = 15\ bar = 15 \times 10^5\ N/m^2$

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

Normal displacement $= 10\,cm^3/rev$

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

Torque Input $= 15Nm$

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

Ideal Flow rate $=$ Normal displacement $\times$ speed

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

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

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

$= 0.294$

$= 29.4\%$ = ANS

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II) Fluid Power $= Q \times \Delta P$

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

$= 124.95\ W$ = ANS

III) Shaft Power $= 2\pi T \times$ speed of rotation

$= 2\pi \times 15 \times 28.33$

$= 2670.04\ W$ = ANS

iv) Overall Efficiency $= \dfrac{\text{Fluid Power}}{\text{Shaft Power}}$

$= \dfrac{124.95}{2670.04}$

$= 0.0468$

$= 46.8\%$ = ANS