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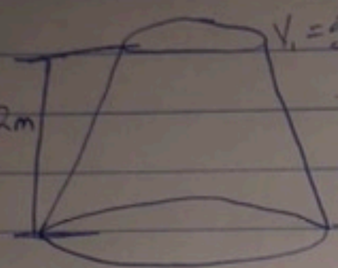
18/ENG06/045
Mechanical Engineering
ENG 2 (Fluid mechanics)

1)



$P_{T_1} = \frac{P_1}{w} = 2.5m$

$H_L = \frac{0.35(V_1 - V_2)^2}{2g}$

using Bernoill's equation, $\frac{P_2}{w} = ?$

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

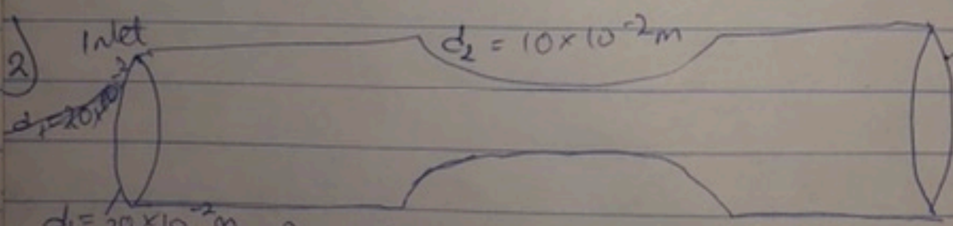
$\therefore \frac{P_2}{w} = \frac{P_1}{w} + \left[\frac{V_1^2 - V_2^2}{2g}\right] + \left[Z_1 - Z_2\right] - H_L$

$\frac{P_2}{w} = 2.5 + \left[\frac{5^2 - 2^2}{2\times 9.81}\right] + 2 - \frac{0.35(5-2)^2}{2\times 9.81}$

$\frac{P_2}{w} = 5.409m$

$\therefore$ The pressure head at the lower end = 5.409m

2)



$P_1 = 17.658 N/cm^2 = 17.658\times 10^4 N/m^2$, $Cd = 0.98$

$P_2 = 300cmHg = 300\times 10^{-2} mHg$ $Q = ?$

$A_1 = \frac{\pi\times(20\times 10^{-2})^2}{4}$, $A_2 = \frac{\pi\times(10\times 10^{-2})^2}{4}$

$A_1 = 0.03m^2$, $A_2 = 7.85\times 10^{-3} m^2$

$\frac{P_2}{w} = 0.3\times 13.6 = ~~4.08~~$ 4.08 mHg

$= -4.08 mHg$ (since vaccum pressure)

$$\frac{P_1}{\omega} = \frac{17.058 \times 10^4}{9.81 \times 10^3} = 18 m Hg$$

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

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

$$Q = \frac{0.98 \times 0.03 \times (7.85 \times 10^{-3}) \times \sqrt{2 \times 9.81 \times 22.08}}{\sqrt{(0.03^2 - (7.85 \times 10^{-3})^2}}$$

$$Q = 0.166 m^3/s$$

3) $d_o = 15 \times 10^{-2} m$ | $d_1 = 30 \times 10^{-2} m$ | $C_d = ~~0.66~~ 0.64$

$A_o = \frac{\pi \times (15 \times 10^{-2})^2}{4} = 0.0177 m^2$ | $y = 50 \times 10^{-2} m Hg$ | $Q = ?$

S.G of oil $= 0.9$ | $S_{hi} = 13.6$

$A_1 = \frac{\pi \times (30 \times 10^{-2})^2}{4} = 0.0707 m^2$ | $H = y\left(\frac{S_{hi}}{S_o} - 1\right)$ | $S_o = 0.9$

$$H = 50 \times 10^{-2} \left[\frac{13.6}{0.9} - 1\right]$$

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

$$H = 7.055 m$$

$$Q = \frac{0.64 \times 0.0177 \times 0.0707 \sqrt{2 \times 9.81 \times 7.055}}{\sqrt{0.0177^2 - 0.0707^2}}$$

$$Q = 0.137 m^3/s$$

4) $y = 170 mm Hg = 170 \times 10^{-3} m Hg$

S.g of mercury $= 13.6 Hg$

S.g of Sea water $= 1.026$

$$H = y \times \left(\frac{S_{hi}}{S_o} - 1\right)$$

$$H = 170 \times 10^{-3} \times \left(\frac{13.6}{1.026} - 1\right)$$

$$H = 208$$

$$\therefore V = \sqrt{2gH}$$

$$V = \sqrt{2 \times 9.81 \times 2.08}$$

$$V = \sqrt{6.39} m/s$$

Name:

5) Actual flowrate (Q) = 0.05 m^3 = 5 dm^3/min = 8.33×10^{-5} m^3/sec

P = 15 bar = 15×10^5 N/m^3

V = 1700 rev/min = 28.33 rev/sec

T = 15 N/m, Normal displacement = 10 cm^3/rev = 1×10^{-5} m^3/rev

1) Volumetric efficiency

$$\frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100\%$$

Ideal flowrate = displacement × Velocity

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

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

∴ Volumetric Efficiency = $\frac{8.33 \times 10^{-5}}{2.833 \times 10^{-4}} \times 100$

= 29.4%

2) Fluid power = $(Q \times \Delta P)$

= $8.33 \times 10^{-5} \times 15 \times 10^5$ = 12495 watts

3) Shaft power = $T \times \omega$

$\omega = 2 \times \pi \times V$

$\omega = 2 \times \pi \times 28.33$ = 178 watts/sec

Shaft power = $T \times \omega$

= 15×178

= 2670 watts

4) Overall Efficiency =

$$= \frac{\text{Fluid power}}{\text{Shaft power}} \times 100\%$$

$$= \frac{124.95}{2670} \times 100$$

= 4.68%