

NO 1

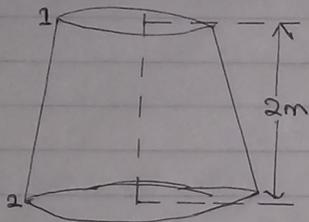
Given: $V_1 = 5 \text{ ms}^{-1}$, $V_2 = 2 \text{ ms}^{-1}$
 $L: z_1 - z_2 = 2 \text{ m}$

$\frac{P_1}{w} = 2.5 \text{ m of liquid}$

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

$$= \frac{0.35(5-2)^2}{2 \times 9.81}$$

$h_f = 0.16$



$$\frac{P_1}{w} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{w} + \frac{V_2^2}{2g} + z_2 + h_f$$

Applying Bernoulli's eqn at point 1 & 2

$$\frac{P_2}{w} = \frac{P_1}{w} + \frac{(V_1^2 - V_2^2)}{2g} + (z_1 - z_2) - h_f$$

$$= 2.5 + \frac{(5^2 - 2^2)}{2 \times 9.81} + 2 - 0.16$$

$= 2.5 + 3.07 - 0.16$

$\frac{P_2}{w} = 5.41 \text{ m of liquid}$

Or

$P_2 = 5.41 \text{ m} \times 9810 \text{ Nm}^{-2}$

$= 53072.1 \text{ Nm}$

$P_2 = 0.53 \text{ bar}$

NO 2

Given:

Inlet diameter (D_1): $20 \text{ cm} = 0.2 \text{ m}$

Area at inlet $A_1 = \frac{\pi}{4} 0.2^2$

$A_1 = 0.0314 \text{ m}^2$

Throat diameter (D_2)
 $= 10 \text{ cm} = 0.1 \text{ m}$

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

Pressure at inlet

$P_1 = 17.658 \text{ kN/m}^2$
 $= 176.58 \text{ kN/m}^2$

Pressure head $\frac{P_1}{w}$

$= \frac{176.58}{9.81}$

$\frac{P_1}{w} = 18 \text{ cm}$

Pressure head at Throat

$\frac{P_2}{w} = -30 \text{ cm of mercury}$

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

Differential head

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

$h = 22.08 \text{ m}$

Rate of flow Q

Using the relation

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

$$= 0.9 \frac{0.031 \times 0.00785}{\sqrt{0.031^2 - 0.00785^2}} \times \sqrt{2 \times 9.81 \times 22.08}$$

$= 0.9 \times \frac{2.43 \times 10^{-4}}{0.0299} \times 20.81$

$= 0.9 \times 8.12 \times 10^{-3} \times 20.81$

$Q = 0.15 \text{ m}^3 \text{ s}^{-1}$

NO 3

Given:

Diameter of pipe (D_1): $30 \text{ cm} = 0.3 \text{ m}$

Area of pipe $A_1 = \frac{\pi}{4} \times 0.3^2$
 $= 0.0707 \text{ m}^2$

Diameter of orifice

$(D_0) = 15 \text{ cm} = 0.15 \text{ m}$

Area of orifice $A_0 = \frac{\pi}{4} \times 0.15^2$

$= 0.0177 \text{ m}^2$

$C_d = 0.64$

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

$0.64 \frac{0.0177 \times 0.0707 \sqrt{2 \times 9.81 \times 7.055}}{\sqrt{(0.0707^2 - 0.0177^2)}}$

$Q = \frac{1.25 \times 10^{-2} \times 11.765}{0.0684} \times 0.64$

$= 0.64 \times 0.215$

$Q = 0.1376 \text{ m}^3 \text{ s}^{-1}$

$h = y \left[\frac{S_{H1}}{S_0} - 1 \right]$

S_{H1} = Specific gravity of heavier liquid

$= 13.6$

y = reading of differential manometer

i.e. 50 cm

y = 0.5 m of mercury

$S_0 = 0.9$

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

$= 0.5 \times 14.11$

$h = 7.055$

NO 4

Reading of the manometer (y)
 $= 170 \text{ mm} = 0.17 \text{ m of mercury}$

Sp. gravity of mercury, $S_{H1} = 13.6$

" " seawater, $S_1 = 1.025$

$h = y \left[\frac{S_{H1}}{S_1} - 1 \right]$

$h = 0.17 \left[\frac{13.6}{1.025} - 1 \right]$

$$h = 0.17 \times 12.27$$

$$h = 2.08$$

∴ Velocity of submarine

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

$$= \sqrt{2 \times 9.81 \times 2.086}$$

$$v = 6.4 \text{ ms}^{-1}$$

NR 5

Given

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

Actual flow rate = $0.005 \text{ m}^3/\text{min}$

$$Q = \frac{0.005}{60} = 8.33 \times 10^{-5} \text{ m}^3/\text{s}$$

Pressure change ΔP

$$= 15 \times 10^5 \text{ N}$$

Speed (n) = $1700 \text{ rev}/\text{min}$

$$\frac{1700 \times 2\pi}{60 \text{ s}}$$

$$n = 28.3 \text{ rev}/\text{sec}$$

normal displacement (m^3/rev)

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

$$100^3 \text{ cm}^3 = 1^3 \text{ m}^3$$

$$10^6 \text{ cm}^3 = 1 \text{ m}^3$$

$$10^5 \text{ cm}^3 = 10^{-5} \text{ m}^3$$

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

ideal flow rate

normal displacement \times speed

$$= 10^{-5} \times 28.3$$

$$= 2.83 \times 10^{-4} \text{ m}^3/\text{s}$$

i) Volumetric Efficiency

$$= \frac{Q}{\text{ideal F.R.}} \times 100$$

$$= \frac{0.33 \times 10^{-5}}{2.83 \times 10^{-4}} \times 100$$

$$v_e = 29.48\% \quad v_e = 29.44\%$$

$$ii) Pf = Q \cdot \Delta P$$

$$= 0.33 \times 10^{-5} \times 15 \times 10^5$$

$$= 12495 \text{ W or Watts}$$

$$= 124.95 \text{ kW} \approx 125 \text{ kW}$$

iii) shaft power = $T \times \omega$

$$T = \text{Torque input (Nm)}$$

$$\omega = \text{angular speed (rad/sec)}$$

$$T = 15 \text{ Nm} \quad \omega = 2\pi n$$

$$n = 28.3 \text{ rev/sec}$$

$$\omega = 2\pi \times 28.3$$

$$= 177.8 \text{ rad/sec}$$

$$\text{shaft power} = 15 \times 177.8$$

$$= 2667 \text{ W or kW}$$

Overall Efficiency

$$= \frac{\text{fluid power}}{\text{shaft power}} \times 100\%$$

$$= \frac{12495}{2667} \times 100\%$$

$$= 46.85\%$$

$$= 46.85\% \quad 4.68\%$$