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1. $L = 2.0m$

$V_1 = 5m/s$

$V_2 = 2m/s$, $P_1 = 2.5m$

$H_L = 0.35$

Using

$$\frac{P_1}{W} + z_1 + \frac{V_1^2}{2g} = \frac{P_2}{W} + Z_2 + \frac{V_2^2}{2g}$$

Let the loss of head, $H_L = \frac{0.35(V_1 - V_2)^2}{2g}$

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

$$= 0.161m$$

Let the Pressure head at the left end =

Applying Bernoullis Equation

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

$Z_1 = 2.0$ & $Z_2 = 0$

Input the values

$$2.5 + \frac{5^2}{2 \times 9.81} + 2.0 - \frac{2^2}{2 \times 9.81} + 0 + 0.161$$

$$P_L = 2.5 + \frac{25}{19.62} + 2 - \left(\frac{4}{19.62} + 0.161\right) = P_2$$

$$= 577.4 - 0.365 = P_2$$

$P_2 = 5.409m$ of Fluid

Using

$$Q_{actual} = \frac{C_d \cdot A_1 \cdot A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$$

$d_1 = 20cm$

$= 0.2m$

$$A_1 = \frac{3.142 \times (0.2)^2}{4} = 0.0314 m^2$$

$d^2 = 10cm$

$= 0.1m$

$$A_2 = \frac{3.142 \times (0.01)^2}{4}$$

$A_2 = 7.855 \times 10^{-3} m^2$

$P_1 = 17.658 N/cm^2$

$\therefore 0.1766 N/m^2$

Specific Gravity of Mecury = 13.6

$$\frac{P_1}{w} = \frac{P_1}{\rho g} = \frac{0.1766}{1000 \times 9.81}$$

$= 1.8 \times 10^{-5}$

Vaccum Pressure

$$\frac{P_2}{w} = \frac{0.3m}{1000 \times 9810}$$

$= 4.08m$

$h = P_1 + P_2$

$= 0.17658 + 4.08$

$= 4.2566$

$$Q_{actual} = \frac{0.98 \times 0.0314 \times 7.855 \times 10^{-3} \sqrt{2 \times 9.81 \times 4.2566}}{\sqrt{(0.0314)^2 - (7.855 \times 10^{-3})^2}}$$

$$= \frac{2.209 \times 10^{-3}}{9.2426 \times 10^{-4}} = \frac{2.209 \times 10^{-3}}{0.03040}$$

$Q_{actual} = 0.07266.$

3. $Q_{actual} = \frac{C_d \cdot A_1 \cdot A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$d_1 = 15\,cm$

$= 0.15m$

$A_1 = \frac{3.14 \times (0.15)^2}{4}$

$A_1 = 0.0177m^2$

$d_2 = 30cm$

$= 0.3m$

$A_2 = \frac{3.14 \times (0.3)^2}{4}$

$= 0.07065m^2$

$P_1 = 50cm$

$= 0.5m$

$h = P\left(\frac{S.g \text{ of Mercury}}{S.g \text{ of Oil}} - 1\right)$

$h = 0.5\left(\frac{13.6 - 1}{0.9}\right)$

$h = 0.5\left(\frac{12.6}{0.9}\right)$

$h = 7.16$

$Q = \frac{0.64 \times 0.0177 \times 0.07065\sqrt{2 \times 9.81 \times 7.16}}{\sqrt{(0.07065)^2 - (0.177)^2}}$

$Q = \frac{8.003 \times 10^{-4} \times 11.85}{0.0683}$

$= 1.3885 m^3/s$

4. Submarine diameter = 15m

Reading Difference in Manometer = 170mm

Convert to meter = 0.17m

The head is expressed as

$h = P\left(\frac{S.g \text{ of Mercury}}{S.g \text{ of Sea water}} - 1\right)$

$P = 0.17m$

$0.17\left(\frac{12.6}{1.026}\right)$

$h = 0.17 \times 12.28$

$h = 2.087m$ of Sea Water

The Speed of the Sub-marine

$V = \sqrt{2gh}$

$= 2 \times 9.81 \times 2.087$

$= 6.39m/s$

5. Volumetric Flow rate

$10dm = 1m$

$10^3 dm^3 = 1m^3$

$1000dm^3 = 1m^3$

$5dm^3 = ?$

$? = \frac{5}{1000} = 0.005$

Volumetric Flow rate: $0.005m^3/min$

Actual flow rate: $\frac{0.005}{60} =$

$= 8.33 \times 10^{-5} m^3/sec$

Speed: 1700 rpm

$\frac{1700}{60} = 28.33 rps$

$dp = 15bar = 15 \times 10^5 N/m^2$

Nominal displacement = $10cm^3/rev$

Note that $100^3 cm^3 = 1m^3$

$10cm^3 = x$

$x = \frac{10}{100^3} = 1 \times 10^{-5} m^3/rev$

ideal Flowrate = Nominal displacement × Speed

$28.33 \times 1 \times 10^{-3}$

$= 28.33 \times 10^{-4}$

i Volumetric Efficiency

$= \frac{\text{Actual Flowrate}}{\text{Ideal Flowrate}} \times 100\%$

$= \frac{8.33 \times 10^{-5}}{2.833 \times 10^{-4}}$

$= 29.4\%$

ii $P_F = Q \cdot \delta p$

$8.33 \times 10^{-5} \times 15 \times 10^{5}$

$= 124.95$ Nm/sec

iii Shaft Power = T × W

T = 15 Nm

$W = 2 \times \frac{22}{7} \times 28.33 = 178.07$ rad/sec

∴ Shaft Power = 15 × 178.07 = 2671.05 Watts

iv Overall Efficiency = $\frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100\%$

$= \frac{124.95}{2671.05} \times 100\% = 4.67\%$