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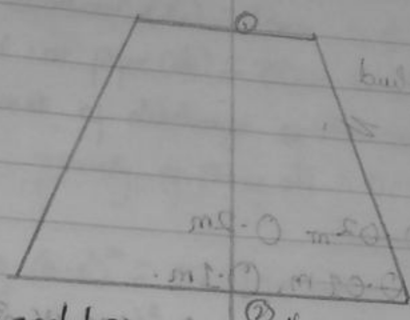
COURSE: FLUID MECHANICS (ENG 212).

1).



Let smaller end be represented by ①, and larger end be represented by ②

$l = 2.0m$, $V_1 = 5ms^{-1}$, $V_2 = 2ms^{-1}$, $P_1/\rho g = 2.5m$ of the ~~fluid~~ liquid.

① Loss of head at the tube.

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

$$= \frac{0.35(5-2)^2}{2\times9.81} = \frac{0.35(3)^2}{2\times9.81} = \frac{0.35\times9}{19.62} = \frac{3.15}{19.62}$$

$$= 0.16m$$

Pressure head $= \frac{P_1}{\rho g}$

Applying Bernoulli's equation;

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

Let the

$Z_2 = 0$, $Z_1 = 2.0$

$$2.5 + \frac{(5)^2}{2\times9.81} + 2.0 = \frac{P_2}{\rho g} + \frac{(2)^2}{2\times9.81} + 0 + 0.016.$$

$$2.5 + \frac{25}{19.62} + 2.0 = \frac{P_2}{\rho g} + \frac{4}{19.62} + 0.016.$$

$2.5 + 1.27 + 2.0 = \frac{P_2}{\rho g} + 0.203 + 0.16$

$5.77 = \frac{P_2}{\rho g} + 0.363$

$\frac{P_2}{\rho g} = 5.77 - 0.363$

$\frac{P_2}{\rho g} = 5.407$ m of fluid

2) Inlet diameter $(d_1) = 20$ cm $= 0.2$ m

Throat diameter $(d_2) = 10$ cm $= 0.1$ m.

Area of inlet $= \frac{\pi}{4} \times (0.2)^2 = 0.0314\ m^2$

Area of throat $= \frac{\pi}{4} \times (0.1)^2 = 7.85 \times 10^{-3}$ m

$C_d = 0.98$, Pressure $(P_1) = 17.658 \times 10^4\ N/m^2$, $\rho = 1000\ kg/m^3$

$\frac{P_1}{\rho g} = \frac{17.658 \times 10^4}{9.81 \times 1000} = \frac{17.658 \times 10^4}{9810} = 18$ m of water.

$\frac{P_2}{\rho g} = 80$ cm of mercury $= -0.3 \times 13.6 = -4.08$

Differential head

$h_1 = \frac{P_1}{\rho g} - \frac{P_2}{\rho g} = 18 - (-4.08)$

$= 22.08$ m. water.

$$Q = \frac{C_d \times a_1 a_2 \sqrt{2gh}}{\sqrt{(a_1)^2 - (a_2)^2}}$$

$$Q = \frac{0.98 \times 0.0314 \times 7.85 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 22.08}}{\sqrt{(0.0314)^2 - (7.85 \times 10^{-3})^2}}$$

$$Q = \frac{2.415602 \times 10^{-4} \times \sqrt{433.2096}}{\sqrt{(9.8596 \times 10^{-4}) - 6.16225 \times 10^{-5}}}$$

$$Q = \frac{2.415602 \times 10^{-4} \times 20.8136878}{\sqrt{9.243375 \times 10^{-4}}}$$

$$Q = \frac{5.0277 \times 10^{-3}}{0.0304}$$

$Q = 0.165 m$

$Q = 165.56 \text{ lt/s}$

8). Orifice diameter $(d_0) = 15cm = 0.15m$

Diameter of pipe $(d_1) = 30cm = 0.30m$

Co-efficient of discharge of the meter $= 0.64$

Specific gravity of flow of oil $= 0.9$

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

~~$A_1 = \frac{\pi}{4}(0.30)^2$~~ $\quad A_1 = \frac{\pi}{4}(0.30^2) = 0.70 \quad 0.07068 m^2$

$$H = \left(\frac{13.6}{0.9} - 1\right) \times 50cm \text{ of oil}$$

$$= (15.1 - 1) \times 0.5m$$

$$= 14.1 \times 0.5$$

$$= 7.05$$

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

$$Q = \frac{0.64 \times 0.07068 \times 0.01767 \times \sqrt{2 \times 9.81 \times 7.05}}{\sqrt{(0.07068)^2 - (0.01767)^2}}$$

$$Q = \frac{7.993 \times 10^{-4} \times \sqrt{138.321}}{\sqrt{(4.9956624 \times 10^{-3}) - (3.122289 \times 10^{-4})}}$$

$$Q = \frac{7.993 \times 10^{-4} \times 11.76}{\sqrt{4.6834335 \times 10^{-3}}}$$

$$Q = \frac{9.399768 \times 10^{-3}}{0.0684}$$

$Q = 0.137 m^3/sec$

$Q = 137 \text{ l/sec}$

10). Diff of mercury level $(x_1) = 170mm = 0.17m$

Specific gravity of sea water $= 1.026$

Specific gravity of mercury $= 13.6$

$$h = \left(\frac{13.6}{1.026} - 1\right) \times 0.17$$

$$= (13.255 - 1) \times 0.17$$

$$= 12.255 \times 0.17$$

$$= 2.083\ m$$

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

$$= \sqrt{2 \times 9.81 \times 2.083}$$

$$= \sqrt{40.8765}$$

$$V = 6.393\ ms^{-1}$$

$$\therefore V\ (km/h) = \frac{6.393 \times 60 \times 60}{1000}$$

$$= \frac{23\,004}{1000}$$

$$\therefore V = 23.004\ km/hr$$

$\therefore$ Speed of submarine = 23.004 km/hr.

5) Actual flow rate (Q) = $5 dm^3/min$ = $8.335 \times 10^{-5} m^3/sec$

Speed rotation (N) = 1700 rev/min = 28.3 rev/sec

Normal Displacement = $10 cm^3/rev$ = $1 \times 10^{-5} m^3/rev$.

Torque input = 15 Nm

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

Ideal flow rate = Normal displacement × speed rotation.

$= 1 \times 10^{-5} \times 28.3$

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

i) Volumetric ~~Equation~~ Efficiency = $\frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100\%$

$= \frac{8.33 \times 10^{-5}}{2.83 \times 10^{-4}} \times 100\%$

$= 0.2943 \times 100\%$

29.4%

ii) Fluid Power = Actual flow rate × Pressure change.

$= 8.335 \times 10^{-5} \times 15 \times 10^5$

= 124.95 Nm/sec.

iii) Shaft Power = Torque input × Angular speed

Angular Speed = 2 × π × speed of rotation

= 2×π × 28.3

= 177.8 rev/sec.

Shaft power = 15 × 177.8

= 2667.2 Nm/sec.

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

$= \frac{124.95}{2667.2} \times 100\%$

= 0.0468 × 100% = 4.68%