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Assignment

1) pressure head at smaller end = 2.5m P_1/w
length of tube = 2.0m
Velocity of flow at ~~higher~~ lower end = 5ms⁻¹ V_1
Velocity of flow at higher end = 2ms⁻¹ V_2

$$\text{loss of head} = \frac{0.35(V_1 - V_2)^2}{2g} \; h_L$$

$$\text{loss of head} = \frac{0.35(5-2)^2}{2 \times 9.81} = 0.16m$$

Pressure head at higher end, $\frac{P_2}{w}$

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

$$Z_2 = 0, \quad Z_1 = 2.0m$$

$$2.5 + \frac{5^2}{2 \times 9.8} + 2 = \frac{P_2}{w} + \frac{2^2}{2 \times 9.8} + 0.016$$

$$5.775 = \frac{P_2}{w} + 0.364$$

$\frac{P_2}{w} = 5.775 - 0.364 = 5.411m$ of liquid pressure head at higher end $= 5.411m$

Vacaum pressure at the throat

$\frac{P_2}{w} = -300mm = -0.3 \times 13.6 = -4.08m$ of water

Differential head, $h = \frac{P_1}{w} - \frac{P_2}{w} = 18.01 - (-4.08) = 22.09m$

Rate of flow, Q

Using the relation $= Q = \frac{Cd \times A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$

$Q = \frac{0.98 \times 0.0314 \times 0.00785}{\sqrt{(0.0314)^2 - (0.00785)^2}} \times \sqrt{2 \times 9.81 \times 22.09}$

$= \frac{0.000241 \times 20.82}{0.0304}$

$Q = 0.165 m^3/s$

Discharge of water through Venturimeter $= 0.165 m^3/s$

3) Orifice diameter $A_0 = 15cm = 0.15m^2$

Pipe diameter $= 30cm = 0.3m^2$

Manometer reading $= 0.5m$ of mercury

S.g of oil $= 0.9$ C.d $= 0.64$

Solution

Area of Orifice, $\frac{\pi}{4} \times 0.15^2 = 0.077m^2$

Area of pipe, $\frac{\pi}{4} \times 0.30 = 0.707m = A_1$

Differential head, $h = y\left[\frac{Sh}{So} - 1\right]$

$= 0.5\left[\frac{13.6}{0.9} - 1\right] = 7.06m$ of oil

Discharge Q:

Using the relation, $Q = Cd \times \frac{A_0 \cdot A_1 \sqrt{2gh}}{\sqrt{A_1^2 - A_0^2}}$

$Q = \frac{0.64 \times 0.707 \times 0.0177 \times \sqrt{2 \times 9.8 \times 7.06}}{\sqrt{(0.707)^2 - (0.0177)^2}}$

$= \frac{0.0942}{0.707} = 0.133 m^3/s$

Rate of oil discharge $= 0.133 m^3/s$

4) Reading of Manometer $y = 170mm = 0.17m$ mercury

Sp. gravity of mercury, $Sh = 13.6$

Sp gravity of water, $S_1 = 1.026$

To find the head, (h) using the relation

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

$L = 0.12 \left[\frac{13.6}{1.026} - 1 \right] = 2.08$

∴ Speed of the Submarine

$V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.08} = 6.38$ m/sec

5) Actual flow rate $= 0.05 m^3/ = 0.05/60 = 8.3 \times 10^{-4} m^3/s$

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

Speed of rotation $= 1700$ rev/min $= 1700/60 = 28.3$ cps

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

Torque input $= 15$ Nm

Ideal flow rate = nominal x speed displacement

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

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

i) Volumetric efficiency $= \frac{\text{Actual flow rate}}{\text{Ideal flow rate}} \times 100$

$= \frac{8.3 \times 10^{-4} \times 100}{2.83 \times 10^{-4}}$

$= 296$ %

ii) Fluid power $= Q \cdot dp$

$= 8.3 \times 10^{-4} \times 15 \times 10^5$

$= 1245$ watts

iii) Shaft Power $= T \cdot \omega$

T = torque input

ω = angular speed

$T = 15Nm$

$\omega = 2\pi N$ for rps

$\omega = \frac{2\pi N}{60}$

$\omega = 2 \times \frac{22}{7} \times 28.3 = 177.89 rad/s$

Shaft power $= 15 \times 177.89$

$= 2668.35 watts$

(v) Overall efficiency $= \frac{\text{fluid power}}{\text{shaft power}} \times 100\%$

$= \frac{1245}{2668.35} \times 100$

$= 46.66\%$