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1) Pressure head at smaller end = 2.5m
Length of tube = 2.0m
Velocity of flow at low end = $5ms^{-1}$ v_1
" " " " higher " = $2ms^{-1}$ v_2
Loss of head = $\frac{0.35(v_1 - v_2)^2}{2g}$ h_L

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

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

$$\frac{P_1}{\omega} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\omega} + \frac{V_2^2}{2g} + Z_2 + h_L \quad [Z_2 = 0, Z_1 = 2.0m]$$

$$2.5 + \frac{5^2}{2 \times 9.8} + 2 = \frac{P_2}{\omega} + \frac{2^2}{2 \times 9.8} + 0.16$$

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

$$\frac{P_2}{\omega} = 5.775 - 0.364 = 5.411m \text{ of liquid}$$

Pressure head at higher end = 5.411m

2) Inlet diameter = 20cm = 0.2m
Throat diameter = 10cm = 0.1m
Pressure at inlet = $17.658N/cm^2$ = $176.58kN/m$
30cm of mercury
Coefficient of discharge = 0.98
Soln
Area of inlet $A_1 = \frac{\pi}{4} \times 0.2^2 = 0.0314 m^2$

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

$$\frac{P_1}{\omega} = \frac{176.58}{9.8} = 18.01m$$

Vacuum pressure at the throat.

$\frac{P_2}{w} = -300m = -0.3 \times 13.6 = -4.08m$ 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, $Q = C_1 \times \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$

$= 0.98 \times \frac{0.0314 \times 0.00785}{\sqrt{(0.0314)^2 - (0.00785)^2}} \times \sqrt{2 \times 981 \times 22.09}$

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

$Q = 0.165 m^3/s$

~~3) Area~~

~~Q(3) Area of orifice diameter A_0 = 15cm = 0.15m^2~~

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

~~Manometer~~

3) Area of orifice, $\frac{\pi}{4} \times 0.15^2 = 0.0177m^2 = A_0$

Area of pipe, $\frac{\pi}{4} \times 0.3^2 = 0.707m^2 = A_1$

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

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

Discharge Q: Using the relation; $Q = C_1 \times \frac{A_0 \cdot A_1 \cdot \sqrt{2gh}}{\sqrt{A_1^2 - A_0^2}}$

$Q = \frac{0.64 \times 0.707 \times 0.0177 \times \sqrt{2 \times 9.8 \times 7.06}}{\sqrt{(0.707)^2 - (0.0177)^2}} = \frac{0.0942}{0.707} = 0$

4) ~~Reading of~~ Using the relation; $h = y\left[\frac{S_m}{S_l} - 1\right]$

$h = 0.17\left[\frac{13.6}{1.026} - 1\right] = 2.08$

∴ Speed of the submarine,

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

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

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

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

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

Torque input = 15Nm

Ideal flow rate = normal × speed displacement

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

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

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

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

$= 296\%$

ii) Fluid power $= Q \cdot \Delta p$

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

= 1245 watts or Nm/sec

iii) ~~Fluid power~~ Shaft power = $T \cdot \omega$ [T = Torque input, ω = angular speed] T = 15Nm,

T = 15Nm

$\omega = 2\pi N$ for rps

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

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

Shaft power $= 15 \times 177.89$

= 2668.35 watts

iv) Overall efficiency = $\frac{\text{Fluid power}}{\text{Shaft power}} \times 100$

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

$= 46.66\%$