i) Pressure head at smaller end = 2.5m P_1/w

Length of tube = 2.0m

Velocity of flow at lower end = $5ms^{-1}$ V_1

" " " " higher " = $2ms^{-1}$ V_2

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

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

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

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

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

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

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

$\frac{P_2}{w}$ = 5.775 − 0.304 = 5.411m of liquid

Pressure head at higher end = 5.411m

Vacuum 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 relations $Q = \frac{Cd \times A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$

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

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

$Q = 0.165 m^3/s$

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

3) Orifice diameter A_o = 15cm = 0.15m²
Pipe diameter = 30cm = 0.3m²
Manometer reading = 0.5m of mecury
Sg of oil = 0.9 Cd = 0.64

Solution

Area of ~~pipe~~ Orifice, $\frac{\pi}{4} \times 0.15^2 = 0.0177m^2$

Area of pipe, $\frac{\pi}{4} \times 0.30^2 = 0.707m^2 = A_1$

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

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

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

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

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

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

4) Reading of manometry y = 170 mm = 0.17m mecury
Sp. gravity of mecury, S_{hL} = 13.6
Sp gravity of ~~S~~ sea water, S_1 = 1.026
To find the head, (h) using the relation:

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

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

∴ Speed of the submarine
$V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.08} = 6.38m/s$

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

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

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

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

Torque input $= 15 Nm$

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 $= Q \cdot dp$

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

$= 1245$ watts

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

$T =$ torque input

$\omega =$ angular speed

$T = 15 Nm$

$\omega = 2\pi N$ 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

iv) Overall efficiency $= \frac{\text{fluid Power}}{\text{Shaft power}} \times 100\%$

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

$= 46.66\%$