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Question 1

length of tube $l = 2m$
V at small end $= 5m/s$
V at lower end $= 2m/s$
P head at smaller end $\frac{P_1}{\rho g} = 2.5m$

$$\text{Head loss} = \frac{0.35(V_1 - V_2)^2}{2g}$$

$$h_2 = \frac{0.35(5-2)^2}{2 \times 9.81} = 0.16m$$

Apply Bernoullis at section (1) and 2

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + h_2 \quad -(1)$$

let datum be at section 2 $\therefore Z_1 = 2m, \; Z_2 = 0$

Put values in eqn (1)

$$2.5 + \frac{(5)^2}{2 \times 9.81} + 2 = \frac{P_2}{\rho g} + \frac{2^2}{2 \times 9.81} + 0 + 0.16$$

$$2.5 + 1.27 + 2 = \frac{P_2}{\rho g} + 0.203 + 0.16$$

$\frac{P_2}{\rho g}$ = (2.5 + 1.27 + 20) − (0.203 + 0.16)

= 5.77 − 0.363 = 5.407m of fluid

Question 2

d at inlet d_1 = 20 cm

Area at inlet A_1 = $\frac{\pi}{4} \times (20)^2$ = 314.16 cm^2

d at throat d_2 = 10 cm

Area of throat A_2 = ~~10cm~~ $\frac{\pi}{4} \times (10)^2$ = 78.79 cm^2

Discharge Q is given by

$$Q = \frac{Cd\, a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$$

Cd = 0.98

h is difference between throat and inlet

Pressure at inlet P_1 = 17.658 × 10^4 N/m^2

Water $\frac{P_1}{\rho g}$ = $\frac{17.658 \times 10^4}{9.81 \times 100}$ = 18m of water

Pressure at throat $\frac{P_2}{\rho g}$ = −0.3m of mercury

= −0.3 × 13.6 = −4.08 of water

differential head h $= \frac{P_1}{\rho g} - \frac{P_2}{\rho g}$

$= 18 - (-4.08)$

$= 22.08m$ of water or 2208 cm

In equ (2)

$$Q = 0.98 \times \frac{314.16 \times 78.54}{\sqrt{(314.16)^2 - (78.54)^2}} \times \sqrt{2 \times 9.81 \times 22.08}$$

$Q = 165483.3\ cm^3/s$

$Q = 165.48 l/s$

Question 3

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

$$h = y\left(\frac{\rho_m}{\rho_f} - 1\right)$$

$$h = \frac{50}{100}\left(\frac{13.6}{0.9} - 1\right) = 7.05m$$

$$Q = \frac{0.64 \times \pi/4\ (0.3)^2 \times \pi/4 \times (0.15)^2 \times \sqrt{2 \times 9.81 \times 7.05}}{\sqrt{(\pi/4\ (0.3)^2)^2 - (\frac{\pi}{4}(0.15)^2)^2}}$$

$Q = 0.13742 m^3/sec$

Question 4

$h = y\left[\frac{\rho_m}{\rho_f} - 1\right]$

ρ_m = density of mercury
ρ_f = density of flowing fluid
y = manometer reading

$= \frac{170}{1000}\left(\frac{13.6}{1.026} - 1\right)$

$h = 2.083m$

V = velocity of submarine

$V = \sqrt{2gh}$

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

$= 6.393 m/s$

Question 5

Flow rate Q = $50 dm^3/min$
Pressure change (ΔP) = 15 bar
Speed = 1700 rpm
Nominal displacement = $10 cm^3/rev$
Torque input T = 15Nm

Ideal flow rate = Nominal displacement x Speed

$= 10 cm^3/rev \times 1700 rpm$

$= 17000 cm^3/min = 17 dm^3/min$

Volumetric efficiency = $\frac{\text{Actual flow}}{\text{Ideal flow}}$

$= \frac{0.05}{0.017}$

$= 2.9411$ or 294.11%

11 $Q = \frac{0.05}{60}$ m^3/sec = 83.3×10^{-5} m^3/sec

$\Delta P = 15 \times 10^5$ N/m^2

Fluid power = $\Delta P \times Q$ = 83.3×10^{-5} m^3/sec $\times$ 15×10^5 N/m^2
= 1250 watts

Shaft power = $\frac{2\pi NT}{60}$ = $\frac{2\pi \times 1700 \times 15}{60}$
= 2670.354 watts

Overall Efficiency = $\frac{\text{fluid power}}{\text{shaft power}}$
= $\frac{1250}{2670.354}$
= 0.4681

Overall Efficiency = 46.81%