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18/ENG03/003
Civil Engineering

1) Given: Length of tube $L = 2m$

Velocity at smaller end $V_1 = 5m/s$

velocity at lower end $V_2 = 2m/s$

pressure head at smaller end $= \frac{P_1}{\rho g} = 2.5m$

Head loss $= \frac{0.35(V_1 - V_2)^2}{2g} \Rightarrow \frac{0.35(5-2)^2}{2 \times 9.81}$

$h_L = 0.16m$

Applying Bernoulli's equation

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

let the datum be at lower end

$\therefore Z_1 = 2m$

$Z_2 = 0$

Putting values in eq (1)

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

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

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

$$= 5.77 - 0.363 = 5.407\ m$$

2)

2) Diameter of inlet $d_1 = 20\,cm$

Area of inlet $a_1 = \pi/4 \times (20)^2 = 314.16\,cm^2$

Diameter at throat $d_2 = 10\,cm$

Area of throat $a_2 = \pi/4 \times (10)^2 = 78.74\,cm^2$

Discharge (Q) is given by

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

where

$C_d = 0.98$

h = diff in head

Pressure at inlet $= P_1 = 17.658\,N/cm^2$

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

Pressure at throat $= \frac{P_2}{\rho g} = -30$ cm of mercury

$= -0.3\,m$ of mercury

$= -0.3 \times 13.6$

$= -4.08$ of water

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

$= 18 - (-4.08)$

$= 22.08\,m$ of water

$= 2208\,cm$ of water

$$\therefore Q = \frac{0.98 \times 314.16 \times 78.54}{\sqrt{(314.16)^2 - (78.74)^2}} \times \sqrt{2 \times 9.81 \times 22.08}$$

$Q = 165\,483.3122\ cm^3/s$

$Q = 165.48\ L/s$

3) Actual discharge is given by

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

$$h = y\left(\frac{S_m}{S_f} - 1\right)$$

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

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

$Q = 0.13742\ m^3/sec$

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

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

$h = 2.083\,m$

V = velocity of submarine

$v = \sqrt{2gh}$

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

$= 6.393\,m/s$

3) A

5) Flowrate (Q) = 0.05 m^3/min => 50 dm^3/min

Pressure change (ΔP) = 15 bar

Speed (N) = 1700 rpm

Norminal displacement = 10 cm^3/rev

Torque Input (T) = 15 Nm

Ideal flow rate = Norminal displacement × Speed

= 10 cm^3/rev × 1700 rpm

= 17 000 cm^3/min =

17 dm^3/min => 0.017 m^3/min

Volumetric efficiency = Actual flow / ideal flow

= 0.05 / 0.017

= 2.9411 or 294.11%

Q

Conitunation of 5

ii) $Q = \frac{0.05}{60} m^3/sec = 83.3 \times 10^{-5} m^3/sec$

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

Fluid power $= \Delta p \times Q = 83.3 \times 10^{-5} \times 15 \times 10^5$

$= 1250$ 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 $= 46.81\%$