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DEPT: MECHATRONICS

(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 $= \frac{P_1}{\rho g} = 2.5$

Let the smaller end be represented by (1) and lower end by (2)

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

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

$$h_2 = 0.16m$$

Applying Bernoulli's equation between section (1) and section (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 the datum be at section (2)

$\therefore Z_1 = 2m$

$Z_2 = 0$

Putting values in eq(1)

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

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

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

$$= 5.77 - 0.363 = 5.407m \text{ of fluid}$$

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(2) Diameter at inlet $d_1 = 20cm$

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

Diameter at throat $d_2 = 10cm$

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

The discharge 'Q' is given by

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

where

$C_d = 0.98$

h is the difference in head between throat and Inlet in fluid flowing

Pressure at Inlet $= P_1 = 17.658 N/cm^2$

$= 17.658 \times 10^4 N/m^2$

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

Pressure at throat $= P_2/\rho g = -30cm$ of mercury

$= -0.3cm$ of mercury

$= -0.3 \times 13.6$

$= -4.08$ of water

Differential head $h = P_1/\rho g - P_2/\rho g$

$= 18 - (-4.08)$

$= 22.08m$ of water

$= 2208 cm$ of water

Putting value in equation (2)

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

$Q = 165483.3122 cm^3/s$

$Q = 165.48 l/s$

This discharge through $= 165.48 l/s$ venturimeter.

(3)

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Discharge through Orifice is given by $Q = \frac{C_d A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \sqrt{2gh}$

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

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

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

$Q = 0.13742 m^3/sec$

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

ρ_m = density of mercury

ρ_f = density of flowing fluid

y = manometric reading

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

$h = 2.083m$

V = velocity of submarine

$V = \sqrt{2gh}$

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

$= 6.393 m/s$

(5)

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Flowrate (Q) = 0.05m³/min ⇒ 50dm³/min

Pressure change (ΔP) = 15bar

Speed (N) = 1700rpm

Norminal displacement = 10cm³/rev

Torque Input (T) = 15Nm

i) Ideal flow rate = Norminal displacment × Speed

= 10cm³/rev × 1700rpm

= 17000cm³/min = 17dm³/min ⇒ 0.017m³/min

Volumetric efficiency = Actual flow / Ideal flow

= 0.05 / 0.017

= 2.941%

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

= 1250 watts

Shaft power = $\frac{2\pi N T}{60} = \frac{2\pi \times 1700 \times 15}{60}$

= 2670.354 watts

Overal effeciency = $\frac{\text{Fluid power}}{\text{Shaft Power}}$

$= \frac{1250}{2670.354}$

= 0.4681

Overall efficiency = 46.81%