EKOJA-OBE INALEGWU PHILIP
18/ENG03/026
Civil Engineering

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Fluid Mechanics Assignment 2

1) Let smaller end be represented (1)
Let lower end be (2)

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 small end $= \frac{P_1}{\rho g} = 2.5m$

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 eqn between (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 the datum at section (2)
$\therefore Z_1 = 2m$
$Z_2 = 0$

putting values in eqn (1)

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

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

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

$= 5.77 - 0.363$
$= 5.407m$ of fluid

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2) Diameter at inlet $d_1 = 20cm$

Area of inlet $a_1 = \frac{\pi}{4} \times (20)^2 = 314.16cm^2$

Diameter at throat at $2 = 10cm$

Area of throat $a_2 = \frac{\pi}{4} \times 10^2$

$= 78.7cm^2$

The discharge 'Q' 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 = difference in head between throat and inlet

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

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

where $\frac{P_1}{\rho g} = \frac{17.658 \times 10^4}{9.81 \times 10^6} = 18m$ of water

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

$= -0.3m$ of mercury

$= -0.3 \times 13.6$

$= -4.08$ of water

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

$= 18 - (-4.08)$

$= 22.08cm$ of water

put values in eqn 2

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

$Q = 165483.3122 cm^3/s$

$= 165.48 L/s$

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3) Actual discharge through orifice meter is given by

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

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

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

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

$$Q = 0.13742 m^3/sec$$

4) Calculate the head

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

$$= \frac{170}{1000}\left(\frac{136}{1026} - 1\right)$$

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

$$h = 2.083m$$

V = Velocity of submarine

$$V = \sqrt{2gh}$$

$$= 6.393 m/s$$

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

pressure change (ΔP) = 15bar

Speed (N) = 1700 rpm

Nominal displacement = 10 cm^3/rev

Torque input (T) = 15Nm

i. Ideal flow rate = nominal displacement x speed

= 10 cm^3/rev x 1700rpm

$= 17000 cm^3/min$

$= 17 dm^3/min$

$\Rightarrow 0.017 m^3/min$

Volumetric efficiency = Actual flow/ideal flow

$= 0.05/0.017$

$= 2.9411$ or 294.11%

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 $= \frac{2\pi NT}{60}$

$= \frac{2\pi \times 1700 \times 15}{60}$

$= 2670.354$ watts

Overall ~~velocity~~ efficiency $= \frac{\text{fluid power}}{\text{shaft power}}$

$= \frac{1250}{2670.354}$

$= 0.4681$

Overall Efficiency $= 46.81\%$