Civil Engineering

Fluid Mechanics: Assignment

Question 1 ; Solution

Length of tubes, L = 2.0m

$V_1 = 5m/s$

$P_1/\rho g$ = 2.5m of head

$V_2 = 2m/s$

Loss of head $= h_L = \frac{0.35(v_1 - v_2)^2}{2g}$

$= \frac{0.35[5-2]^2}{2g} = \frac{0.35 \times 9}{2 \times 9.81}$

$= 0.16m$

Pressure head, $\frac{P_2}{\rho g} = ?$

Applying Bernoulli's equation

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + h_L$$

$Z_2 = 0, \quad Z_1 = 2.0$

$\therefore 2.5 + \frac{5^2}{2 \times 9.81} + 2.0 = \frac{P_2}{\rho g} + \frac{2^2}{2 \times 9.81} + 0.16$

$2.5 + 1.27 + 2.0 = \frac{P_2}{\rho g} + 0.203 + 0.16$

$\frac{P_2}{\rho g} = (2.5 + 1.27 + 2.0) - (0.203 + 0.16)$

$\frac{P_2}{\rho g} = 5.77 - 0.363$

$= 5.407m$

Question 2 : Solution

given Inlet dia : $d_1 = 20cm$

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

Throat dia ; $d_2 = 10cm$

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

$= 78.74 \ cm^2$

$P_1 = 17.658 \ N/cm^2 = 17.658 \times 10^4 N/m^2$

ρ of water = 1000 kg/m³

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

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

$= -0.30m$ of mercury

$\therefore -0.30 \times 13.6 = -4.08m$ of water

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

$= 18 - (-4.08)$

$= 22.08m = 2208cm$

The discharge:

$$Q = C_d \frac{a_1 a_0}{\sqrt{a_1^2 - a_0^2}} \times \sqrt{2gh}$$

$= 0.98 \times \frac{314.16 \times 78.54 \times \sqrt{2 \times 981 \times 2\ldots}}{\sqrt{(314.16)^2 - (78.54)^2}}$

$= \frac{5083...37.21 \times 165555 \ cm^3/s}{304}$

$= 165.553 \ lt/s$

The discharge:

$$Q = C_d \frac{a_0 a_1}{\sqrt{a_1^2 - a_0^2}} \times \sqrt{2gh}$$

$= 0.64 \times \frac{176.7 \times 706.85}{\sqrt{(706.85)^2 - (176.7)^2}} \times \sqrt{2 \times 9.81 \times 705.5}$

$= \frac{94046517.14}{684.4}$

$= 137414.25 \ cm^3/s = 137.414 \ lt/s$

Question 3: Solution

Orifice diameter. $d_0 = 15cm$

$a_0 = \frac{\pi}{4}(15)^2 = 176.7 cm^2$

Dia of pipe $d_1 = 30cm$

$a_1 = \frac{\pi}{4} \times 30^2 = 706.85 cm^2$

Sp. gr of oil $S_0 = 0.9$

Reading of diff. manometer $x = 50cm$ of m

∴ Differential head.

$h = x\left[\frac{S_g}{S_0} - 1\right] = 50\left[\frac{13.6}{0.9} - 1\right]$ cm of oil

$= 50 \times 14.11 = 705.5cm$ of oil

$C_d = 0.64$

Question 4: Solution

Diff. of mercury level, $x = 170mm = 0.17m$

Sp. gr. of mercury, $S_g = 13.6$

Sp. gr. of sea water $S_o = 1.026$

$\therefore h = x\left[\frac{S_g}{S_o} - 1\right] = 0.17\left[\frac{13.6}{1.026} - 1\right]$

$= 2.0854m$

$\therefore V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.0854}$

$= 6.393 \ m/s$

$= \frac{6.393 \times 60 \times 60}{1000}$

$= 23.01 \ km/hr$

Question 5 : solution

Actual flow rate = 0.05 m^3/min

m^3/min to m^3/sec

60 sec → 1 min

$= \frac{0.05}{60} = 8.33 \times 10^{-4}\ m^3/sec$

∴ $Q = 8.33 \times 10^{-4}\ m^3/sec$

Speed of rotation (N) = 1700 rev/min

$= \frac{1700}{60} = 28.3$ rev/sec

$= 28.3$ rps

Pressure change = 15 bar
$= 15 \times 10^5 \ N/m^2$

Nominal displacement = $10 cm^3/rev$
100cm = 1m
$100^3 cm^3 = 1m^3$
$10cm^3 = x$
$\therefore x = \frac{10}{1000000} = 1 \times 10^{-5} m^3/rev$

Ideal flow rate = Nominal x speed displacement
$= 28.3 \times 1 \times 10^{-5}$
$= 2.83 \times 10^{-4} \ m^3/sec$

i) Volumetric Efficiency = $\frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100\%$

$= \frac{8.33 \times 10^{-4}}{2.83 \times 10^{-4}} \times 100\%$

$= 294.3\%$

ii) P_f = Actual flowrate (Q) x pressure change (H)
$= 8.33 \times 10^{-4} \times 15 \times 10^5$
$= 1249.5$ watts or Nm/sec

iii) Shaft power = T . ω
Where; T = Torque input (Nm)
ω = Angular speed (rad/sec)
T = 15Nm
ω = $2\pi N = 2 \times \frac{22}{7} \times 28.3$

Shaft Power = 15×177.89
$= 2668.35$ watts

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

$= \frac{1249.5}{2668.35} \times 100\%$

$= 46.8\%$