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1 $V_1 = 5ms^{-1}$ $V_2 = 2ms^{-1}$

$P_T = \frac{P_1}{w} = 2.5m$

$H_L = \frac{0.35(V_1 - V_2)^2}{2g}$

$\frac{P_1}{w} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{w} + \frac{V_2^2}{2g} + Z_2 + H_L$

$\frac{P_2}{w} = \frac{P_1}{w} = \frac{V_1^2 - V_2^2}{2g} + (Z_1 - Z_2) - \frac{0.35(V_1 - V_2)^2}{2g}$

$\frac{P_2}{w} = 2.5 + \frac{5^2 - 2^2}{2(9.81)} + 2 - \frac{0.35(5-2)^2}{2 \times 9.81}$

$\frac{P_2}{w} = 2.5 + 1.07 + 2 - 0.161$

$\frac{P_2}{w} = 5.409m$ of liquid

2 Inlet: $d_1 = 20cm = 20 \times 10^{-2} m$

$A = \frac{\pi d^2}{4} = \frac{\pi \times (20 \times 10^{-2})^2}{4} \Rightarrow A_1 = 0.0314m^2$

$P_1 = 17.668N/cm^2$

$= 17.668 \times 10^4 N/m^2$

$C_d = 0.98$

Throat Diameter: $d_2 = 10cm = 10 \times 10^{-2} m$

$A = \frac{\pi d^2}{4} = \frac{\pi \times (10 \times 10^{-2})^3}{4}$

$A_2 = 7.85 \times 10^{-3} m^2$

$\Rightarrow \frac{P_1}{w} - \frac{P_2}{w} = h$

$P_1 = 17.668 \times 10^4 \, N/m^2$

$w = 9.81 \times 10^3 \, N/m^3$

Throat Vacuum Pressure = 30cm of Hg

$= 0.3 m Hg$

$= 0.3 \times 13.6 = 4.08$

$\frac{P_2}{w} = -4.08$

Then $\frac{P_1}{w} = \frac{17.658 \times 10^4}{9.81 \times 10^3} = 18$

$\therefore \frac{P_1}{w} - \frac{P_2}{w} \Rightarrow 18 - (-4.08) = 22.08_4$

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

$$= 0.98 \times 0.0314 \times 7.85 \times 10^{-3} \times \sqrt{\frac{2 \times 9.81 \times 22.08}{(0.0314^2 - (7.85 \times 10^{-3})^2)}}$$

$= 2.4136 \times 10^{-4} \times 684.59$

$= 0.1653$

$Q_{actual} = 0.1653 \, m^3/s_4$

3. Orifice meter ; Given that

$d_o = 15cm = 15 \times 10^{-2} m$ $\quad$ $d_p = 30cm = 30 \times 10^{-2} m$

$A_o = \frac{\pi \times (15 \times 10^{-2})^2}{4}$ $\quad$ $A_p = \frac{\pi \times (30 \times 10^{-2})^2}{4}$

$= 0.01767 m^2_5$ $\quad$ $= 0.07069 m^2_6$

S.P.G of oil = 0.9 (50)

Coefficient of discharge = 0.64

Reading of differential = 50cmHg

Differential head $h = y\left[\frac{Shl}{So} - 1\right]$

$Shl = 13.6$

$y = 50 \times 10^{-2}$

$h = 50 \times 10^{-2}\left[\frac{13.6}{0.9} - 1\right]$

$h = 50 \times 10^{-2} \times 14.11$

$= 7.055m$

$Q = \frac{Cd A_o A_p \sqrt{2gh}}{\sqrt{A_p^2 - A_o^2}}$

$\Rightarrow \frac{0.64 \times 0.01767 \times 0.07069 \times \sqrt{2 \times 9.81 \times 7.055}}{\sqrt{(0.07069^2) - (0.01767^2)}}$

$\Rightarrow \frac{7.944 \times 10^{-4} \times 11.765}{\sqrt{4.68 \times 10^{-3}}}$

$\Rightarrow 0.1374 m^3/s$

4. $y = 170mmHg = 0.17mHg$, $s.g Hg = 13.6$ $s.g sw = 1.026$

$\Delta h = y\left(\frac{s.g Hg}{s.g sw} - 1\right)$

$\Delta h = 0.17\left(\frac{13.6}{1.026} - 1\right)$

$\Delta h = 2.08m$

$V = \sqrt{2g\Delta h}$

$= \sqrt{2 \times 9.81 \times 2.08}$

$= 6.388 m/s$

5. $Q = 0.05 dm^3/min = 8.33 \times 10^{-5} m^3/sec$

Speed of rotation = 1700 Rev/min = 28.3 Rev/sec

Normal Displacement = $10 cm^3/rev = 10^{-5} m^3/rev$

Torque Input = 15Nm

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

Ideal Flowrate = Nominal displacement × Speed Rotation

$= 10^{-5} \times 28.3 = 2.83 \times 10^{-4} m^3/sec$

a) Volume Efficiency = $\frac{\text{Actual Flowrate}}{\text{Ideal Flowrate}} \times 100$

$= \frac{8.33 \times 10^{-5}}{2.83 \times 10^{-4}} \times 100$

$= 29.45\%$

b) Fluid Power, $P_F = Q \times \Delta P$

$= 8.33 \times 10^{-5} \times 15 \times 10^5$

$= 124.95$ watts

c) Shaft Power = $T \times \omega$

$\omega = 2 \times \pi \times$ speed of rotation

$= 2 \times \pi \times 28.3$

$= 177.81$ rad/sec

∴ Shaft power = 15×177.81

$= 2667.2$ watts

d) Overall Efficiency = $\frac{\text{Fluid power}}{\text{Shaft Power}} \times 100$

$= \frac{124.95}{2667.2} \times 100$

$= 4.68\%$