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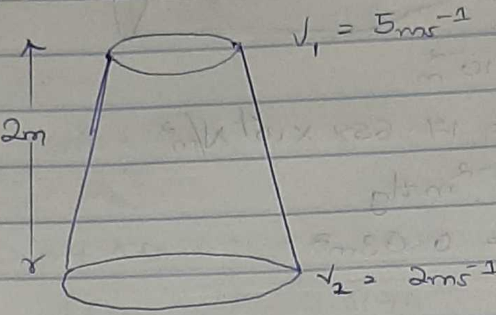


Solution

Head loss $= H_L = \frac{0.35(V_1 - V_2)}{2g} = \frac{0.35(5-2)^2}{2 \times 9.81} = 0.161m$

$H_L = 0.161m$

Pressure of head at lower end $(P_L) = x$

Applying Bernoulli's equation

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + Z_2 + H$$

where $P_s = \frac{P_1}{\rho g}$ and $P_L = \frac{P_2}{\rho g}$

$Z_1 = 2.0$ and $Z_2 = 0$

Substituting the values of all parameters into the equation:

$$2.5 + \frac{5}{2 \times 9.81} + 2.0 = P_L + \frac{2^2}{2 \times 9.81} + 0 + 0.161$$

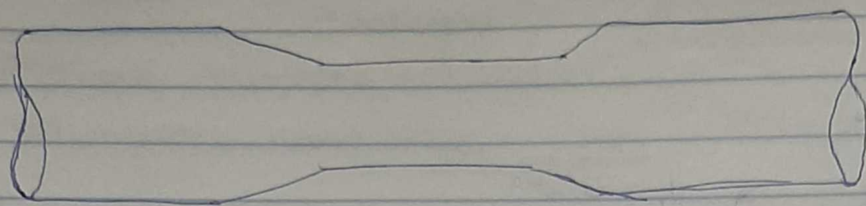
$$2.5 + \frac{25}{19.62} + 2.0 = P_L + \frac{4}{19.62} + 0.161$$

$$2.5 + \frac{25}{19.62} + 2 - \left(\frac{4}{19.62} + 0.161\right) = P_L$$

$$5.774 - 0.365 = P_L$$

$P_L = 5.409m$ of fluid.

Number 2



Diameter = 20×10^{-2} m

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

$P_2 = 30cm\ Hg = 30 \times 10^{-2}\ m\ Hg$

$A_1 = \frac{\pi \times (20 \times 10^{-2})^2}{4} = 0.03m^2$

$Cd = 0.98$

$Q = ?$

$A_2 = \frac{\pi \times (10 \times 10^{-2})^2}{4} = 7.85 \times 10^{-3}\ m^2$

$\frac{P_2}{w} = 0.3 \times 13.6 = 4.08\ m\ Hg$

$\frac{P_2}{w} = -4.08$ $\frac{P_1}{w} = \frac{17.058 \times 10^4}{4.81 \times 10^3} = 18$

$h = \frac{P_1}{w} - \frac{P_2}{w} = 18 - (-4.08) = 22.08$

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

$Q = \frac{0.98 \times 0.03 \times (7.85 \times 10^{-3}) \times \sqrt{2 \times 9.81 \times 22.08}}{\sqrt{(0.03^2 - (7.85 \times 10^{-3})^2)}}$

$Q = 0.166 m^3/s$

Number 3

$d_1 = 30 \times 10^{-2}\ m$ $S_{h_1} = 13.6$

$y = 50 \times 10^{-2}\ m\ Hg$ $S_o = 0.9$

$Cd = 0.64$

Sg of oil $= 0.9$

$H = y \left[\frac{S_h}{S_o} - 1 \right]$

$D = 15 \times 10^{-2} m$

$A_o = \frac{\pi d^2}{4} = \frac{\pi \times (15 \times 10^{-2})^2}{4} = 0.0707 m^2$

$H = 50 \times 10^{-2} \left[\frac{13.6}{6.9} - 1 \right]$

$H = 7.055 m$

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

$Q = \frac{0.64 \times 0.0176 \times 0.0707 \sqrt{2 \times 9.81 \times 7.055}}{\sqrt{(0.0707^2 - 0.0176^2)}}$

$Q = \underline{0.137 m^3/s}$

Number 4

$y = 170 mmHg = 170 \times 10^{-3} m hg$

S.g of mercury = 13.6Hg

Sg of sea water = 1.026

$V = \sqrt{2gh}$

$V = 6.37 m/s$

$H = \frac{y \times S_{h_1}}{S_o} - 1$

$H = 170 \times 10^{-3} \times \left(\frac{13.6}{1.025} - 1 \right) = \underline{2.08 m}$

Number 5

$Q = 0.05 m^3/mm = 50 dm^3/mm$

$P = 15 bar = 15 \times 100000 = 15 \times 10^5 N/m^2$

Speed = 170 rev/min

$T = 15 Nm$, $ND = 10 cm^3/rev$

i) Volumetric efficiency $= \frac{\text{Actual flow rate}}{\text{Ideal flow rate}}$

Ideal flow rate = Nominal flow rate × speed

$= 10 cm^3/rev \times 1700 rev/min$

$= 17000 cm^3/min$

Ideal flow rate $= \frac{17000}{1000000} = 0.017 m^3/mm$

Actual flow rate $= 0.05 m^3/mm$

Volumetric efficiency $= \frac{0.05}{0.017} = 2.94\% = 294\%$

ii) Fluid power $= P \times Q$

$P = 15 \times 15 N/m^2$

$Q = 0.05 m^3/mm = \frac{0.05}{60} = 8.33 \times 10^{-4} ms^{-1}$

Fluid Power $= 15 \times 10^5 \times 8.33 \times 10^{-4}$

$= 1249.5$ watts

iii) Shaft power $= \frac{2\pi NT}{60} = \frac{2\pi \times 1700 \times 15}{60}$

Shaft power $= 2670.35$ watts

Overall efficiency $= \frac{\text{Fluid Power}}{\text{Shaft power}}$

$\frac{\text{Fluid power}}{\text{Shaft power}} := \frac{1249.5}{2670.35} = 0.468$

Overall efficiency $= 0.468 \times 100 = 46.8\%$