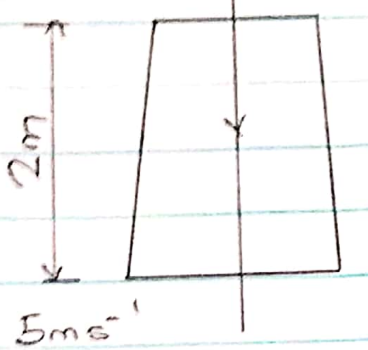
Olawoyin Sadeeq Babalola
18/ENG05/048 (200 Level)
Mechatronics Engineering [Fluid Mechanics]

1



$V_1 = 5ms^{-1}$ $z_1 = 2$

$V_2 = 2ms^{-1}$ $z_2 = 0$

$P_1 = 2.5m$ of liquid

$P_2 = ?$

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

$= \frac{0.35(5-2)^2}{2 \times 9.81} = 0.161m$

Applying Bernoulli's Equation

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

From the eqn above, $P_1 = \frac{P_1}{w}$ and $P_2 = \frac{P_2}{w}$

$$\frac{P_2}{w} = \frac{P_1}{w} + \frac{V_1^2}{2g} - \frac{V_2^2}{2g} + z_1 - z_2 - H_L$$

$$\frac{P_2}{w} = \frac{P_1}{w} + \frac{V_1^2 - V_2^2}{2g} + (z_1 - z_2) - H_L$$

$$\frac{P_2}{w} = 2.5 + \frac{5^2 - 2^2}{2 \times 9.81} + (2 - 0) - 0.161$$

$$\frac{P_2}{w} = 5.41m \text{ of fluid}$$

$\therefore P_2 = 5.41m$ of fluid.

2 $d_1 = 20 \times 10^{-2} m$ $C_d = 0.98$

$A_1 = \frac{\pi}{4} \times (20\times10^{-2})^2 = 0.0314 m^2$

$d_2 = 10 \times 10^{-2} m$

$A_2 = \frac{\pi}{4} \times (10\times10^{-2})^2 = 7.85\times10^{-3} m^2$

$P_1 = 17.658 \times 10^{4} Nm^{-2}$

$\frac{P_1}{w} = \frac{17.658\times10^4}{1000 \times 9.81} = 18m$

Vacuum pressure $= \frac{P_2}{w} = -30cmHg$

$= -30\times10^{-2} m$ of mecury $\times 13.6$

$= -4.08 m$

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

$= 22.08m$

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

$$= \frac{0.98\sqrt{2\times9.81\times22.08} \times 0.0314 \times 7.85\times10^{-3}}{\sqrt{(0.0314)^2 - (7.85\times10^{-3})^2}}$$

$= 0.165 m^3/sec$

3 $d_p = 30\times10^{-2} m$

$A_p = \frac{\pi}{4}(30\times10^{-2})^2 = 0.071m^2$

$d_o = 15\times10^{-2} m$

$A_o = \frac{\pi}{4}(15\times10^{-2})^2 = 0.018m^2$

Sg of oil $S_o = 0.9$

Sg of mercury $S_{hg} = 13.6$

Differential manometer reading $X = 50cm$ of mercury

$= 50\times10^{-2} m$ of mercury

$Cd = 0.64$

$$h = x\left(\frac{S_{Hg}}{S_o} - 1\right)$$

$$= 50\times10^{-2}\left(\frac{13.6}{0.9} - 1\right)$$

h = 7.056 m of oil

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

$$= \frac{0.64 \times 0.018 \times 0.071 \times \sqrt{2\times9.81\times7.056}}{\sqrt{0.071^2 - 0.018^2}}$$

$$= 0.14\ m^3/s.$$

4. Manometer reading = 170 mm Hg

= 170×10^{-3} m Hg

S_{Hg} = 13.6

$S_{seawater}$ = 1.026

$$h = y\left(\frac{S_{Hg}}{S_{sw}} - 1\right)$$

$$= 170\times10^{-3}\left(\frac{13.6}{1.026} - 1\right)$$

$$= 2.083\ m$$

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

$$= \sqrt{2\times9.81\times2.083}$$

$$= 6.39\ ms^{-1}$$

5 Actual flow rate = $5 dm^3/min$

= $5 l/min$

$P = 15 \times 10^5 Nm^{-2}$

Speed = 1700 rpm

Displmt = ~~10×10^{-6}~~ $10 cm^3/rev$

$T = 15 Nm$

Volumetric Efficiency = $\frac{\text{Theoretical flow}}{\text{Actual flow}} \times 100$

Theoretical flow = $\underline{0.01 \times 1700}$ = $17 l/min$

Vol Efficiency = $\frac{5}{17} \times 100$ = 29.4%

(b) Fluid power = Pressure x Actual flow

$= \frac{15 \times 10^5 \times 5}{60\ 000}$

= 125 W

(c) Shaft power = $T \times \omega$

$\omega = 2\pi \times speed$

$= 2\pi \times {}^{1700}/_{60}$

= 178.024 rad/sec

Shaft power = 16×178.024 = 267.035 W

(d) Overall Efficiency = $\frac{\text{Fluid power}}{\text{Shaft power}}$

$\mathcal{E} = \frac{125}{267.035} \times 100$

= 46.8%