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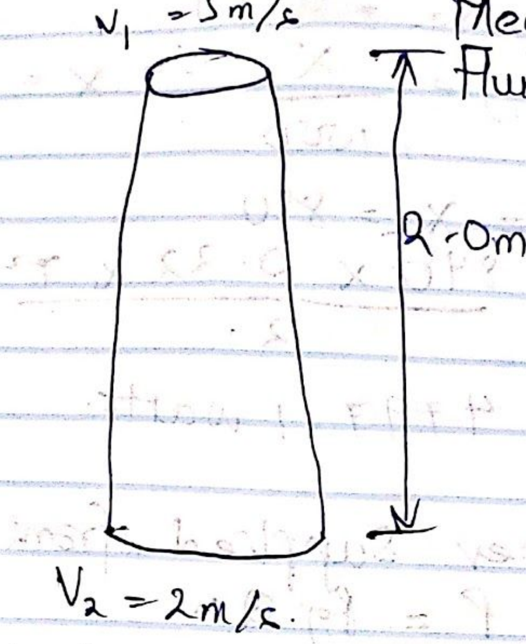
18/ENG05/064
Mechatronics Eng.
Fluid Mechanics.

Assignment 1.

1.



Length $L = 2.0m$

V_1 (Velocity of flow at small end) $= 5m/s$.

V_2 (at lower end) $= 2m/s$.

Pressure Head $(P_1/w) = 2.5m$ of liquid at smaller end.

Pressure head at lower end $\left(\frac{P_2}{w}\right) = ?$

H_L = Loss of Head $= \frac{0.25(V_1-V_2)^2}{2g}$

$$= \frac{0.85\,(5-2)^2}{2 \times 9.81} = 0.16\,m$$

Applying Bernoulli's Equation.

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

$$+ H_L$$

$Z_1 = 2m.$

$Z_2 = 0$

$$\Rightarrow 2.5 + 2 + \frac{5^2}{2(9.81)} = \frac{P_2}{W} = 0 + \frac{2^2}{2(9.81)}$$

$$+ 0.16$$

$$5.77 = \frac{P_2}{W} + 0.364$$

$$\frac{P_2}{W} = 5.77 - 0.364 = \underline{5.406\,m}$$

of Liquid.

2.

Inlet diameter, $d_1 = 20cm = 0.2m$

$$A_1 = \frac{\pi d^2}{4} = \frac{\pi (0.2)^2}{4}$$

$$= 0.0314 m^2$$

Throat diameter, $d_t = 10cm = 0.1m$

$$A_t = \frac{\pi (0.1)^2}{4} = 0.00785 m^2$$

P_1 (Pressure of Inlet) $= 17.658 N/cm^2$
$= 176580 N/m^2 = 17.658 \times 10^4 N/m^2$.

P_1 (Pressure of through) = 80 cm of meary

$C_d = 0.98$

$$\Rightarrow \frac{P_1}{w} = \frac{17.658 \times 10^4}{1000 \times 9.81} = 18m \text{ of}$$

water.

$\Rightarrow \frac{P_t}{w} = -0.3 \times 13.6 = -4.08$

of water.

where S.g of mercury = 13.6.

S.g of water = 1.

Differential head $h = \frac{P_1}{w} - \frac{P_t}{w}$

$= 18 - (-4.08)$

$= 22.08 m$

Discharge for Venturimeter,

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

$$= \frac{0.98 \times 0.0314 \times 0.00785 \times \sqrt{2gh}}{\sqrt{0.0314^2 - 0.00785^2}}$$

$$= \frac{5.0278 \times 10^{-3}}{0.0304}$$

$= 0.165 m^3/s$.

3. Orifice Diameter = d_0 = 15 cm = 0.15 m

$$A_0 = \frac{\pi (0.15)^2}{4} = 0.01767 m^2$$

Diameter of pipe, d_1 = 30 cm = 0.3 m

$$A_1 = \frac{\pi (0.3)^2}{4} = 0.07068 m^2$$

Differential manometer reading = 50 cm of mercury.

s.g of oil = 0.9.

Cd = 0.64.

⇒ Differential Head, $h = x\left[\frac{S_g}{S_{oil}} - 1\right]$

where s.g of mercury = 13.6.

$$h = 0.50\left[\frac{13.6}{0.9} - 1\right] = 7.055 \text{ m of oil}$$

⇒ Rate of flow = $Q = \frac{C_d A_2 A_1 \sqrt{2gh}}{\sqrt{A_2^2 - A_1^2}}$

$$Q = \frac{0.64 \times 0.01767 \times 0.07068 \times \sqrt{2gh}}{\sqrt{0.07068^2 - 0.01767^2}}$$

$$Q = \frac{9.404 \times 10^{-3}}{0.0684}$$

$$= 0.137 \ m^3/s$$

(4) Difference in mercury level $= x = 170mm$
$= 0.17m$

Speed of Submarine = ?

S_g = Sg of mercury = 13.6.
S_a ⇒ Sg of sea water = 1.026.

Differential Head, $h = x\left[\frac{S_g}{S_a} - 1\right]$

$$= 0.17\left[\frac{13.6}{1.026} - 1\right] = 2.0834 \text{ m of water.}$$

Velocity / Speed of Submarine:

$$V = \sqrt{2gh}$$
$$= \sqrt{2 \times 9.81 \times 2.0834}$$
$$= 6.393 \ m/s$$

5. $Q = 5\, dm^3/min$

$= \frac{5 \times 0.001}{60} = 8.33 \times 10^{-5} m^3/s$

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

Speed of rotation $= 1700\, rev/min$;

$= \frac{1700}{60} = 28.33\, rev/s$.

Normal Displacement $= 10\, cm^3/rev$

$= 1 \times 10^{-5}\, m^3/rev$.

Torque Input $= 15\, Nm$.

(i) Volumetric Efficiency $= \frac{Q}{\text{Ideal Flow rate}}$.

Ideal flow rate = Normal displacement $\times$ speed,

$= (1 \times 10^{-5}) \times 28.33$

$= 2.833 \times 10^{-4}\, m^3/s$.

Volumetric Efficiency = $\frac{8.33 \times 10^{-5} m^3/s}{2.833 \times 10^{-4} m^3/s}$

$= 0.294$

$= 24.9\%$

(ii) Fluid Power $= Q \times \Delta P$

$= (8.33 \times 10^{-5}) \times (15 \times 10^3)$

$= 124.95$ W

(iii) Shaft Power = $2\pi T \times$ Speed of rotation;

$= 2\pi \times 15 \times 28.33$

$= 2670.04$ W

(iv) Overall Efficiency;

$= \frac{\text{Fluid Power}}{\text{Shaft Power}}$

$= \frac{124.95}{2670.04} = 0.0468$

$= 46.8\%$.