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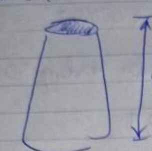
15/ENG05/055
Mechatronics

1. $v = 5m/s$



$V_0 = 2m/s$

Length $L = 2.0m$

v_1 < velocity of flow at small end) = 5m/s

V_0 (at lower end) = 2m/s

Pressure $(P_1/w) = 25m$ of Liquid at smaller end

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

H_L = loss of head $\Rightarrow \frac{0.25(v_1 - v_0)^2}{2g}$

$= \frac{0.35(5-2)^2}{2 \times 9.81} = 0.16m$

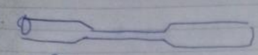
Applying Bernoulli's Equation

$\frac{P_1}{w} + z_1 + \frac{v_1^2}{2g} = \frac{P_2}{w} + z_2 + \frac{V_2^2}{2g}$

$\Rightarrow 2.5 + 2 + \frac{5^2}{2(9.81)} = \frac{P_2}{w} = 0 + \frac{2^2}{2(9.81)} + 0.16$

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

$\frac{P_2}{w} = 5.77 - 0.364 = 5.406m$ of Liquid

2. 

$d_t = 2cm$

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

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

$= 0.0314m^2$

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

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

P_1 (Pressure of ~~Intt~~ Inlet) = 17.658N/cm²

= 176580N/m² = 17.658

P_t (Pressure of ~~Inlet~~ throat) = ~~17.658N/cm²~~

= 30cm of mercury

$C_d = 0.98$

$\frac{P_1}{w} = \frac{17.658 \times 10^4}{1000 \times 9.81} = 15m$ of water.

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

where Sg of mercury = 13.6

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

$= 15 - (-4.08)$

$= 22.08m$

Discharge for venturimeter

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

$= \frac{0.98 \times 0.0319 \times 0.00785 \times \sqrt{2gh}}{\sqrt{0.0314^2 - 0.00785^2}}$

$= \frac{5.0276 \times 10^{-3}}{0.0304}$

$= 0.165m^3/s$

(3) Orifice Diameter = $d_0 = 15cm = 0.15m$

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

Diameter of pipe, $d_1 = 30cm = 0.3m$

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

Differential manometer reading 50cm of mercury

sg of oil = 0.9

$C_d = 0.64$

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

where sg of mercury = 13.6

$h = 0.50\left(\frac{13.6}{0.9} - 1\right) = 7.055m$

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

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

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

$= 0.137m^3/s$

4 Diff in mercury level = $x = 170mm = 0.17m$

speed of submarine = ?

S = Sg of mercury = 13.6

Sg of Sg of water = 1.026

Differential Head, $h = x\left(\frac{S_g}{S_g} - 1\right)$

$= 0.17\left[\frac{13.6}{1.026} - 1\right] = 2.0534$ of water velocity / speed of submarine

$v = \sqrt{2gh}$

$= \sqrt{2 \times 9.81 \times 2.60634}$

$= 6.393 m/s$

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

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

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 $= 10cm^3/rev$

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

Torque input = 15Nm

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

Ideal flow rate = Normal displacement × speed:

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

$= 28.33 \times 10^{-4} m^3/s$

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

~~= 0.294~~

=

$= 29.4\%$

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

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

$= 124.95W$

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

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

$= 2670.04W$

(iv) Overall Efficiency,

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

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

$= 46.8\%$