OBI-OBUOHA ABIAMAMELA

18/ENG05/040

MECHATRONICS ENGINEERING

FLUID MECHANICS ASSIGNMENT

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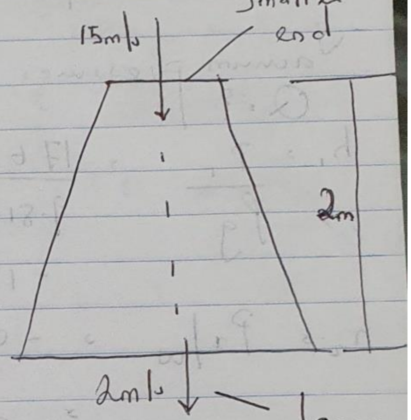


(1) Length of conical tube = 2m

$v_1 = 5m/s$

$v_2 = 2m/s$

pressure head of smaller end = 2.5m

loss of head = $0.35 (v_1 - v_2)^2 / 2g$

Loss of head = $\frac{0.35 (5-2)^2}{2 \times 9.81} = \frac{0.35 (3)^2}{19.62}$

$h_L = 0.160 m$

The pressure at larger end = P_2/w

Applying Bernoulli's equation for conical tube

$\frac{P_1}{w} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{w} + \frac{v_2^2}{2g} + z_2 + h_L$

$Z_1 = 2m \quad Z_2 = 0m$

$2.5 + \frac{5^2}{(9.81)2} + 2 = \frac{P_2}{w} + \frac{2^2}{(9.81)2} + 0 + 0.160$

$\Rightarrow 2.5 + 1.27 + 2 = P_2/w + 0.203 + 0.160$

$5.77 = P_2/w + 0.363$

$P_2/w = 5.77 - 0.363$

$P_2/w = 5.41m$

head at larger end = 5.41m

(2) $d_1 = 20cm = 0.2m$ (inlet)

$A_1 = \frac{\pi \times (0.2)^2}{4} = 0.03142m^2$

$d_2 = 10cm = 0.1m$ (throat)

$A_2 = \frac{\pi \times (0.1)^2}{4} = 0.00785m^2$

Vacuum pressure = 30cm Hg = 0.3m Hg

Q = ?

N/B:

$C_d = 0.98$

$P_1 = 17.658 \ N/cm^2$

$= \frac{17.658}{10^{-4}}$

$= 176580 \ N/m^2$

$h_1 = \frac{P_1}{\rho g} = \frac{176580}{9.81 \times 1000}$

$= 18m$

$h_2 = P_2/w = -0.3m$ of mercury

$= -0.3 \times 13.6 = -4.08m$ of water

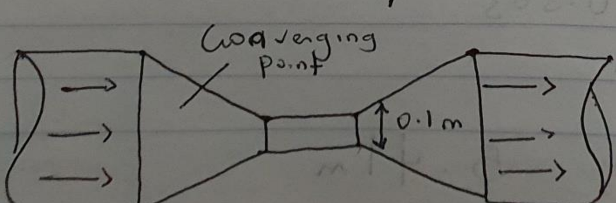
$h = \frac{P_1}{w} - \frac{P_2}{w} = 18 - (-4.08) = 22.08m$

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

$$Q = \frac{0.98 \times 0.03142 \times 0.00785 \times \sqrt{2 \times 9.81 \times 22.08}}{\sqrt{0.0314_2^2 - 0.00785^2}}$$

$Q = 2.42 \times 10^{-4} \times \sqrt{433.21} \Big/ \sqrt{9.26 \times 10^{-4}}$

$Q = 5.037 \times 10^{-3} \Big/ 0.0304 = 0.166 \ m^3/s$



(3) $d_o = 15cm = 0.15m$
$d_1 = 30cm = 0.30m$

$C_d = 0.64$
Sg of o.l = 0.9
Reading of differential manometer
$y = 50cmHg$
$= 0.5mHg$

$A_o = \pi(0.15)^2/4 = 0.0177m^2$

$A_1 = \pi(0.3)^2/4 = 0.07m^2$

$h = y\left(\frac{S_{hc}}{S_o} - 1\right) = 0.5\left(\frac{13.6}{0.9} - 1\right)$

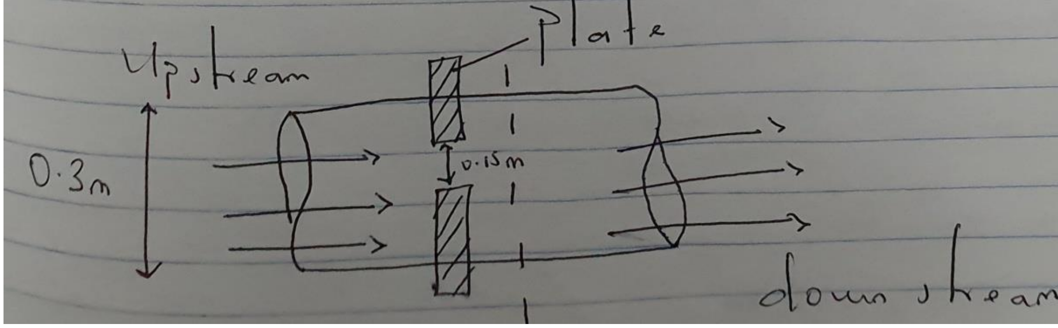
$h = 7.05m$

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

$$Q = \frac{0.64 \times 0.0177 \times 0.07 \times \sqrt{2 \times 9.81 \times 7.05}}{\sqrt{0.07^2 - 0.0177^2}}$$

$$Q = \frac{7.9296 \times 10^{-4} \times \sqrt{138.32}}{\sqrt{4.59 \times 10^{-3}}}$$

$$Q = 9.326 \times 10^{-3} / 0.068 = 0.137 m^3/s$$



(4) Reading from manometer = ~~170mm~~

= 170mm Hg = 0.17 m Hg

Specific gravity of mercury is 13.6

Specific gravity of sea water = 1.026

$h = y\left(\frac{S_m}{S_w} - 1\right)$

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

$h = 0.17(12.26)$

$h = 2.084m$

$V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.084}$

$= \sqrt{40.89}$

$= 6.39 m/s$

(5) Actual flow Rate = $5 dm^3/min$ = $5 L/min$

(a) P = 15 bar   speed = 1700 rpm   Displacement = 10 cc/rev

Torque = 15 Nm, Volumetric efficiency = $\frac{\text{Theoretical flow}}{\text{actual flow}} \times 100$

Theoretical flow = Displacement × speed.

but $10 cm^3/rev = 10 \times 10^{-3} = 0.01 L/rev$

Theoretical flow = $0.01 \times 1700 = 17 L/min$

Volumetric efficiency = $\frac{5}{17} \times 100 = 0.294 \times 100$
= 29.4%

(b) Fluid power = $\frac{\text{Pressure} \times \text{actual flow}}{600} = \frac{15 \times 5}{600}$

= 0.125 KW
= 125 watt

(c) Shaft power = $\frac{\text{fluid power}}{\text{efficieny of pump}}$ ~~×~~ ⇒ 125 / 0.294

= 425.17 W

General / overall efficieny
= Volumetric efficieny × hydraulic/mechanical efficiency

Hydraulic efficieny = $\frac{\text{Theoretical } \sout{\text{efficieny}} \text{ torque}}{\text{actual torque}}$

Theoretical torque = (Displacement × Pressure) / 2π

= $(10 \times 15) / (20 \times 3.142)$ = 2.39 Nm

Hydraulic/mechanical efficieny = 2.39 / 15 = 0.16

Overall efficieny = $0.294 \times 0.160 \times 100$

= 4.7%

VISTALINE