MECHATRONICS

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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 $= \frac{0.35(5-2)^2}{2 \times 9.81} = 0.160m$

$h_L = 0.160m$

The pressure at larger end $= P_2/w$

Applying Bernoulli's eqn for conical tube

$$\frac{P_1}{w} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{w} + \frac{V_2^2}{2g} + Z_2 + k_2$$

$Z_1 = 2m$ $Z_2 = 0m$

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

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

$$5.77 = P_2/w + 0.363$$

$$P_2/w = 5.77 - 0.363$$

$$P_2/w = 5.41m$$

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 = 30cmHg = 0.3mHg

Q = ?

$h_1 = \frac{P_1}{\rho g} = \frac{176580}{9.81 \times 1000} = 18m$

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

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

W/B

$C_d = 0.98$

$P_1 = 17.658 \ N/cm^2$

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

$= 176580 \ N/m^2$

$h = P_1/w - P_2/w$

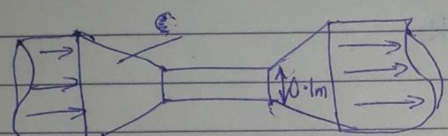
$= 18 - (-4.08) = 22.08m$

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

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

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

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



3) $d_0 = 15cm = 0.15m$

$d_1 = 30cm = 0.30cm$

$A_0 = (0.15)^2/4 = 0.0177m^2$

$h = y\left(\frac{S_H}{S_0} - 1\right) = 0.5\left(\frac{13.6}{0.9} - 1\right)$

$h = 7.05m$

$Cd = 0.64$

Sg of O.1 = 0.9

Reading of differential manometer

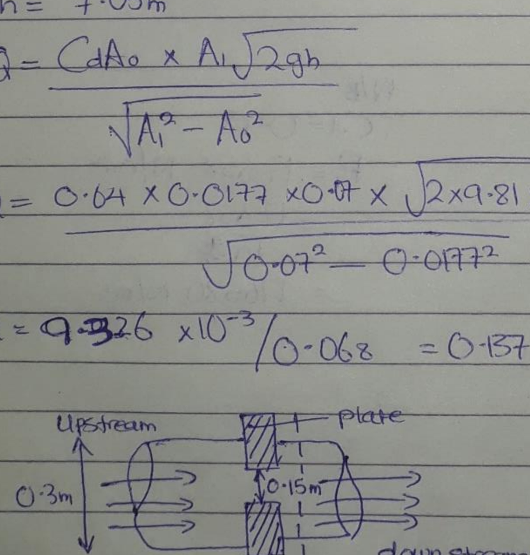
$y = 50cm\ Hg$

$= 0.5m\ Hg$

$$Q = \frac{C_d A_0 \times A_1 \sqrt{2gh}}{\sqrt{A_1^2 - A_0^2}}$$

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

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



4) Reading from manometer $= 170mmHg = 0.17mHg$

Specific gravity of mercury is 13.6

Specific gravity of sea water $= 1.026$

$$h = y\left(\frac{\int_m}{\int_L} - 1\right)$$

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

$$h = 0.17(12.26)$$

$$h = 2.084m$$

$$V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.024}$$

$$= \sqrt{40.89}$$

$$= 6.39 m/s$$

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

a) $P = 15bar$ Speed $= 1700rpm$ Displacement $= 10cc/rev$

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

Theoretical flow = Displacement x Speed

but $10cm^3/rev = 10 \times 10^3 = 0.012/rev$

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

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

b) Fluid power $= \frac{\text{Pressure} \times \text{Actual flow}}{600} = \frac{15 \times 5}{600} = 0.125kw$

c) Hall power $= \frac{\text{Fluid power}}{\text{efficiency of pump}} = 125/0.294 = 425.17w$

General/overall efficiency = Volumetric efficiency x hydraulic/mechanical efficiency

Hydraulic efficiency $= \frac{\text{Theoretical torque}}{\text{Actual torque}}$

Theoretical torque $= (10 \times \sqrt{5})/ 20 \times 3.142 = 2.39 Nm$

Hydraulic efficiency $= 2.39/15 = 0.16$

Overall efficiency $= 0.294 \times 0.160 \times 100 = 4.7\%$