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1) A conical tube of length 2.0m is fixed vertically with its smaller end upwards. The velocity of flow at the smaller end is 5m/s while at the lower end it is 2m/s. The pressure head at the smaller end is 2.5m of liquid. The loss of head in the tube is given as $\left(\frac{0.35(V_1-V_2)^2}{2g}\right)$

Determine the pressure head at the lower end. Flow takes place in the downward direction.

Solution

$V_1 = 5m/s$ $V_2 = 2m/s$

smaller end = 2.5m $l = 2.0m$

$h_L = \left(\frac{0.35(V_1-V_2)^2}{2g}\right)$

$Z = Z_1 - Z_2$

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

$$\frac{P_2}{w} = \frac{P_1}{w} + \frac{1}{2g}(V_1^2 - V_2^2) + (Z_1 Z_2)h_E$$

$$= 2.5 + \frac{5^2 - 2^2}{2\times 9.81} - 2 - \frac{(0.35(5-2)^2}{2\times 9.81}$$

$= 2.5 + 1.07 + 2 - 0.016055$

$P_2 = 5.409$ bar

Pressure at lower end 5.409bar

2) Inlet diameter = ~~200m~~ 20cm

Outlet diameter = ~~100m~~ 10cm

$P_1 = 12.658m$

$J = 300m$ of mercury

$Cd = 0.98$

$$A_1 = \frac{\pi d^2}{4} = \left(\left(\frac{30}{100}\right)^2 \times 3.142\right) \div 4 = 0.03142m^2$$

...ically with
... at the
... it is 2m/s
... of liquid
$0.35(V_1-V_2)^2$
$2g$
... law takes

$A_2 = \frac{\pi d^2}{4} = (0.1^2 \times 3.142) \div 4 = 7.855 \times 10^{-3}$

$y = 30cm$ (0.3m of mercury)

$P_1 = 17.658$

$\frac{P_1}{\omega} = \frac{17.658}{1,000} = 1.8 \times 10^{-4}m$ of H_2O

$\frac{P_2}{\omega} = 0.3 \times 13.6 = 4.08$ of H_2O

$h = \frac{P_1}{\omega} - \frac{P_2}{\omega} = 1.8 \times 10^{-4} - (-4.08018)$

$h = 4.08m$

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

$Q = \frac{0.98 \times 0.0314 \times 7.853 \times 10^{-3}}{\sqrt{(0.0314)^2 - (7.855 \times 10^{-3})^2}} \times \sqrt{2 \times 9.81 \times 4.08018}$

$Q = \frac{0.000241 \times 8.949}{0.0304 m^2}$

$Q = 0.0709 m^3/s$

3) $D_1 = 15cm$ $D_2 = 30cm$

500mm of mercury = 0.5m $Q = ?$

$S.G = 0.9$ $C_d = 0.64$

$A_1 = \frac{\pi d^2}{4} = \left(\frac{(15/100)^2 \times 3.142}{4}\right) = 0.0176m^2$

$A_2 = \frac{\pi d^2}{4} = \left(\frac{(30/100)^2 \times 3.142}{4}\right) = 0.0706m^2$

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

$h = 0.5\left[\frac{13.6}{0.9} - 1\right]$

$= 7.05m$

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

$Q = \frac{0.64 \times 0.0176 \times 0.070}{\sqrt{(0.0706)^2 - (0.070)^2}} \times \sqrt{2 \times 9.81 \times 7.05}$

$Q = \frac{9.35 \times 10^{-3}}{4.0128}$

$Q = 2.33 \times 10^{-3}\ m^3/s$

4) $h = 15m$ $h_1 - h_2 = 170mm$

Sp.gr = 13.6

S.g of sea water = 1.06 v = ?

$h = y\left(\frac{h_1}{s} - 1\right)$

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

$h = 2.083m$

$V = \sqrt{2gh}$

$V = \sqrt{2 \times 9.81 \times 2.083}$

$V = 6.39 m/s$

5) $Q = 0.05 m^3/min$ $P_1 = P_2 = 15bar$

1700 rpm

10cm² Pav

15Nm

a) Volumetric Efficiency = $\frac{\text{Actual flowrate}}{\text{Theoretical flowrate}} \times 100$

Theoretical flowrate = speed of rotation × displacement

$= 28.333 \times 1 \times 10^{-5}$

$= 2.83 \times 10^{-4}\ m^3/rev$

volumetric efficiency = $\frac{8.33 \times 10^{-5}}{2.83 \times 10^{-4}} \times 100$

$= 29.45\%$

2) Fluid power = $Q(P_2 - P_1)$

$8.33 \times 10^{-5} (1.5 \times 10^6)$

$= 124.95$ water

3) Shaft power = $T \times \omega$

$\omega = 2 \times \pi \times$ speed of rotation

$\omega = 2 \times \pi \times 28.3 = 177.8$ rad/sec

Shaft

5) Over

Vol

Pre

Spe

ne

to

Shaft power = 15×177.81

$= 2667.2$ watts

) Overall efficiency = $\frac{\text{fluid power}}{\text{shaft power}} \times 100$

$= \frac{124.95}{2667.2} \times 100$

~~= 4.68 %~~

$= 0.0468 \times 100$

$= 4.68\%$

Volumetric flow rate rate = $0.05 m^3/min$ = $8.33 \times 10^{-5} m^3/s$

Pressure change = 15 bar = $1.5 \times 10^6 N/m^2$

Speed of rotation = 1700 rev/min = 28.33 rev/s

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

torque input = 15 Nm