MATRIC NO: 17/MH301/314
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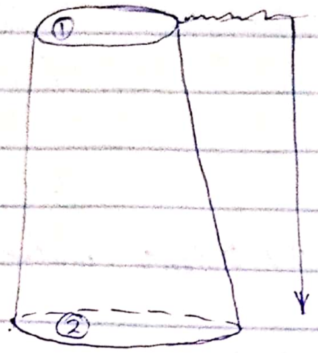
DEPARTMENT: Mechanical Engineering
COURSE: FLUID MECHANICS

1. Given,



$L = 2m$ $\quad V_1 = 5m/s$ $\quad V_2 = 2m/s$

$\frac{P_1}{\rho g} = 2.5m$ of liquid $\quad \frac{P_2}{\rho g} = ?$

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

$Z_2 = 2.0 \quad Z_1 = 0$

SOLUTION:

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

$\frac{P_1}{\rho g} + z_1 + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + z_2 + \frac{V_2^2}{2g} + h_L$

$\Rightarrow 2.5 + 2 + \frac{5^2}{2 \times 9.81} = \frac{P_2}{\rho g} + 0 + \frac{2^2}{2 \times 9.81} + 0.16$

$5.77 = \frac{P_2}{\rho g} + 0.35$

$\frac{P_2}{\rho g} = 5.77 - 0.35$

$\therefore$ Pressure head at larger opening $= 5.42m$ of liquid

2. Considering a Venturimeter,

$d_{IN} = 20cm \quad d_T = 10cm$

$A_{IN} = \pi\left(\frac{d_{IN}}{2}\right)^2 = 314.16cm^2 \quad A_T = \pi\left(\frac{d_T}{2}\right)^2 = 78.54cm^2$

Vac. $P_T = 30cm$ of mercury $\quad C_d = 0.98 \quad Q = ?$

$P_{IN} = 17.658N/cm^2 = 17.658 \times 10^4 N/m^2$

SOLUTION:

$\rho_{water} = 1000kg/m^3$

$$\frac{P_{IN}}{\rho g} = \frac{17.658 \times 10^4}{1000 \times 9.81} = 18 m \text{ of water}$$

$$\frac{P_T}{\rho g} = -30 cm \text{ of mercury}$$
$$= -0.3 m \text{ of mercury}$$
$$= -0.3 \times 13.6$$
$$= -4.08 m \text{ of water}$$

Differential head, h

$$h = \frac{P_{IN}}{\rho g} - \frac{P_T}{\rho g} = 18 - (-4.08) = 22.08 m \text{ of water}$$

$$\therefore h = 2208 cm \text{ of water}$$

$$Q = C_d \cdot \frac{a_{IN} a_T}{\sqrt{a_{IN}^2 - a_T^2}} \times \sqrt{2gh}$$

$$\Rightarrow Q = 0.98 \times \frac{314.16 \times 78.54}{\sqrt{314.16^2 - 78.54^2}} \times \sqrt{2 \times 9.81 \times 2208}$$

$$= 16545.52 \ cm^3/s$$

$$\therefore Q = 165.5 \ ltr/s$$

B. Considering an orifice meter

$d_o = 15 cm$ $\quad$ $d_p = 30 cm$

$A_o = \pi \left(\frac{d_o}{2}\right)^2 = 176.71 cm^2$ $\quad$ $A_p = \pi \left(d_p/2\right)^2 = 706.86 cm^2$

Reading of diff. manometer, $Y = 50 cm$ of mercury

SG oil $= 0.9$ $\quad$ $C_d = 0.64$ $\quad$ $Q = ?$

SOLUTION:

$$\text{differential head, } h = Y\left(\frac{SG_{mercury}}{SG_{oil}} - 1\right)$$
$$= 50\left(\frac{13.6}{0.9} - 1\right)$$

$$\therefore h = 705.56 cm \text{ oil}$$

$$Q = C_d \cdot \frac{a_o a_p}{\sqrt{a_p^2 - a_o^2}} \times \sqrt{2gh}$$

$\Rightarrow Q = 0.64 \times \left(\frac{176.71 \times 706.86}{\sqrt{706.86^2 - 176.71^2}}\right) \times \sqrt{2 \times 9.81 \times 705.56}$

$= 13742.67 \, cm^3/s$

$\therefore Q = 137.427 \, ltr/s$

4. Considering a pitot tube,

SG mercury = 13.6 — difference of mercury level, x

SG sea water = 1.026 — $x = 170mm = 0.17m$ — $V = ?$

SOLUTION:

$$h = x\left(\frac{SG \text{ mercury}}{SG \text{ seawater}} - 1\right)$$

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

$$\therefore h = 2.0834 \, m$$

$$V = \sqrt{2gh}$$

$$= \sqrt{2 \times 9.81 \times 2.0834}$$

$$= 639.35 \, cm/s$$

$$= 6.394 \, m/s$$

$$= \frac{6.394 \times 60 \times 60}{1000}$$

$\therefore$ Speed $= 23.02 \, km/hr$

5. Given

actual flow = ~~~~5 dm^3/min = ~~0.5m/min~~ ~~0.5×~~ $5 \times 10^{-3} m/min$

pressure = 15bar

displacement = $10cm^3/rev$

torque input = 15N/m

speed of rotation = 1700 rev/min

i. Volumetric efficiency = ?

Vol Eff = $\frac{\text{actual flow}}{\text{theoritical flow}}$ ~~xxxx~~ $\times 100$

~~⇒ Vol. Eff~~

Theoretical flow = displacement × speed

$= 10\,cm^3/rev \times 1700\,rev/min$

$= 17 \times 10^3\,cm^3/min$

$= 17 \times 10^{-3}\,m^3/min$

⇒ Vol. Eff. $= \dfrac{5 \times 10^{-3}}{17 \times 10^{-3}} \times 100$

$= 29.41\%$

ii. Fluid power = ?

Fluid power = actual flow × pressure

~~$5 \times 15 \times 10^5\,N/m^2$~~

actual flow $= 5 \times 10^{-3}\,m^3/min \times \dfrac{1\,min}{60\,s} = 8.33 \times 10^{-5}$

pressure = 15 bar = $15 \times 10^5\,N/m^2$

⇒ Fluid power $= 8.33 \times 10^{-5} \times 15 \times 10^5$

$= 125\,W$

iii. Shaft power $= T \times \omega$

speed $= 1700\,rev/min \times \dfrac{1\,min}{60\,s} = 28.33\,rev/s$

ω (in rad/s)

2π rad = 1 rev

$x = 28.33/s$

$x = 178.003\,rad/s$

⇒ Shaft power $= 15 \times 178.003$

$= 2670.03\,W \simeq 2.67\,kW$

iv. Overall Efficiency $= \dfrac{\text{Fluid power}}{\text{Shaft power}} \times 100$

$= \dfrac{124.995}{2670.03} \times 100$

$= 4.68\%$