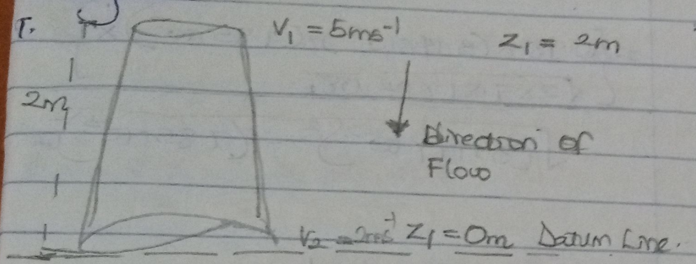
NAME: LONGJOHN BOMAFINITAMUNOPIRI ADANGO
MATRIC NO: 19/ENG01/020
DEPARTMENT: CHEMICAL
COURSE CODE: ENG 214
[redacted]

Assignment.



Applying Bernoulli's equation for real fluids

$$\frac{P_1}{\omega} + z_1 + \frac{v_1^2}{2g} = \frac{P_2}{\omega} + z_2 + \frac{v_2^2}{g} + \text{head loss}$$

$$\frac{P_1}{\omega} = 2.5m \text{ of fluid}$$

$$\text{Head loss } (h_L) = \frac{0.35(v_1 - v_2)^2}{2g}$$

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

$$= \frac{0.35 \times 3^2}{2(9.81)} = 0.16m$$

$Z_1 = 2m$, $Z_2 = 0$
$v_1 = 5\ ms^{-1}$ $v_2 = 2ms^{-1}$

Substituting into eqn ①

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

$$5.77 = \frac{P_2}{\omega} + 0.36$$

$$\frac{P_2}{\omega} = 5.77 - 0.36$$

$$\frac{P_2}{\omega} = 5.40m \text{ of liquid}$$

$$\frac{P_2}{\omega} = \text{Pressure head.}$$

Question 2

$D_1 = 20cm \rightarrow 0.2m$

$D_2 = 10cm \rightarrow 0.1m$

$P_1 = 17.658 N/cm^2 \rightarrow 17.658 \times 10^4 N/m^2$

$C_d = 0.98$

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

$= 3.14 \times 10^{-2} m^2$

$A_2 = \frac{\pi d^2}{4} = \frac{\pi \times 0.1^2}{4}$

$= 7.85 \times 10^{-3} m^2$.

h (head difference)

$= \frac{P_1}{\omega} - \frac{P_2}{\omega}$

$\frac{P_1}{\omega} = \frac{17.658 \times 10^4 N/m^2}{1000 \times 9.81 N/m^3}$

$= 18m$ of water.

$\frac{P_2}{\omega} = -30cm$ of Hg

$= -30cm \times \frac{1m}{100cm} \times 13.6$

$= -4.08m$ of water.

$h = 18 - (-4.08)$

$= 22.08m$ of water.

$Q_{water} = \cdot C_d$

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

$= \frac{\{0.98 \times (3.14 \times 10^{-2}) \times (7.85 \times 10^{-3}) \times \sqrt{2 \times 9.81 \times 22.08}\}}{\sqrt{(3.14 \times 10^{-2})^2 - (7.85 \times 10^{-3})^2}}$

$= 0.165 m^3 s^{-1}$

Question 3

$D_o = 15cm = 0.15m$

$D_1 = 30cm = 0.30m$

$y = 50cm$ of Hg

$= 0.5m$ of Hg

$Cd = 0.64$

$S_{Hg} = 13.6$

$S_o = 0.9$

$$A_o = \frac{\pi d^2}{4} = \frac{\pi \times 0.15^2}{4}$$

$$= 1.77 \times 10^{-2} m^2.$$

$$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.3^2}{4}$$

$$= 7.07 \times 10^{-2} m^2.$$

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

$= 7.05m$ of oil.

$$Q_{oil} = \frac{Cd\, A_o A_1 \sqrt{2gh}}{\sqrt{A_1^2 - A_o^2}}$$

$$= \frac{0.64 \times 1.77 \times 10^{-2} \times 7.07 \times 10^{-2} \times \sqrt{2 \times 9.81 \times 7.05}}{\sqrt{(7.07 \times 10^{-2})^2 - (1.77 \times 10^{-2})^2}}$$

$= 0.1376 m^3 s^{-1} \simeq 0.138 m^3 s^{-1}$

Question 4

$v = \sqrt{2g\Delta h}$

where

v = velocity

Δh = difference in pressure head.

y = manometric reading.

$S_{Hg} = 13.6$

$S_w = 1.026.$

~~$A = y(\frac{S_{Hg}}{S_w} - 1)$~~

$y = 170mm = 0.17m$

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

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

$= 2.08m$

$v = \sqrt{2 \times 9.81 \times 2.08}$

$v = 6.39 ms^{-1}$

Question 5

Flow rate (Q_{actual}) = $5 dm^3/min$

$\frac{5 dm^3}{min} \times \frac{1 m^3}{10^3 dm^3} \times \frac{1 min}{60 sec}$

$= 8.33 \times 10^{-5} m^3 sec^{-1}$

Speed (v) = 1700 rev/mins

$\frac{1700 rev}{min} \times \frac{1 min}{60 sec} = 28.3 revs/sec$

Change in Pressure (δP) = 15 bars

$15 bar \times \frac{10^5 Nm^{-2}}{1 bar} =$

$15 \times 10^5 Nm^{-2}$.

Nominal Displacement = $10 cm^3/rev$

$\frac{10 cm^3}{rev} \times \frac{m^3}{10^6 cm^3} = 10^{-5} m^3/rev$.

Ideal Flowrate (Q_i) =
Nominal Displacement x Speed

$= 10^{-5} \frac{m^3}{rev} \times 28.3 \frac{rev}{sec}$

$= 28.3 \times 10^{-5} m^3/sec$.

T = 15N.

a. Volumetric efficiency

$\frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100$

$= \frac{8.33 \times 10^{-5}}{28.3 \times 10^{-5}} \times 100\%$

$= 29.4\%$.

b. Fluid Power = $Q_a \times \delta P$

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

$= 124.95 kJ$

c. Shaft Power = $\tau \cdot \omega_c$.

where

τ = torque input

ω_c = angular speed in rad/sec

$\omega_c = 2\pi v$ for rps

$\omega_c = 2 \times \pi \times 28.3$

$= 178.02 rad/sec$

Shaft Power = 15×178.02

$= 2670.35 kJ$

d. Overall efficiency

$= \frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100\%$

$= \frac{124.95 kJ}{2670.35 kJ} \times 100\%$

$= 4.68\%$