NAME: ABUBAKAR HANNY OSHIOZOKHAI

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DEPT: MECHATRONICS

COURSE CODE: ENG 214

ABUBAKAR HANNY OSHIOZOKHAI
18 /ENG05 /003
MECHATRONICS ENGINEERING
ASSIGNMENT

(1) length $l = 2.0m$

The velocity flow at smaller end $(V_1) = 5m/s$

The velocity flow at lower end $(V_2) = 2m/s$

Let the pressure head at the smaller end $(P_s) = 2.5m$ of liquid

Loss of head $(H_L) = \frac{0.35(V_1 - V_2)^2}{2g} = \frac{0.35(5-2)^2}{2 \times 9.81} = 0.161m$

~~Let the~~ pressure head at lower end $(P_L) = ?$

Applying Bernoullis equation

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

where $P_s = \frac{P_1}{\rho g}$ and $P_L = \frac{P_2}{\rho g}$

$z_1 = 2.0$ and $z_2 = 0$ (datum line passes through section 2)

Inputting values into the equation

$$2.5 + \frac{5^2}{2 \times 9.81} + 2.0 = P_L + \frac{2^2}{2 \times 9.81} + 0 + 0.161$$

$$2.5 + \frac{25}{19.62} + 2 = P_L + \frac{4}{19.62} + 0.161$$

$$2.5 + \frac{25}{19.62} + 2 - \left(\frac{4}{19.62} + 0.161\right) = P_L$$

$$5.774 - 0.365 = P_L$$

$P_L = 5.409m$ of fluid

2) Let inlet diameter $(D_1) = 20cm$

Let thread diameter $(D_2) = 10cm$

~~Let~~ inlet area $(A_1) = \frac{\pi D_1^2}{4} = \frac{\pi (20)^2}{4} = 314.16cm^2$

throat area $(A_2) = \frac{\pi D_2^2}{4} = \frac{\pi (10)^2}{4} = 78.54 cm^2$

Density of water, $\rho = 1000 kg/m^3$

Pressure at inlet $= 17.658 N/cm^2 = 17.658 N/m^2$

$\therefore \frac{P_1}{\rho g} = \frac{17.658 \times 10^4}{1000 \times 9.81} = 18m$

$\frac{P_2}{\rho g} = -30cm$ of mercury

Specific gravity = 13.6

$\frac{P_2}{\rho g} = -30 \times 10^{-2} m$ of mercury $\times 13.6$

$= -4.08m$

Let Differential Head $= H = \frac{P_1}{\rho g} - \frac{P_2}{\rho g}$

$= 18 - (-4.08)$

$= 18 + 4.08 = 22.08m \times 100$

$H = 2208cm$

Using $Q = \frac{(d\sqrt{2gh} \cdot A_1 A_2)}{\sqrt{A_1^2 - A_2^2}} = \frac{0.98 \times \sqrt{2 \times 9.81 \times 2208} \times 314.16 \times 78.54}{\sqrt{(314.16)^2 - (78.54)^2}}$

$= \frac{0.98 \times 2081.37 \times 24674.1204}{304.184112} = 165455.3 cm^3/s$

$= \frac{165455.3}{1000} = 165.455$ lit/sec

3) Diameter of pipe $d_1 = 30cm$

$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi (30)^2}{4} = 706.86 cm^2$

Diameter of orifice, $d_2 = 15cm$

$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi (15)^2}{4} = 176.72 cm$

Specific gravity of oil, $S_0 = 0.9$

" " " mercury, $S_{hg} = 13.6$

Differential manometer reading, $X = 50cm$ of mercury

Coefficient of discharge, $Cd = 0.64$

Differential head, $h = x\left(\frac{S_{hg}}{S_o} - 1\right) = 50\left(\frac{13.6}{0.9} - 1\right)$

$h = 705.56$ cm of oil

∴ The rate of flow of oil is

$$Q = \frac{C_d\sqrt{2gh} \cdot A_1A_2}{\sqrt{A_1^2 - A_2^2}}$$

$$Q = \frac{0.64 \times \sqrt{2 \times 9.81 \times 705.56} \times 706.86 \times 176.72}{\sqrt{(706.86)^2 - (176.72)^2}}$$

$Q = 137443.29$ cm³/s

$$Q = \frac{137443.29}{1000} = 137.44 \text{ lit/s.}$$

4) Diff of mercury lead $(x) = 170$ mm $= 0.17$ m

Specific gravity of mercury $(S_{hg}) = 13.6$

" " " sea water $(S_o) = 1.026$

Speed $V = ?$

$U = \sqrt{2gh}$, $h = ?$

$$h = x\left[\frac{S_g}{S_o} - 1\right] = 0.17\left[\frac{13.6}{1.026} - 1\right] = 2.0834\text{m}$$

$$\therefore V = \sqrt{2 \times 9.81 \times 2.0834} = 6.393 \text{ m/s}$$

In Km/hr

$$V = \frac{6.393 \times 60^2}{1000} = 23.01 \text{ km/hr}$$

5) $Q = 0.05\text{m}^3/\text{min} = 50\text{dm}^3/\text{min}$

$P_o = 15\text{bar} = 15 \times 100000 = 15 \times 10^5 \text{ N/m}^2$

Speed $= 1700$ rev/min

$T = 15$ Nm, ~~AID~~ $= 10\text{cm}^3/\text{rev}$

i) Volumetric efficiency $= \dfrac{\text{Actual flow rate}}{\text{Ideal flow rate}}$

Ideal flow rate = Nominal flow rate x Speed

$= ~~100~~ \; 10 cm^3/rev \times 1700 \; rev/min$

$= 17000 \; cm^3/min$

Ideal flow rate $= \frac{17000}{1000000} = 0.017 \; m^3/min$

Actual flow rate $= 0.05 m^3/min$

$\therefore$ Volumetric efficiency $= \frac{0.05}{0.017} = 2.94\%$

ii) Fluid power $= P \times Q$

$P = 15 \times 10^5 \; N/m^2$

$Q = 0.05 m^2/mm = \frac{0.05}{60} = 8.33 \times 10^{-4} \; m/s$

Fluid power $= 15 \times 10^5 \times 8.33 \times 10^{-4}$

$= 15 \times 10^5 \times 83.3 \times 10^{-5}$

$= 1249.5 \times 10^0 = 1249.5$ Watts

iii) Shaft power $= \frac{2\pi NT}{60} = \frac{2\pi \times 1700 \times 15}{60} = 2670.35$ watts