

NWACHUKWU

MARSHALL

18/ENG05/036

MECHATRONICS

ENG 21A

ASSIGNMENT

$$= 294.51 \text{ m}$$

$$\begin{aligned} \text{ii) Efficiency} &= \frac{\text{Power of Jet}}{\text{Power of Reservoir}} \times 100\% \\ &= \frac{4797.1}{57442.3} \times 100\% \\ &= 0.83\% \end{aligned}$$

$$\begin{aligned} \text{6) } P &= \rho g Q z \\ z &= 20 \text{ m} = h \\ \rho &= 1000 \\ g &= 9.81 \\ Q &= VA \\ d &= 10 \text{ cm} = 10 \times 10^{-2} \text{ m} \\ A &= \frac{\pi d^2}{4} = 7.85 \times 10^{-3} \text{ m}^2 \end{aligned}$$

But we need the velocity at height of initial velocity using one of the equation of motion,

$$v = 0$$

$$v^2 = u^2 - 2gh$$

$$u = \sqrt{v^2 + 2gh}$$

$$u = \sqrt{0^2 + 2 \times 9.81 \times 20}$$

$$u = \sqrt{392.4}$$

$$u = 19.809 \approx 19.81 \text{ m/s}$$

$$\text{The velocity} = 19.81$$

$$\begin{aligned} \therefore Q &= VA \\ &= 19.81 \times 7.85 \times 10^{-3} \\ &= 0.15558 \text{ m}^3/\text{s} \\ &\approx 0.156 \text{ m}^3/\text{s} \end{aligned}$$

Then;

$$P = \rho g Q z$$

Overall Efficiency

$$\frac{\text{Fluid power}}{\text{Shaft power}} \times 100\%$$

$$\frac{200.4}{1963.5} \times 100\% = 10.206 \approx 10.21\%$$

② Pump delivery =  $35 \text{ dm}^3/\text{min}$

$$\frac{35 \times 10^{-6}}{60} = 5.83 \times 10^{-4}$$

$$P = 100 \text{ bar} = 100 \times 10^5 \text{ Nm}^{-2}$$

Overall Efficiency = 87%

Fluid power =  $Q \cdot dp$

$$= 5.83 \times 10^{-4} \times 100 \times 10^5$$

$$= 5830 \text{ watts}$$

Recall,

$$\text{Overall Efficiency} = \frac{\text{Fluid power}}{\text{Shaft power}} \times 100\%$$

$$\therefore \text{Shaft power} = \frac{\text{Fluid power} \times 100}{\text{Overall Efficiency}}$$

$$= \frac{5830 \times 100}{87}$$

$$= 6701.149 \text{ watts}$$

③ Nominal displacement of  $50 \text{ cm}^3/\text{rev}$

$$= 50 \times 10^{-6} \text{ m}^3/\text{rev}$$

$$\text{pressure} = 100 \text{ bar} = 100 \times 10^5 \text{ N/m}^2$$

$$\text{Shaft power} = 15 \text{ kW} = 15000 \text{ watts}$$

$$\text{Actual Flowrate} = 35 \text{ dm}^3/\text{min} = \frac{35 \times 10^{-6} \text{ m}^3}{60}$$

$$= 5.83 \times 10^{-4} \text{ m}^3/\text{s}$$

$$\text{Speed} = 850 \text{ rev/min} = \frac{850}{60}$$

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

$$= 0.17 \times 12.255$$

$$= 2.0834 \text{ m}$$

Recall  $v = \sqrt{2gh}$

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

$$v = \sqrt{40.87}$$

$$v = 6.393 \text{ m/s}$$

$$= 14.166 \approx 14.17 \text{ rev/s}$$

$$\text{ideal flowrate} = \text{Nominal displacement} \times \text{speed}$$

$$= 50 \times 10^{-6} \text{ m}^3/\text{rev} \times 14.17 \text{ rev/s}$$

$$= 7.085 \times 10^{-4} \text{ m}^3/\text{s}$$

i

$$\text{Volumetric efficiency} = \frac{\text{Real Flowrate}}{\text{Ideal Flowrate}} \times 100\%$$

$$= \frac{5.83 \times 10^{-4}}{7.085 \times 10^{-4}}$$

$$= 82.29\%$$

ii

$$\text{Fluid Power} = Q \cdot dp$$

$$= 5.83 \times 10^{-4} \times 100 \times 10^5$$

$$= 5830 \text{ Watts}$$

$$\text{Overall Efficiency} = \frac{5830}{15000} \times 100$$

$$= 38.867\%$$

4

$$z = 2400 \text{ cm} = 24 \text{ m}$$

$$\text{volumetric Flowrate, } Q = 13 \text{ litres/sec}$$

$$= 0.013 \text{ m}^3/\text{sec}$$

$$\text{velocity} = 66 \text{ m/sec}$$

The general formula,

$$P = \rho g Q \left( \frac{p}{\rho g} + \frac{v^2}{2g} + z \right)$$

$$P = Qp + \rho \frac{Qv^2}{2} + \rho g Qz$$

But introducing here (power of jet)

pressure head = 0

$$z = 0$$

$$\therefore P = \frac{\rho Q v^2}{2}$$

$$\begin{aligned}
 \text{Real Flowrate} &= 10 \text{ dm}^3/\text{min} \quad T = 12.5 \text{ Nm} \\
 &= \frac{10 \times 10^{-3}}{60} = 1.67 \times 10^{-4} \text{ m}^3/\text{s}
 \end{aligned}$$

$$\text{Pressure} = 12 \text{ bar} = 12 \times 10^5 \text{ N/m}^2$$

$$\text{Speed} = 1500 \text{ rev/min} = \frac{1500 \text{ rev}}{60} = 25 \text{ rev/sec}$$

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

$$\begin{aligned}
 \text{Ideal Flowrate} &= \text{Nominal displacement} \times \text{speed} \\
 &= 1 \times 10^{-5} \frac{\text{m}^3}{\text{rev}} \times 25 \frac{\text{rev}}{\text{sec}}
 \end{aligned}$$

$$= 2.5 \times 10^{-4} \text{ m}^3/\text{sec}$$

$$\text{i Volumetric efficiency} = \frac{\text{Real Flowrate}}{\text{ideal Flowrate}} \times 100\%$$

$$= \frac{1.67 \times 10^{-4}}{2.5 \times 10^{-4}} \times 100\%$$

$$= 66.8\%$$

$$\text{ii Fluid Power} = Q \cdot dp$$

$$= 1.67 \times 10^{-4} \times 12 \times 10^5$$

$$= 200.4 \text{ watts}$$

$$\text{iii Shaft power} = \tilde{T} \cdot \omega$$

$$\omega = 2\pi N = 2 \times \pi \times N$$

$$= 2 \times \pi \times 25$$

$$= 157.0796$$

$$\approx 157.08$$

$$\therefore \text{Shaft power} = 12.5 \times 157.08$$

$$= 1963.5 \text{ watts}$$

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

$$P_1 - P_2 = 19.62(z_2 - z_1) + 0.803 V_2^2 - ii$$

$$z_2 - z_1 = 0.06 \text{ m}$$

equating equi & equii

$$19.62(z_2 - z_1) + 587.423 = 19.62(z_2 - z_1) + 0.803 V_2^2$$

$$0.803 V_2^2 = 587.423$$

$$V_2^2 = \frac{587.423}{0.803}$$

$$V_2^2 = 731.535$$

$$V_2 = \sqrt{731.535}$$

$$V_2 = 27.0469$$

$$\approx 27.047 \text{ m/s}$$

$$Q_{\text{ideal}} = A_2 V_2$$

$$= 27.047 \times 0.0314$$

$$Q_{\text{ideal}} = 0.8492$$

$$\approx 0.85 \text{ m}^3/\text{s}$$

$$Q_{\text{real}} = C_d \times Q_{\text{ideal}}$$

$$= 0.96 \times 0.85$$

$$= 0.816 \text{ m}^3/\text{s}$$

8) Throat diameter = 0.676 m ( $d_2$ )

Vertical diameter = 0.152 m ( $d_1$ )

Relative density = 0.8

Throat being = 0.914 m

$C_d = 0.91$

Bernoulli's equ.

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

Recall that

$$Q = V_1 A_1, \quad Q = V_2 A_2$$

$$A_2 = \frac{\pi d^2}{4} = \frac{\pi \times 0.076^2}{4}$$

$$= 4.64 \times 10^{-3} \text{ m}^2$$

$$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.0152^2}{4}$$

$$= 0.0191 \text{ m}^2$$

ii) Then  $P_1 - P_2 = 15170$

$$\left( \frac{P_1}{\rho g} + z_1 \right) - \left( \frac{P_2}{\rho g} + z_2 \right) = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

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

Recall,  $Q = VA$ ,  $V = \frac{Q}{A}$

$$\frac{15170}{800 \times 9.81} = \left( \left( \frac{Q}{A_2} \right)^2 - \left( \frac{Q}{A_1} \right)^2 \right) - 0.914$$

$$\frac{15170}{7848} = Q^2 \left( \left( \frac{1}{A_2} \right)^2 - \left( \frac{1}{A_1} \right)^2 \right) - 0.914$$

$$1.932 = Q^2 \frac{(48516.36 - 3052.41)}{2g} - 0.914$$

$$(1.932 + 0.914) 2g = Q^2 (48516.36 - 3052.41) - 0.914$$

$$\frac{56.378}{45463.95} = Q^2 \frac{45463.95}{45463.95}$$

$$Q^2 = 1.24 \times 10^{-3}$$

$$Q = \sqrt{1.24 \times 10^{-3}}$$

$$Q = 0.0352 \text{ m}^3/\text{s}$$

$$Q = 0.0352 \text{ m}^3/\text{s}$$



and,  $Q = 0.013$ ,  $\rho = 1000$ ,  $V = 66 \text{ m/s}$ .

$$P = \frac{1000 \times 0.013 \times (66)^2}{2}$$

$$P = 28314 \text{ watts} = 28.314 \text{ kilowatts}$$

ii) power supplied from reservoir

At atmospheric pressure,  $p = 0$  and  $V = 0$ .

$$P = \rho g Q z$$

$$= 1000 \times 9.81 \times 0.013 \times 240$$

$$= 30607.2 \text{ watts}$$

$$\approx 30.607 \text{ kilowatts}$$

iii) power loss in transmission,

= power of reservoir - power of jet

$$= (30607.2 - 28314)$$

$$= 2293.2 \text{ watts}$$

$$\approx 2.2932 \text{ kilowatts}$$

Head loss in pipeline = 2.2932 kilowatts.

$h = \frac{\text{power lost in transmission}}{\rho g Q}$

$$= \frac{2293.2}{1000 \times 9.81 \times 0.013}$$

$$= \frac{2293.2}{127.53}$$

$$= 17.98 \text{ m}$$

$$h = 17.98 \text{ m}$$

Efficiency =  $\frac{\text{power of Jet}}{\text{power of reservoir}} \times 100\%$

$$= \frac{28314}{30607.2} \times 100$$

$$= 92.51\%$$

$$= 92.51\%$$

$$\begin{aligned}
 d_1 &= 300 \text{ mm} = 0.3 \text{ m} \\
 d_2 &= 150 \text{ mm} = 0.15 \text{ m} \\
 \therefore A_1 &= 0.0706 \text{ m}^2 \\
 A_2 &= 0.0177 \text{ m}^2 \\
 Q &= 10 \text{ lit/sec} = 0.01 \text{ m}^3/\text{sec}
 \end{aligned}$$

$$\begin{aligned}
 z_1 &= 10 \text{ m}, \quad z_2 = 6 \text{ m} \\
 P_1 &= 400 \text{ kN/m}^2, \quad P_2 = ? \\
 \frac{P_1}{\rho g} + z_1 + \frac{V_1^2}{2g} &= \frac{P_2}{\rho g} + z_2 + \frac{V_2^2}{2g}
 \end{aligned}$$

$$\text{But, } Q = A_1 V_1$$

$$\therefore V_1 = \frac{Q}{A_1} = \frac{0.01}{0.0706}$$

$$V_1 = 0.1416 \text{ m/s} \approx 0.14 \text{ m/s}$$

$$\text{Then } V_2 = \frac{Q}{A_2} = \frac{0.01}{0.0177}$$

$$V_2 = 0.565 \text{ m/s} \approx 0.57 \text{ m/s}$$

$$\frac{P_1}{\rho g} (z_1 - z_2) + \left( \frac{V_1^2}{2g} - \frac{V_2^2}{2g} \right) = \frac{P_2}{\rho g}$$

$$\frac{400 \text{ kN}}{9.81 \text{ kN}} + (10 - 6) + \left( \frac{0.1416^2}{2 \times 9.81} - \frac{0.565^2}{2 \times 9.81} \right) = \frac{P_2}{9.81 \text{ kN}}$$

$$40.77 + 4 + (-0.2438) = \frac{P_2}{9.81 \text{ kN}}$$

$$44.52 \times 9.81 = P_2$$

$$P_2 = 436.74 \text{ kN}$$

$$\begin{aligned}
 10) \text{ Reading of Manometer} &= 170 \text{ mm} \\
 &= 0.17 \text{ m}
 \end{aligned}$$

$$\text{Specific gravity of mercury} = 13.6$$

$$\text{Specific gravity of seawater} = 1.026$$

$$y = 0.17 \text{ m}$$

$$\text{For } h = y \left( \frac{S_h}{S} - 1 \right)$$

5)  $S_g \text{ oil} = 0.89$

$$Z = 30,000 \text{ cm} = 300 \text{ m}$$

$$Q = 220 \text{ L/sec} = 0.22 \text{ m}^3/\text{sec}$$

$$V = 7 \text{ m/sec}$$

i) Introducing,  $Z = 0$ , Pressure = 0

$$i) P = \frac{\rho Q V^2}{2}$$

but,  $S_g = 0.89$

$$S_g = \frac{x}{1000}$$

ii)

$$\therefore x = 0.89 \times 1000$$

$$x = 890$$

$$\therefore P = x = 890$$

$$P = \frac{890 \times 0.22 \times (7)^2}{2}$$

$$P = 4797.1 \text{ watts}$$

ii) power supplied from reservoir.

$$P = \rho g Q Z$$

$$P = 890 \times 9.81 \times 0.22 \times 300$$

$$P = 576239.4 \text{ watts}$$

$$\approx 576.2394 \text{ kilowatts}$$

iii) power loss in transmission

$$= \text{power reservoir} - \text{power of Jet}$$

$$= (576239.4 - 4797.1) \text{ kilowatt}$$

$$= 571442.3 \text{ watts}$$

$$= 571.4423 \text{ kilowatt}$$

Head used to overcome losses

$$= \frac{571442.3}{890 \times 9.81 \times 0.22}$$

$$890 \times 9.81 \times 0.22$$

$$= 1000 \times 9.81 \times 0.156 \times 20$$

$$p = 30510.7677 \text{ N/m}^2$$

$$\approx 30.5 \text{ kilonewtons}$$

$$7) \quad d_1 = 0.3 \text{ m}$$

$$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi \times 0.3^2}{4}$$

$$= 0.07068 \text{ m}^2 \approx 0.0707 \text{ m}^2$$

$$d_2 = 0.2 \text{ m}$$

$$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi \times 0.2^2}{4}$$

$$= 0.031415 \text{ m}^2 \approx 0.0314 \text{ m}^2$$

$$C_d = 0.96$$

$$\text{Specific weight of gas} = 19.62 \text{ N/m}^3$$

$$S = \frac{mg}{V} = \rho g$$

$$= \frac{19.62}{9.81} = \frac{\rho \times 9.81}{9.81} \quad \text{so, } \rho g = 19.62$$

$$\therefore \rho = 2 \text{ kg/m}^3$$

$$\text{calculating } Q_1 = A_1 V_1, \quad Q_2 = A_2 V_2, \quad Q_1 = Q_2$$

$$\therefore V_1 = \frac{Q_1}{A_1}$$

$$V_2 = \frac{Q_2}{A_2}$$

$$V_1 = \frac{Q}{0.0707}$$

$$V_2 = \frac{Q}{0.0314}$$

For the manometer

$$p_1 + \rho_f g z_1 = p_2 + \rho_f g (z_2 - h_p) + \rho_w g h_p$$

$$p_1 - p_2 = \rho_f g (z_2 - h_p) + \rho_w g h_p - \rho_f g z_2$$

$$p_1 - p_2 = 19.62 (z_2 - z_1) + 587.423 - i$$

For the Venturimeter,