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ENG 214 assignment.

$$\textcircled{1} \text{ Volumetric flow rate, } Q = 10 \text{ dm}^3/\text{min} = 10 \times \frac{1}{1000 \times 60}$$
$$= \frac{10}{1000 \times 60} = 1.67 \times 10^{-4} \text{ m}^3 \text{ s}^{-1}.$$

$$\text{Speed} = 1500 \text{ rev/min} = 1500 \times \frac{1}{60} =$$

$$= 25 \text{ rps} =$$

$$\text{Pressure change; } \Delta p = 12 \text{ bar}$$
$$= 12 \times 10^5 \text{ N m}^{-2}.$$

$$\text{Nominal displacement} = 10 \text{ cm}^3/\text{rev}$$
$$= \frac{10}{1000} = 1 \times 10^{-5} \text{ m}^3 \text{ rev}^{-1}.$$

$$\text{Ideal flow rate} = \text{Nominal displacement} \times \text{speed}.$$
$$= 1 \times 10^{-5} \times 25$$
$$= 2.5 \times 10^{-4} \text{ m}^3 \text{ s}^{-1}.$$

$$\textcircled{2} \text{ Volumetric efficiency} = \frac{\text{Actual flow rate}}{\text{Ideal flow rate}} \times 100$$
$$= \frac{1.67 \times 10^{-4}}{2.5 \times 10^{-4}} \times 100$$
$$= 66.8\%$$

$$\textcircled{3} \text{ Fluid power} = \text{Flow rate} \times \text{change in pressure}$$
$$= 1.67 \times 10^{-4} \times 12 \times 10^5$$
$$= 200.4 \text{ W}.$$

$$\textcircled{4} \text{ Shaft power} = \text{Torque input} \times \text{angular speed}.$$
$$\text{Torque input} = 12.5 \text{ Nm}.$$
$$\text{Angular speed, } \omega = \frac{25 \text{ rps}}{60} = \frac{2\pi n}{60}.$$

$$= \frac{2 \times \pi \times 25}{60} = 157.14 \text{ rad/s}.$$

$$\text{Shaft power} = 12.5 \times 157.14 = 1964.25 \text{ W}.$$

$$\begin{aligned} \textcircled{1} \text{ Overall efficiency} &= \frac{\text{Fluid power}}{\text{Shaft power}} \times 100 \\ &= \frac{200.4}{1964.25} \times 100 \\ &= 10.2\% \end{aligned}$$

$$\begin{aligned} \textcircled{2} \text{ Pressure change, } \Delta P &= 100 \text{ bar} \\ &= 100 \times 10^5 \text{ Nm}^{-2} \\ &= 10^7 \text{ Nm}^{-2} \end{aligned}$$

$$\begin{aligned} \text{Actual flow rate, } Q &= 35 \text{ dm}^3/\text{min} \\ &= 35 \times \frac{1}{1000 \times 60} \\ &= 5.83 \times 10^{-4} \text{ m}^3 \text{ s}^{-1} \end{aligned}$$

$$\begin{aligned} \text{Fluid power} &= \Delta P \cdot Q \\ &= 10^7 \times 5.83 \times 10^{-4} \\ &= 5830 \text{ W} \end{aligned}$$

$$\text{Efficiency} = \frac{\text{Fluid power}}{\text{shaft power}} \times 100$$

$$\begin{aligned} \text{Shaft power} &= \frac{\text{Fluid power}}{E} \times 100 \\ &= \frac{5830}{87} \times 100 \\ &= 6701.15 \text{ W} \end{aligned}$$

$$\begin{aligned} \textcircled{3} \text{ Nominal displacement} &= 50 \text{ cm}^3 \text{ rev}^{-1} \\ &= \frac{50 \times 1}{10^6} = 50 \times \frac{1}{10^6} = 5 \times 10^{-5} \text{ m}^3 \text{ rev}^{-1} \end{aligned}$$

$$\begin{aligned} \text{Actual flow rate, } Q &= 35 \text{ dm}^3/\text{min} \\ &= 35 \times \frac{1}{1000 \times 60} = 5.83 \times 10^{-4} \text{ m}^3 \text{ s}^{-1} \end{aligned}$$

$$\begin{aligned} \text{Pressure change, } \Delta P &= 100 \text{ bar} = 100 \times 10^5 \\ &= 10^7 \text{ Nm}^{-2} \end{aligned}$$



$$\begin{aligned} \text{Fluid power} &= \Delta P \cdot Q \\ &= 10^7 \times 5.83 \times 10^{-4} \\ &= 5830 \text{ W.} \end{aligned}$$

$$\text{Shaft power} = 15 \text{ kW} = 15 \times 10^3 \text{ W.}$$

$$\begin{aligned} \Rightarrow \text{Overall efficiency} &= \frac{\text{Fluid power}}{\text{Shaft power}} \times 100 \\ &= \frac{5830}{15000} \times 100 \\ &= 38.87\% \end{aligned}$$

$$\text{Volumetric efficiency} = \frac{\text{Actual flow rate}}{\text{Ideal flow rate}} \times 100$$

Ideal flow rate = Nominal displacement  $\times$  speed.

$$\text{Angular speed} = 850 \text{ rpm} = \frac{850}{60} = 14.17 \text{ rps.}$$

$$\begin{aligned} \text{Ideal flow rate} &= 5 \times 10^{-5} \times 14.17 \\ &= 7.085 \times 10^{-4} \text{ m}^3 \text{ s}^{-1} \end{aligned}$$

$$\begin{aligned} \text{Volumetric efficiency} &= \frac{5.83 \times 10^{-4}}{7.085 \times 10^{-4}} \times 100 \\ &= 82.29\% \end{aligned}$$

$$Z_1 = 2400 \text{ mm} = 240 \text{ m.}$$

$$Q = 13 \text{ litres/sec} = 13 \times 10^{-3} \text{ m}^3 \text{ s}^{-1}$$

$$V = 6 \text{ m s}^{-1}$$

The jet issued from the nozzle will be at atmospheric pressure and datum level;

$$\text{thus } P_2 = 0; Z_2 = 0$$

density,  $\rho$  of water =  $1000 \text{ kg m}^{-3}$ .

$$\text{Power, } P = P \cdot Q + \frac{\rho Q V^2}{2} + \rho g Q P$$

$$= \frac{\rho Q V^2}{2}$$

$$= \frac{1000 \times 13 \times 10^{-3} \times (66)^2}{2}$$

$$= 28.314 \text{ kW.}$$

(ii) For power supplied from a reservoir ;  
 $P = 0$  ;  $V = 0$

$$\text{Power} = P\phi + \frac{\rho g V^2}{2} + \rho g \phi z$$

$$P = \rho g \phi z$$

$$= 1000 \times 9.81 \times 13 \times 10^{-3} \times 240$$

$$= 30.6072 \text{ kW.}$$

(iii) Power loss = Reservoir power - Jet power  
 $= 30.6072 - 28.314$   
 $= 2.293 \text{ kW.}$

$$\text{Head loss} = \frac{\text{Power loss}}{\rho g \phi}$$

$$= \frac{2293.2}{1000 \times 9.81 \times 13 \times 10^{-3}}$$

$$= 17.982 \text{ m.}$$

(iv) Efficiency =  $\frac{\text{Jet power}}{\text{Reservoir power}} \times 100$   
 $= \frac{28.314}{30.6072} \times 100$   
 $= 92.5\%$



$$\text{Power} = \rho Q + \frac{\rho g V^2}{2} + \rho g Q Z$$

$$Z = 30000 \text{ cm} = 300 \text{ m.}$$

$$\text{Specific gravity} = 0.89.$$

$$Q = 220 \text{ liters/sec} = 2.2 \times 10^{-1} \text{ m}^3 \text{ s}^{-1}$$

$$\text{velocity of jet} = 7 \text{ m s}^{-1}.$$

$$\begin{aligned} \text{Power of jet} &= \frac{\rho g V^2}{2} \\ &= \frac{(0.89 \times 1000) \times 0.22 \times 7^2}{2} \\ &= 4997.1 \text{ W.} \end{aligned}$$

$$\begin{aligned} \text{Power supplied from reservoir} &= \rho g Q Z \\ &= (0.89 \times 1000) \times 9.81 \times 0.22 \times 300. \\ &= 576239 \text{ W.} \end{aligned}$$

$$\begin{aligned} \text{Power loss in transmission} &= 576239 - 4997.1 \\ &= 571441.9 \text{ W.} \end{aligned}$$

$$\begin{aligned} \text{Head loss} &= \frac{\text{Power loss}}{\rho g Q} = \frac{571441.9}{(0.89 \times 1000) \times 9.81 \times 0.22} \\ &= 297.5 \text{ m.} \end{aligned}$$

$$\text{Efficiency} = \frac{4997.1}{576239} \times 100 = 0.83\%$$

$$h = 20 \text{ m.}$$

$$d = 10 \text{ cm} = 0.1 \text{ m.}$$

$$g = 9.81 \text{ m s}^{-2}$$

According to law of conservation of energy

$$\frac{1}{2} m v^2 = m g h$$

$$\frac{v^2}{2} = g h, \quad v^2 = 2 g h$$

$$v = \sqrt{2(9.8)(20)}$$

$$= 19.8 \text{ ms}^{-1}$$

This is the velocity of the stream at its base.

$$\text{Flow rate} = A \cdot v$$

$$= \frac{\pi d^2}{4} \cdot v$$

$$= \frac{\pi (0.1)^2}{4} \times 19.8$$

$$= 0.156 \text{ m}^3 \text{ s}^{-1}$$

$$\text{mass flow rate} = \rho \cdot Q$$

$$= 1000 \times 0.156$$

$$= 156 \text{ kg s}^{-1}$$

$$\text{Power} = \frac{\text{Work done}}{\text{time}} = \frac{mgh}{t}$$

$$= \frac{m}{t} \cdot g \cdot h$$

$$= 156 \times 9.81 \times 20$$

$$= 30607.2 \text{ W}$$

$$= 30.6 \text{ kW}$$

7.  $d_1 = 0.3 \text{ m}$

$d_2 = 0.2 \text{ m}$

$C_d = 0.96$

$\rho g = 19.62 \text{ Nm}^{-3}$

$$A_1 = \frac{\pi d_1^2}{4} = 0.0707 \text{ m}^2$$

$$A_2 = \frac{\pi d_2^2}{4} = 0.0314 \text{ m}^2$$

$$Q = A \cdot v$$

$$v_1 = \frac{Q}{A_1} = \frac{Q}{0.0707}$$



$$V_2 = \frac{Q}{A_2} = \frac{Q}{0.0314}$$

For the manometer,

$$P_1 + \rho g z = P_2 + \rho g (R)$$

$$P_1 + \rho g z = P_2 + \rho g (z_2 - R) + \rho_w g R$$

$$P_1 - P_2 = 19.62 (z_2 - z_1) + 589.423 \dots (1)$$

For the venturimeter

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

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

Combining (1) and (2)

$$0.803 V_2^2 = 589.423$$

$$V_{2 \text{ ideal}} = 24.049 \text{ ms}^{-1}$$

$$Q_{\text{ideal}} = A_2 \cdot V_2 = 0.0314 \times 24.049 = 0.85 \text{ m}^3 \text{ s}^{-1}$$

$$Q = C_d Q_{\text{ideal}} = 0.96 \times 0.85 = 0.816 \text{ m}^3 \text{ s}^{-1}$$

9  $D_1 = 300 \text{ mm} = 0.3 \text{ m}$

$$A_1 = \frac{\pi d^2}{4} = \frac{\pi (0.3)^2}{4} = 0.0707 \text{ m}^2$$

$$P_1 = 400 \text{ kN m}^{-2}$$

$$z_1 = 10 \text{ m}$$

$$D_2 = 150 \text{ mm} = 0.15 \text{ m}$$

$$A_2 = \frac{\pi d^2}{4} = \frac{\pi (0.15)^2}{4} = 0.01767 \text{ m}^2$$

$$z_2 = 6 \text{ m}$$

$$Q = 40 \text{ litres/sec} = \frac{40 \times 1}{10^3} = 0.04 \text{ m}^3 \text{ s}^{-1}$$

$$Q = A_1 V_1 = A_2 V_2$$

$$V_1 = \frac{Q}{A_1} = \frac{0.04}{0.0707} = 0.566 \text{ m s}^{-1}$$

$$V_2 = \frac{Q}{A_2} = \frac{0.04}{0.01767} = 2.264 \text{ m s}^{-1}$$

Applying Bernoulli's equation, you get;

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

$$\frac{P_2}{\rho} = \frac{P_1}{\rho} + \left[ \frac{V_1^2 - V_2^2}{2g} \right] + [Z_1 - Z_2]$$

$$= \frac{400}{9.81} + \left[ \frac{0.566^2 - 2.264^2}{2(9.81)} \right] + [10 - 6]$$

$$= 44.525 \text{ m}$$

$$P_2 = \rho \times 44.525$$

$$= 9.81 \times 44.525$$

$$= 436.8 \text{ kN m}^{-2}$$

10. Manometer reading,  $y = 200 \text{ mm} = 0.2 \text{ m Hg}$ .

Specific gravity of mercury,  $S_{Hg} = 13.6$

Specific gravity of sea water,  $S_s = 1.025$

$$h = y \left[ \frac{S_{Hg}}{S_s} - 1 \right]$$

$$h = 0.2 \left[ \frac{13.6}{1.025} - 1 \right]$$

$$= 2.45$$

$$V = \sqrt{2gh} = \sqrt{2(9.81)(2.45)}$$

$$= 6.93 \text{ m s}^{-1}$$