50%

ONOFIOK ABASIFREKE VICTOR.
CIVIL ENGINEERING
18/ENG03/050 FLUID MECHANICS.

1. Real flow rate = $10 dm^3/min$ - $T = 12.5 Nm$

$= \frac{10 \times 10^{-3}}{60} = 1.67 \times 10^{-4} m^3/s.$

Pressure $= 12$ bar $= 12 \times 10^5 N/m^2$, Speed $= 1500 rev/min$

$= 1500 \div 60 = 25 rev/sec$

Normal displacement $= 10 cm^3/rev = 1 \times 10^{-5} m^3/rev$.

Ideal Flowrate = Nominal displacement x speed.

$= 1 \times 10^{-5} m^3/rev \times 25 rev/sec.$

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

i) Volumetric efficiency = $\frac{\text{Real flowrate}}{\text{Ideal flowrate}} \times 100\%$

$= \frac{1.67 \times 10^{-4}}{2.5 \times 10^{-4}} \times 100\% = 66.8\%$

ii Fluid Power $= Q \cdot dP = 1.67 \times 10^{-4} \times 12 \times 10^5$

$= 200.4$ Watts.

iii) Shaft Power $= T \cdot \omega$

$\omega = 2\pi N = 2 \times \pi \times N = 2 \times \pi \times 25.$

$= 157.0796 \simeq 157.08$

Shaft Power $= 12.5 \times 157.08 = 1963.5$ watts.

iv) Overall efficiency $= \frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100\%$.

$\frac{2004}{1963.5} \times 100\% = 10.206 \simeq 10.21\%$

2) Pump delivery $= 35 dm^3/min = \frac{35 \times 10^{-3}}{60} = 5.83 \times 10^{-4}$

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

Overall Efficiency $= 87\%$,

Fluid Power $= Q \cdot dp = 5.83 \times 10^{-4} \times 100 \times 10^5$

$= 5830$ watts.

Recall, Overall Efficiency $= \frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100\%$

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

$= \frac{5830 \times 100}{87} = 6701.149$ watts.

3. Nominal displacement of $50 cm^3/rev$

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

Pressure = 100 bar = 100×10^5 N/m^2.

Shaft Power = 15KW = 15000 Watts.

Actual Flow rate = 35 dm^3/min = 35×10^{-3} m^3 ÷ 60

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

Speed = 850 rev/min = 850 ÷ 60 = 14.166 ≃ 14.17 rev/s

Ideal flow rate = Nominal displacement × Speed

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

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

i) Volumetric efficiency = $\frac{\text{Real flowrate}}{\text{Ideal flowrate}} \times 100\%$

$= \frac{5.83 \times 10^{-4}}{7.085 \times 10^{-4}} \times 100\% = 82.29.$

ii) Fluid Power = Q·dp = $5.83 \times 10^{-4} \times 100 \times 10^5$

= 5830 Watts.

Overall Efficiency = $\frac{5830}{15000} \times 100 = 38.867\%$.

4) Z = 2400 cm = 24 m

Volumetric flowrate, Q = 13 litres/sec.

= 0.013 m^3/sec.

Velocity = 66m/sec

The general formula

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

$$P = QP + \rho\frac{QV^2}{2} + \rho g Q z$$

But introducing here (Power of Jet).

Pressure head = 0

$z = 0$

$\therefore\ P = \rho Q V^2 \div 2$

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

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

P = 28314 watts = 28.314 kilowatts.

ii) Power supplied from reservoir

At Atmospheric Pressure ; $P = 0$ and $V = 0$

$\therefore\ P = \rho g Q z$

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

$= 30607.2$ watts $\simeq$ 30.607 kilowatts

iii) Power loss in transmission.

= Power of reservoir − Power of Jet

$= (30607.2 - 28314) = 2293.2$ Watts.

$\Rightarrow$ 2.2932 Kilowatts.

Head loss in Pipeline = 2.2932 Kwatts.

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

$= 2293.2 \div 1000 \times 9.81 \times 0.013 =$

$$= \frac{2293.2}{127.53} = 17.8\text{m}$$

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

$$= \frac{28314}{30607.2} \times 100 = 92.51\%$$

5. Sg of Oil = 0.89, Z = 30,000cm = 300m

$Q = 220\text{l/sec} = 0.22\text{m}^3/\text{sec}$ $V = 7\text{m/sec}$

Introducing Z = 0, Pressure = 0

1 $P = \frac{\rho Q V^2}{2}$ but, Sg = 0.89 $Sg = \frac{x}{1000}$

$\therefore x = 0.89 \times 1000 \quad x = 890$

$\therefore \rho = x = 890 \quad P = \frac{890 \times 0.22 \times (7)^2}{2}$

$P = 4797.1$ watts.

ii) Power Suppied from reservoir

$P = \rho g Q z$

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

$P = 576239.4$ watts $\simeq 576.2394$ Kwatts.

iii) Power ~~Suppied~~ loss in transmission

= Power reservoir − Power of Jet.

$(576239.4 - 4.7971)$ Kilowatt.

$= 571442.3$ watts ; 571.4423 Kilowatt.

. Head used to overcome losses.

$= 571442.3 \div 890 \times 9.81 \times 0.22$

$= 297.51 m.$

iv) Efficieng = Power of Jet ÷ Power of Reservor ×100%

$= \frac{4797.1}{571442.3} \times 100\% = 0.83\%$

6. $P = \rho g Q Z$

$Z = 20m = h$ $\quad \rho = 1000$ $\quad g = 9.81$ $\quad Q = VA$

$d = 10cm = 10 \times 10^{-2}m$ $\quad A = \frac{\pi d^2}{4} = 7.85 \times 10^{3} m^2$

To find the Velocity at height of initial Velocity Using one of the equation of motion

$V = 0 \quad V^2 = U^2 - 2gh \quad U = \sqrt{0^2 + 2 \times 9.81 \times 20}$

$U = \sqrt{392.4} \quad U = 19.809 \simeq 19.81 m/s$

The Velocity $= 19.81$

$\therefore Q = VA = 19.81 \times 7.85 \times 10^{-3}$

$= 0.15558 m^3/s \simeq 0.156 m^3/s$

Then: $P = \rho g Q z$

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

$P = 30510.7677$ Watts $\simeq 30.5$ Kilo Watts

7. $d_1 = 0.3m \quad A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.3^2}{4}$

$= 0.07068 m^2 \cong 0.0707 m^2$

$d_2 = 0.2m$

$A_2 = \frac{\pi d^2}{4} = \frac{\pi \times 0.2^2}{4} = 0.031415 m^2 \simeq 0.0314 N/m^2$

$Cd = 0.96$.

Specific weight of gas $\simeq 19.62 N/m^2$

$$\rho = \frac{mg}{V} = \frac{19.62}{9.81} = \frac{\rho \times 9.81}{9.81} \therefore \text{so } \rho g = 19.62$$

$$\therefore \rho = 2 kg/m^2$$

Calculating $Q = A_1 V_1$, $Q_2 = A_2 V_2$, $Q_1 = Q_2$

$$\therefore V_1 = Q_1/A_1, \; V_2 = Q_2/A_2$$

$V_1 = Q/0.0707 \quad V_2 = Q/0.0314$

For the manometer

$$P_1 + \rho_g g Z_1 = P_2 + \rho_g g (Z_2 - R_P) + \rho_w g R_P$$

$$P_1 - P_2 = \rho_g g (Z_2 - R_P) - \rho_w g R_P - \rho g g Z$$

$$P_1 - P_2 = 19.62 (Z_2 - Z_1) + 587.423 \text{ --- (i)}$$

For the Venturimeter,

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

$$P_1 - P_2 = 19.62 (Z_2 - Z_1) + 0.803 V_2^2 \text{ --- (ii)}$$

$\& \; Z_2 - Z_1 = 0.06m$

equating equi & equi

$$\cancel{19.62(Z_2 - Z_1)} + 587.423 = \cancel{19.62(Z_2 - Z_1)} + 0.803 V_2^2$$

$$0.803 V_2^2 = 587.423.$$

$V_2^2 = 587.423 \div 0.803$, $V_2^2 = 731.535$

$V_2 = \sqrt{731.535}$ $V_2 = 27.0469 \simeq 27.047 m/s$

$Q_{ideal} = A_2 V_2$

$\therefore 27.047 \times 0.0314$

$Q_{ideal} = 0.8492 \simeq 0.85 m^3/s$

$Q_{real} = Cd \times Q_{ideal}$

$= 0.96 \times 0.85 = 0.816 m^3/s$

8. Throat diameter = 0.076m (d_2)

Vertical diameter = 0.152m (d_1)

Relative density = 0.8

Throat ~~density~~ being = 0.914m $Cd = 0.91$

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:

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

$$A_2 = \frac{\pi d^2}{4} ; \frac{\pi \times 0.076^2}{4} = 4.64 \times 10^{-3} m^2$$

$$A = \frac{\pi d^2}{4} = \frac{\pi \times 0.152^2}{4} = 0.0181 m^2$$

11) 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: $Z_1 - Z_2 = 0.914$.

$$\frac{P_1 - P_2}{\rho g} = \frac{V_2^2}{2g} - \frac{V_1^2}{2g} - 0.914$$

Recall $Q = VA$, $V = Q/A$.

$\rho = 800$, $g = 9.81$

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

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

$$1.932 = \frac{Q^2(4851636 - 3052.41)}{2g} - 0.914$$

$$(1.93 + 0.914)2g = Q^2(48516.36 - 3052.41)$$

$$\frac{56.3678}{45463.95} = \frac{Q^2 \cancel{45463.95}}{\cancel{45463.95}}$$

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

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

$$Q = 0.0352 m^3/s.$$

9. $d_1 = 300mm = 0.3m.$

$d_2 = 150mm = 0.15m.$

$A_1 = 0.07069m^2$

$A_2 = 0.0177m^2$

$Q = 40 lit/sec = 0.04 m^3/sec$

$Z = 10m \quad , Z_2 = 6m$

$P_1 = 400 KN/m^2, P_2 = ?$

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

But, $Q = A_1 V_1$

$$\therefore V_1 = \frac{Q}{A_1} = \frac{0.04}{0.07059}$$

$$V_1 = 0.5658 \simeq 0.57 \, m/s$$

Then $V_2 = \frac{Q}{A_2} = \frac{0.04}{0.0177}$

$$V_2 = 2.2598 \simeq 2.26 m/s.$$

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

$$\frac{400KN}{9.81KN} + (10-6) + \left(\frac{0.57^2 - 2.26^2}{2 \times 9.81}\right) = \frac{P_2}{9.81 KN}.$$

$$40.77 + 4 + (-0.2438) = \frac{P_2}{9.81 KN}.$$

$$44.52 \times 9.81 = P_2$$

$$P_2 = 436.74 KN.$$

10. Reading of manometer = 170mm

= 0.17m

Specific gravity of mercury = 13.6.

" " seawater = 1.026.

$y = 0.17m$

For $h = y\left(\frac{S_{hl}}{S_L} - 1\right)$

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

$$= 0.17 \times 12.256$$

$$= 2.0834 m.$$

Recall $V = \sqrt{2gh}$

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

$$V = \sqrt{40.87}$$

$$V = 6.393 m/s.$$