Image

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Fluid mechanics

1) Real flowrate $= 10\,dm^3/min$, $T = 12.5\,Nm$

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

Pressure $= 12\,bar = 12 \times 10^5\,N/m.$

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

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

Ideal flowrate = Nominald displacement × speed

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

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

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

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

$$= 66.8\%$$

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

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

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

$= 66.8\%$

ii) fluid Power $=$ Q.dp.

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

$= 200.4$ watts.

iii) Shaft power $= \hat{T} \cdot w$

$w = 2\bar{\pi}N = 2 \times \bar{\pi} \times N$

$= 2 \times \bar{\pi} \times 25.$

$= 157.0796$

$\simeq 157.08$

$\therefore$ Shaft Power $= 12.5 \times 157.08$

$= 1963.5$ watts

iv) overall Efficiency

$$\frac{\text{fluid Power}}{\text{shaft Power}} \times 100\%$$

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

2) Pump delivery = 35 dm³/min

$$\frac{35 \times 10^{-3}}{60} = 5.83 \times 10^{-4}$$

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

overall efficiency = 87%

fluid Power = $Q \cdot \Delta P$

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

$$= 5830 \text{ watts}$$

P = 100bar =

overall efficiency = 87%

fluid power = $Q \cdot \Delta P$

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

$= 5830$ watts

Recall,

overall efficiency = ~~fluid × 100%~~ $\dfrac{\text{fluid power} \times 100\%}{\text{shaft power}}$

$\therefore$ shaft power = $\dfrac{\text{fluid power} \times 100\%}{\text{overall efficiency}}$

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

$= 6701.149$ watts

3) Nominal displacement of $50\ cm^3/rev$

$= 50 \times 10^{-5}\ m^3/rev$

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

Shaft power = 15kW = 15000 watts.

Actual flowrate = $35\ dm^3/min = \dfrac{35 \times 10^{-3}\ m^3}{60}$

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

speed = 350 rev/min = $\dfrac{350}{60}$ = 14.166 ≃ 14.17 rev/s

∴ Ideal flowrate = Nominal displacement × speed

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

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

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

$= \dfrac{5.83 \times 10^{-4}}{7.085 \times 10^{-4}} \times 100\%$

$= 82.29\%$

ii fluid power $= Q \cdot dp$

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

$= 5830$ watts

Overall efficiency $= \dfrac{5830 \times 100}{15000}$

$= 38.867\%$

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$= 38.867\%$

4) $Z = 2400cm = 24m$

Volumetric flowrate, $Q = 13$ litres/sec

$= 0.013 m^3/sec$

velocity $= 66 m/sec$

The general formula

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

$$P = QP + \frac{\rho Q v^2}{2} + \rho g QZ$$

But introducing here (Power of jet)

pressure head $= 0$.

$Z = 0$

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

And, $Q = 0.013$, $\rho = 1000$, $v = 66 m/s$.

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

$P = 28314$ watts $= 28.314$ Kilo watts

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

$\simeq 30.607$ Kilowalts.

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iii) Power loss in transmission

= Power of reservoir - power of jet

$= (30607.2 - 28314)$

$= 2293.2$ watts.

$\simeq 2.2932$ kilowatts

Head loss in pipeline = 2.2932 K watts

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

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

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

$h = 17.98\,m$

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

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

$= 92.51\%$

5 Sg of oil $= 0.89$

$Z = 30,000 cm = 300 m$

$Q = 220 l/sec = 0.22 m^3/sec.$

$V = 7 m/sec.$

Introducing, $Z = 0$, Pressure $= 0$.

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

but, $Sg = 0.89$

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

$\therefore x = 0.89 \times 1000$

$x = 890$

$\therefore \rho = x = 890$

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

$P = 4797.1$ watts

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ii) power supplied from reservoir

$P = \rho g \cdot 10g\ Q Z$

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

$P = 576239.4$ watts.

$\simeq 576.2394$ kilowatts

iii) Power loss in transmission

= power reservoir - power of Jet

$= (576.239.4 - 4.7971)$ kilo walt

$= 571442.3$ watts

$= 571.4423$ kilowatts

Head used to overcome losses

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

$= 297.51m.$

iv) $\text{Efficiency} = \dfrac{\text{Power of jet}}{\text{Power of reservoir}} \times 100\%$

$= \dfrac{4797.1}{571442.3} \times 100\%$

$= 0.83\%$

6) $P = \rho g Q z$

$z = 20m = h$

$\rho = 1000$

$g = 9.81$

$Q = vA$

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

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

b) $P = \rho g Q Z$

$Z = 20m = h$

$\rho = 1000$

$g = 9.81$

$Q = VA$

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

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

But we need the velocity at height of initial velocity using one of t

equation of motion.

$v = 0.$

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

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

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

$u = \sqrt{392.4}$

$u = 19.809 \simeq 19.81 m/s.$

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

$\simeq 30.5$ Kilowatts

7) $d_1 = 0.3m$

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

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

$d^2 = 0.2m$

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

$= 0.031415 m^2 \simeq 0.0314 m^2$

$cd = 0.96$

specific weight of gas $= 19.62 N/m^2$

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

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

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

$= 0.031415m^2 \approx 0.0314m^2$

$Cd = 0.96$

specific weight of gas $= 19.62 \, N/m^3$

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

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

$\therefore \rho = 2kg/m^3$

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

$$\therefore V_1 = \frac{Q_1}{A_1}, \quad V_2 = \frac{Q_2}{A_2}$$

$$V_1 = \frac{Q}{0.0707} \qquad V_2 = \frac{Q}{0.0314}$$

for the manometer

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

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

$$P_1 - P_2 = 19.62 (Z_2 - Z_1) + 557.423 \text{ --- i}$$

for the venturimeter

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

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

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

equating equ i & equ ii

$$19\cancel{.62(z_2 - z_1)} + 587.423 = 19.62\cancel{(z_2 - z_1)} + 0.803V_2^2$$

$$0.803V_2^2 = 587.423$$

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

$$V_2^2 = 731.535$$

$$V_2^2 = \sqrt{731.535}$$

$$V_2^2 = 27.0469$$

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

$$Q\,ideal = A_2V_2$$

$$\therefore 27.047 \times 0.0314$$

$$Q\,ideal = 0.8492$$

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

$$Q\,real = Cd \times Q\,ideal$$

$$= 0.96 \times 0.85$$

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

$= 0.96 \times 0.85$

$= 0.816 m^3/s.$

8) Throat diameter $= 0.076 m (d_2)$

vertical diameter $= 0.152 m (d_1)$

Relative density $= 0.8$

Throat being $= 0.914 m$

$cd = 0.91$

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + Z_2.$$

Recall that

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

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

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

$$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.152^2}{4}$$

$$= 0.0181 m^2$$

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, $Z_1 - Z_2 = 0.914$

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

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

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

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

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

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

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

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

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

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

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

9) $d_1 = 300mm = 0.3m$

$d_2 = 150mm = 0.15m$

$\therefore A_1 = 0.07069 m^2$

$A_2 = 0.0177 m^2$

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

$Z_1 = 10m, \quad Z_2 = 6m.$

$P_1 = 400 kN/m^2, \; P_2 = ?$

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

But, $Q = A_1 V_1$

$$\therefore V_1 = \frac{Q}{A_1} = \frac{0.04}{0.07069}$$

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

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

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

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

$$\frac{400 kN}{9.81 kN} + (10-6) + \left(\frac{0.57^2 - 2.26^2}{2 \times 9.8}\right) = \frac{P_2}{9.81 kN}$$

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

$$44.52 \times 9.81 = P_2$$

$$P_2 = 436.74 kN$$

Reading of manometer = 170 mm

$= 0.17 m$

$44.52 \times 9.81 = P_2$

$P_2 = 436.74 kN$

10 Reading of manometer $= 170 mm$
$= 0.17m$

specific gravity of mercury $= 13.6$

specific gravity of Seawater $= 1.026$

$y = 0.17m$

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

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

$= 0.17 \times 12.255$

$= 2.0834m$

Recall $v = \sqrt{2gh}$

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

$v = \sqrt{40.87}$

$v = 6.393 m/s$