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1 Real Flowrate $= 10dm^3/min$ $T = 12.5Nm$

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

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

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

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

ideal Flowrate = Nominal displacement x speed

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

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

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 $= T \cdot w$

$w = 2\pi N = 2 \times \pi \times N$

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

$= 157.0796$

$\simeq 157.08.$

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

$= 1963.5$ watts.

v. 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 $= 35 dm^3/min$

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

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

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 $50 cm^3/rev$

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

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

Shaft power $= 15 kw = 15000$ watts

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

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

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

$= 14.166 \simeq 14.17$ rev/s

Ideal flowrate = Nominal displacement × speed

$= 50 \times 10^{-6}$ m³/rev × 14.17 rev/s

$= 7.085 \times 10^{-4}$ m³/s.

i 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 Fluid power $= Q \cdot dp.$

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

$= 5830$ Watts.

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

$= 38.867\%$

4 $z = 2400$cm $= 24$m

volumetric Flowrate, $Q = 13$ litres/sec

$= 0.013$ m³/sec

velocity = 66m/sec

The general formula,

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

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

But introducing here (power of jet)

pressure head = 0.

$z = 0.$

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

5) S_g oil $= 0.89$

$z = 30{,}000cm = 300m$

$Q = 220L/sec = 0.22m^3/sec$

$v = 7m/sec$

Introducing, $z = 0$, Pressure $= 0$

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

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

ii) power supplied from reservoir.

$P = \rho g Q z$

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

$P = 576239.4$ watts

$\simeq 576.2394$ kilowatts.

iii) power loss in transmission

= power reservoir − power of Jet.

$= (576239.4 - 4.7971)$ kilowatt.

$= 571442.3$ watts

$= 571.4423$ kilowatt.

Head used to overcome losses

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

$= 294.51m$

iv) Efficiency $= \frac{\text{power of Jet}}{\text{power of Reservoir}} \times 100\%$

$= \frac{4797.1}{574442.3} \times 100\%$

$= 0.85\%$

6) $P = \rho g Q z$

$z = 20m = h$

$\rho = 1000$

$g = 9.81$

$Q = VA$

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

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

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

$v = 0$

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

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

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

$u = \sqrt{392.4}$

$u = 19.809 \simeq 19.81 m/s$

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;

$P = \rho g Q z$

$= 1000 \times 9.81 \times 0.156 \times 20$
$P = 30510.7677 \text{ watts}$
$\simeq 30.5 \text{ kilowatts}$

7) $d_1 = 0.3m$

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

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

$d_2 = 0.2m$

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

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

$Cd = 0.96$

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

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

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

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

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

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

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

For the manometer

$P_1 + \rho_g g z_1 = P_2 + \rho_g g (z_2 - h_p) + \rho_w g h_p$

$P_1 - P_2 = \rho_g g (z_2 - h_p) + \rho_w g h_p - \rho_g g z$

$P_1 - P_2 = 19.62 (z_2 - z_1) + 587.423 - i$

For the Venturimeter,

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

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

$\therefore z_2 - z_1 = 0.06m$

equating equi i & equi ii

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

$0.803V_2^2 = 587.423$

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

$V_2^2 = 731.535$

$V_2 = \sqrt{731.535}$

$V_2 = 27.0469$

$\simeq 27.047 m/s$

Q ideal $= A_2 V_2$

27.047×0.0314

Qideal $= 0.8492$

$\simeq 0.85 m^3/s$

Qreal $= Cd \times Q$ideal

$= 0.96 \times 0.85$

$= 0.816 m^3/s$

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

Vertical diameter $= 0.152m\ (d_1)$

Relative density $= 0.8$

Throat 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

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

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

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

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

$$= 0.0181 m^2$$

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

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

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

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

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

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

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

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

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

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

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

$$= 0.17 \times 12.255$$

$$= 2.0834\,m$$

Recall $v = \sqrt{2gh}$

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

$$V = \sqrt{40.87}$$

$$V = 6.393\,m/s.$$

9) $d_1 = 300mm = 0.3m$
$d_2 = 150mm = 0.15m$
$\therefore A_1 = 0.07069m^2$
$A_2 = 0.0177m^2$
$Q = 10lit/sec = 0.04m^3/sec$
$z_1 = 10m, \quad z_2 = 6m$
$P_1 = 400kN/m^2, \quad P_2 = ?$

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

But, $Q = A_1 V_1$

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

$V_1 = 0.5658 \simeq 0.57m/s$

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

$V_2 = 2.2598 \simeq 2.26m/s$

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

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

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

$44.52 \times 9.81 = P_2$

$P_2 = 436.74kN.$

10) Reading of Manometer $= 170mm$
$= 0.17m$

Specific gravity of mercury $= 13.6$
Specific gravity of seawater $= 1.026.$
$y = 0.17m$
For $h = y \left(\frac{S_{hL}}{S_L} - 1\right)$

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

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

$P = 28314$ 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.

$\simeq 2.2932$ kilowatts.

Headloss in pipeline = 2.2932 kwatts.

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

$$= \frac{2293.2}{1000 \times 9.81 \times 0.031}$$

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

$h = 17.98m$

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

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

$= 92.51\%$