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1.) Real flowrate = 10dm³/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 = $\frac{10\ cm^3}{rev} = 1 \times 10^{-5}\ m^3/rev$

Ideal flowrate = Nominal displacement × speed

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

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

i) volumetric efficiency = Real flowrate / Ideal flowrate × 100%

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

ii) Fluid power = Q·d·P

$= 1.67 \times 10^{-4} \times 2 \times 10^5$

= 200.4 watts

iii) Shaft power = T·ω

$\omega = 2\pi N$

$= 2 \times \pi \times 25$

= 157.08

∴ Shaft power = 12.5 × 157.08

= 1963.5 watts

iv) Overall efficiency

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

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

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 · d · P

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

= 5830 watts

Recall

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

∴ shaft power = $\frac{5830 \times 100}{87}$

= 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 flow rate = $35\, dm^3/min = \frac{35 \times 10^{-3}}{60}\, m^3$

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

speed = 850 rev/min = 850/60 = 14.166

Ideal flow rate = Nominal displacement × speed

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

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

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

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

$= 82.29\%$

ii.) Fluid power $= Q \cdot dP$

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

$= 5830$ watts

overall efficiency $= 5830/15000 \times 100$

$= 38.867\%$

4.) $Z = 2400cm = 24m$

volumetric flowrate, $Q = 13$ litres/sec $= 0.013 m^3/sec$

velocity $= 66m/sec$ ~~=0~~

$P = Q P + \frac{\rho Q U^2}{2} + g Q Z$

~~But in order~~ Pressure head $= 0$

$Z = 0$

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

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

$P = 1000 \times 0.013 \times (66)^2 / 2$

$P = 28314$ watts $= 28.314$ kilo watts

ii.) Power supplied from reservoir

$P = \rho g Q Z$

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

$= 30607.2$ watts $= 30.607$ kilowatts

iii.) Power loss in transmission

= Power of reservoir − Power of jet

$= (30607.2 - 28314) = 2.2932$ kilowatts

Headloss in pipeline $= 2.2932$ k watts

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

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

$= \frac{2293.2}{127.53}$

$h = 17.98\ m$

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

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

$= 92.51\%$

5 Sg of oil $= 0.89$

$z = 30,000\ cm = 300m$

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

$v = 7m/sec$

i.) $P = \rho Q v^2/2$

but, $Sg = 0.89$

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

$\therefore x = 0.89 \times 1000$
$x = 890$
$\therefore P = x = 890$
$P = \frac{890 \times 0.22 \times (7)^2}{2}$
$P = 4797.1$ watts

ii) Power supplied from reservoir
$P = \rho g Q z$
$P = 890 \times 9.81 \times 0.22 \times 300$
$P = 576.2394$ kilo watts

iii) Power lost in transmission
= Power of reservoir − Power of jet
$= (576.2394 - 4.7971)$ kilowatt
$= 571.4423$ kilowatt

Head used to overcome losses
$= \frac{571442.3}{890 \times 9.81 \times 0.22}$
$= 297.51$ m.

iv) $\text{Efficiency} = \frac{\text{Power of jet}}{\text{Power of reservoir}} \times 100\%$
$= \frac{4797.1}{571442.3} \times 100\%$
$= 0.83\%$

6.) $P = \rho g Q z$
$z = 20m = h$

$\rho = 1000$

$g = 9.81$

$Q = vA$

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

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

We need velocity at height of initial velocity

$v = 0$

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

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

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

$u = 19.81 m/s$

$Q = vA$

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

$= 0.156 m^3/s$

Then;

$P = \rho g Q Z$

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

$P = 30.5$ kilowatts

7.) $d_1 = 0.3m$

$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.3^2}{4} = 0.0707 m^2$

$d_2 = 0.2m$

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

$C_d = 0.96$

Specific weight of gas = 19.62 N/m²

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

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

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

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 manometer

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

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

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

For the venturimeter

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

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

& $z_2 - z_1 = 0.06m$.

equating eqn i & eqn ii

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

$0.803V_2^2 = 587.423$

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

$V_2^2 = 731.535$

$V_2 = \sqrt{731.535}$

$V_2 = 27.047 m/s$

Q Ideal = $A_2 V_2$

$\therefore 27.047 \times 0.0314$

Q Ideal = ~~0.84~~ 9 0.85 m^3/s

Q real = Cd × Q ideal

= 0.96 × 0.85

= 0.816 m^3/s

5.) Throat diameter = 0.076m (d_2)

vertical diameter = 0.152m (d_1)

Relative density = 0.8

Throat ~~=~~ 0.914m

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

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

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

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

$$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.152^2}{4} = 0.0181 m^2$$

(ii.) Then $P_1 - P_2 = 1.5170$

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

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

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

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

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

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

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

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

$$\frac{56.5678}{45463.95} = \frac{Q^2\ 45463.95}{45463.95}$$

$Q = \sqrt{~~1.244~~} \times 0.0352 m^3/s$

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

$d_2 = 150mm = 0.15m$

$\therefore A_1 = 0.07069 m^2$

$A_2 = 0.0177 m^2$

$Q = 10 \ lit/sec = 0.01 m^3/sec$

$z_1 = 10m, \quad z_2 = 6m$

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

$$\frac{P_1}{\rho g} + z_1 + \frac{U_1^2}{2g} = \frac{P_2}{\rho g} + z_2 + \frac{U_2^2}{2g}$$

$$\therefore V_1 = \frac{Q}{A_1} = \frac{0.04}{0.07059} = 0.57m/s$$

$$\text{Then } V_2 = \frac{Q}{A_2} = \frac{0.04}{0.0177} = 2.26m/s$$

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

$44.52 \times 9.81 = P_2$

$P_2 = 436.74KN$

10. Reading of manometer = 170mm

= 0.17m

specific gravity of mercury = 13.6

" " " seawater = 1.026

$y = 0.17m$

$$\text{for } h = y\left(\frac{Shl}{Sl} - 1\right)$$

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

$= 2.0834m$

Recall $V = \sqrt{2gh}$

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

$V = 6.393m/s$