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

Ideal Flowrate = Nominal displacement × speed.

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

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

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 $= T \cdot \omega$

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

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

$= 157.0796$

$\simeq 157.08.$

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

$= 1963.5$ watts.

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 $= 35 dm^3/min$

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

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

Overall Efficiency $= 87\%$.

Fluid power $= Q \cdot dP$.

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

$= 5830$ watts

Recall,

$$\text{Overall Efficiency} = \frac{\text{Fluid power}}{\text{Shaft power}} \times 100\%.$$

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

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

$= 6701.149$ 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

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

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

i volumetric efficiency = $\frac{\text{Real Flowrate}}{\text{Ideal Flowrate}} \times 100\%$

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

$= 82.29\%.$

ii Fluid power = $Q \cdot dp$

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

$= 5830$ watts.

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

$= 38.867\%$

4. $z = 2400\,cm = 24\,m$

Volumetric flowrate, $Q = 13$ litres/sec

$= 0.013\ m^3/sec$

Velocity = 66 m/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.

$z = 0$

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

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.

$\simeq 2.2932$ Kilowatts

Headloss in pipeline = 2.2932 Kwatts

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

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

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

$h = 17.98$ 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
$Z = 30,000cm = 300m$
$Q = 220L/sec = 0.22m^3/sec.$
$V = 7m/sec.$
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.
≃ 576.2394 Kilowatts

iii Power loss in transmission
= Power reservoir − Power of Jet.
= (576.2394 − 4.7971) Kilowatt
= 571442.3 watts
= 571.4423 Kilowatt

Head used to overcome losses
$= \frac{571442.3}{890 \times 9.81 \times 0.22}$
= 297.5 m.

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

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

$= 0.83\%$.

6.) $P = \rho g Q z$.

$z = 20m = h$

$\rho = 1000$

$g = 9.81$.

$Q = vA$.

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

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

But we need the velocity at height of initial 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;

$P = \rho g Q z$

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

$P = 30510.7677$ watts.

$\simeq 30.5$ kilowatts.

equating equi & equii

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

$$0.803V_2^2 = 587.423$$

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

$$V_2^2 = 731.535$$

$$V_2 = \sqrt{731.535}$$

$$V_2 = 27.0469$$

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

$$Q_{ideal} = A_2V_2$$

$$\therefore 27.047 \times 0.0314$$

$$Q_{ideal} = 0.8492$$

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

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

$$= 0.96 \times 0.85$$

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

8.) Throat diameter = 0.076m (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

$$Q = V_1A_1 \quad , \quad Q = V_2A_2$$

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

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

$$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.\cancel{0}152^2}{4}$$

$$= 0.0181 \text{ m}^2$$

$$V_1 A_1 = V_2 A_2$$

$$\therefore V_1 = \frac{V_2 A_2}{A_1}$$

$$V_1 = \frac{V_2 \times 4.54 \times 10^{-3}}{0.0181}$$

$$V_1 = 0.251 V_2$$

Then it becomes for $p_1 = p_2$, $\rho = 800$.

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

$$Z_1 - Z_2 + \frac{V_1^2}{2g} = \frac{V_2^2}{2g}, \text{ and } Z_1 - Z_2 = 0.914$$

$$0.914 + \frac{(V_2\, 0.251)^2}{2 \times 9.81} = \frac{V_2^2}{2 \times 9.81}$$

$$0.914 = \frac{V_2^2}{19.62} - \frac{0.063 V_2^2}{19.61}$$

$$0.914 = \frac{V_2^2 - 0.063 V_2^2}{19.62}$$

$$V_2^2 - 0.063 V_2^2 = 17.93$$

$$0.937 V_2^2 = 17.93$$

$$V_2^2 = \frac{17.93}{0.937}$$

$$V_2^2 = 19.136$$

$$V_2 = \sqrt{19.136}$$

$$V_2 = 4.37$$

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

$$\therefore Q_{ideal} = A_2 V_2.$$

$$= 4.37 \times 4.64 \times 10^{-3}$$

$$= 0.02027$$

$$\therefore Q_{real} = 0.96 \times 0.02027$$

$$Q_{real} = 0.0195\ m^3/s.$$

7.) $d_1 = 0.3m$

$$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.3^2}{4}$$
$$= 0.07068m^2 \simeq 0.0707m^2$$

$d_2 = 0.2m$

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

$C_d = 0.96$

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

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

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

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

calculating $Q_1 = A_1 V_1$, $Q_2 = A_2 V_2$, $Q_1 = Q_2$.

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

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

For the manometer.

$$P_1 + \rho_g g Z_1 = P_2 + \rho_g g(Z_2 - R_p) + \rho_w g R_p$$
$$P_1 - P_2 = \rho_g g(Z_2 - R_p) + \rho_w g R_p - \rho_g g z$$
$$P_1 - P_2 = 19.62(Z_2 - Z_1) + 587.423 \text{ — i}$$

For the venturimeter,

$$\frac{P_1}{\rho_s g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho_s g} + \frac{V_2^2}{2g} + Z_2$$
$$P_1 - P_2 = 19.62(Z_2 - Z_1) + 0.803 V_2^2 \text{ — ii}$$

& $Z_2 - Z_1 = 0.06m$.

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

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

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

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

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

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

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

$$Q^2 = 1.2\cancel{4} \times 10^{-3}$$

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

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

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

$d_2 = 150mm = 0.15m$.

$\therefore A_1 = 0.07069 m^2$

$A_2 = 0.0177 m^2$.

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

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

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

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

But, $Q = A_1 V_1$

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

$$V_1 = 0.5658 \simeq 0.57 \text{ m/s}$$

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

$$V_2 = 2.2598 \simeq 2.26 \text{ m/s.}$$

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

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

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

$$44.52 \times 9.81 = P_2$$

$$P_2 = 436.74\text{ KN}.$$

10. Reading of manometer = 170mm
= 0.17m

Specific gravity of mercury = 13.6.
" " seawater = 1.026.

$y = 0.17\text{m}$

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

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

$$= 0.17 \times 12.255$$

$$= 2.0834\text{ m}$$

Recall $V = \sqrt{2gh}$

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

$$V = \sqrt{40.87}$$

$$V = 6.393\text{ m/s.}$$