(10) Reading of Manometer = 170mm

$= 0.17m$

Specific gravity of mercury = 13.6

Specific gravity of Seawater = 1.026.

$y = 0.17m$

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

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

$= 0.17 \times 12.255$

$= 2.0834\ m$

Recall $v = \sqrt{2gh}$

$v = \sqrt{40.87}$

$v = 6.393\ ms^{-1}$.

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

$d_2 = 150mm = 0.15m$

$\therefore A_1 = 0.07069\,m^2$

$A_2 = 0.0177\,m^2$

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

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

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

using,

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

But $Q = A_1 V_1$

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

$V_1 = 0.5658 \simeq 0.57\,ms^{-1}$

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

$V_2 = 2.2598 \simeq 2.26\,ms^{-1}$

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

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

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

$44.52 \times 9.81 = P_2$

$P_2 = 436.74\,KN$

(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 that $z_1 - z_2 = 0.914$

$$\frac{P_1 - P_2}{\rho g} = \frac{v_2^2}{2g} - \frac{v_1^2}{2g} - 0.914$$

~~Real~~ Recall, $Q = VA$, $v = \frac{Q}{A}$

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

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

$$\frac{1.932}{1} = \frac{Q^2(48516.36 - 3052.41)}{2g} \times -0.914$$

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

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

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

~~19.62(z2...)~~

$19.62(z_2-z_1) + 587.423 = 19.62(z_2-z_1) + 0.803 v_2^2$

$0.803 v_2^2 = 587.423$

$v_2^2 = \frac{587.423}{0.803}$

$v_2^2 = 731.535$

$v_2 = \sqrt{731.535}$

$v_2 = 27.0469 \simeq 27.047 \, m s^{-1}$

$Q_{ideal} = A_2 v_2$

$\therefore 27.047 \times 0.0314$

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

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

$= 0.96 \times 0.85$

$= 0.816 \, m^3/s$

(8) Throat diameter = 0.076m (d_2)

Vertical dameter = 0.152m (d_1)

Relative density = 0.8

Throat being = 0.914m

$C_d = 0.91$

Using Bernoulli's equation

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

Recall that

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

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

$A_1 = 0.0181 \, m^2$

(a) $d_1 = 0.3m$

$$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.3^2}{4} = 0.07069\, m^2$$

$d_2 = 0.2m$

$$A_2 = \frac{\pi d^2}{4} = \frac{\pi \times (0.2)^2}{4} = 0.031416\, m^2$$

$C_d = 0.98$

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

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

$$= \frac{19.62}{9.81} = \frac{\rho \times 9.81}{9.81}$$

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

Calculating $Q_1 = A_1 v_1$ $\qquad Q_2 = A_2 v_2$ $\qquad Q_1 = Q_2$

$$\therefore v_1 = \frac{Q_1}{A_1} \qquad v_2 = \frac{Q_2}{A_2}$$

$$v_1 = \frac{Q}{0.0707} \qquad v_2 = \frac{Q}{0.0314}$$

For the manometer

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

$$P_1 - P_2 = 19.62 (z_2 - z_1) + 987.423 \quad \text{—— (i)}$$

For the venturimeter

$$\frac{P_1}{\rho_g g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho_g g} + \frac{v_2^2}{2g} + z_2$$

$$P_1 - P_2 = 19.62 (z_2 - z_1) + 0.803 v_2^2 \quad \text{—— (ii)}$$

and $z_2 - z_1 = 0.06 m$

Equating (i) and (ii)

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

$$= \frac{47971}{5714442.3} \times 100\%$$

$$= 0.83\%$$

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

$z = 20m = h$

$\rho = 1000$

$g = 9.81$

$Q = VA$

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

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

But,

$v = 0$

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

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

$u = \sqrt{0 + 2(9.81)(20)}$

$u = \sqrt{392.4}$

$u = 19.809 ms^{-1}$ //

$\therefore Q = VA$

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

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

$P = \rho g Q z$

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

$P = 30510.7677$ watts

$\simeq 30.5 kw.$

(ii) Then $P_1 - P_2 = 19170$

$$\left(\frac{P_1}{\rho g} + z_1\right) - \left(\frac{P_2}{\rho g} + z_2\right) = \frac{v_2^2}{2g} - \frac{v_1^2}{2g}$$

5 S_g of oil $= 0.89$

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

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

$v = 7\,m/sec$

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

but, $S_g = 0.89$

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

$x = 0.89 \times 1000$

$x = 890$

$\rho = x = 890$

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

$P = 4797.1$ watts

(ii) Power Supplied from reservoir

$P = \rho g Q z$

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

$P = 576.2394\ Kw$ //

(iii) Power loss in transmission

$=$ Power reservoir $-$ Power of jet

$= (576.2394 - 4.7971)\ Kw$

$= 571.4423\ Kw$ //

Head used to overcome losses

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

$= 297.51\,m$ //

$= \frac{5.83\times10^{-4}}{7.085\times10^{-4}} \times 100\% = 82.29\%$ //

(ii) Fluid power $= Q \cdot d_p$

$= 5.83\times10^{-4} \times 100\times10^{5}$

$= 5830$ watts

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

4 $Z = 2400cm = 24m$

Volumetric flowrate, $Q = 13\ l/s$

$= 0.013\ m^3/s$

Velocity $= 66ms^{-1}$

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

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

Pressure head = 0

$z = 0$

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

and $Q = 0.013$, $\rho = 1000$, $v = 66ms^{-1}$

$P = \frac{1000\times0.013\times(66)^2}{2}$

$P = 28314$ watts

(ii) Power Supplied from reservoir

At atmospheric pressure, $P = 0$ and $v = 0$

$\therefore P = \rho Q g z$

$= 297.51m.$ //

2) ~~For~~ Pump delivery = $35 dm^3/min$

$$\frac{35\times10^{-3}}{60} = 5.83\times10^{-4}$$

$P = 100\ bar = 100\times10^{5}\ Nm^{-2}$

Overall efficiency = 87%

Fluid power = $Q.\Delta P$

$= 5.83\times10^{-4} \times 100\times10^{5}$

$= 5830$ watts

Recall,

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

$$\text{Shaft power} = \frac{\text{Fluid power}\times100}{\text{Overall efficiency}}$$

$$= \frac{5830\times100}{87} = 6701.149 \text{ watts}$$ //

3) Nominal displacement of $50 cm^3/rev = 50\times10^{-6}\ m^3/rev$

Pressure = 100bar = $100\times10^{5}\ N/m^2$

Shaft power = 15 kw = 15000 watts

Actual flowrate = $35 dm^3/min = \frac{35\times10^{-3}}{60} m^3 = 5.83\times10^{-4}\ m^3/s$

Speed = 850 rev/min = $850/60$

$= 14.166 \approx 14.17$ rev/s

Ideal flow rate = Nominal displacement × Speed

$$= \frac{50\times10^{-6}\ m^3}{\cancel{rev}} \times \frac{14.17\ \cancel{rev}}{sec}$$

$$= 7.085\times10^{-4}\ m^3/s.$$

(i) Volumetric Efficiency = $\frac{\text{Real flow rate}}{\text{Ideal flow rate}} \times 100\%$

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

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

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

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

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

Ideal flowrate = Nominal displacement × speed

$= \frac{1 \times 10^{-5} m^3}{\cancel{rev}} \times \frac{25\ \cancel{rev}}{sec} = 2.5 \times 10^{-4}\ m^3/sec.$

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 $= T \cdot \omega$

$\omega = 2\pi N = 2 \cdot \pi \cdot 25 = 157.0796$

$\simeq 157.08$

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

$= 1963.5$ watts

iv) Overall efficiency

$\frac{\text{Fluid power}}{\text{Shaft power}} \times 100\% \Rightarrow \frac{200.4}{1963.5} \times 100\% = 10.21\%$

$= 297.51m.$