NAME: ODILI BLOSSOM ONYINYECHI MAT NO: 18/ENG01/016
DEPT: CHEMICAL ENGINEERING

1A (i) $Q = 10dm^3/min = \frac{10}{1000 \times 60} = 1.67 \times 10^{-4} m^3/sec$

Speed of rotation = 1500Rev/min = $\frac{1500}{60}$ Rev/sec = 25 Rev/sec

Normal displacement = $10cm^3/Rev = 10^{-5} m^3/rev$

Torque Input = 12.5

Pressure change = 12bar = $12 \times 10^5 N/m^2$

Idea flowrate = Normal displacement × Speed Rotation

$= 10^{-5} \times 25 = 2.5 \times 10^{-4} m^3/sec$

(i) Volumetric efficiency = $\frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100$

$= \frac{1.67 \times 10^{-4}}{2.5 \times 10^{-4}} \times 100 = 66.8\%$

(ii) fluid power P_f = $Q \times \Delta P$

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

$= 200.4$ watts

(iii) Shaft power = $T \times \omega$

$\omega = 2 \times \pi \times$ speed of Rotation

$\omega = 2 \times \pi \times 25 = 157.08$

Shaft power = $12.5 \times 157.08 = 1963.5$ watts

(iv) Overall efficiency = $\frac{\text{fluid power}}{\text{Shaft power}} \times 100$

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

$= 10.21\%$

(2) $Q = 35\, dm^3/min = \frac{35}{1000 \times 60} = 5.83 \times 10^{-4}\, m^3/sec$

Pressure Change = 100 bar = $100 \times 10^5 = 10^7\, N/m^2$

Overall efficiency = 87%

fluid power = $Q \times \Delta P = 5.83 \times 10^{-4} \times 10^7$

$= 5.83 \times 10^3$ watt

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

Shaft power = $\frac{\text{fluid power} \times 100}{\text{over all efficiency}}$

Shaft power = $\frac{5.83 \times 10^3 \times 100}{87}$

= 6705 watt

(3) normial displacement $= 50 cm^3/rev = \left(\frac{50}{100 \times 100 \times 100}\right) m^3/rev$

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

shaft power = 15,000 watts

Q = Actual flow rate $= 35 dm^3/min = \left(\frac{35}{10 \times 10 \times 10 \times 60}\right)$ m/sec

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

Speed of rotation = 850 rpm = 850 r/min

$= \left(\frac{850}{60}\right)$ rev/sec $= 14.167$ rev/sec

$\Delta P = 100 bar = 10^7 N/m^2$

Idea flowrate = Normial displacement × speed Rotation

$= 5 \times 10^{-5} \times 14.167$

$= 7.08 \times 10^{-4} m^3/sec$

Volumetric efficency $= \frac{\text{Actual flowrate}}{\text{Idea flowrate}} \times 100$

$= \frac{5.83 \times 10^{-4}}{7.08 \times 10^{-4}} \times 100$

$= 82.3\%$

fluid power $= Q \times \Delta P = 5.83 \times 10^{-4} \times 10^7$

$= 5.83 \times 10^3$ watt

~~Shaft power =~~

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

$= \frac{5.83 \times 10^3}{15000} \times 100$

$= 38.87\%$

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

Volumetric flowrate, $Q = 13$ Litres/sec $= 0.013 m^3/sec$

Velocity = $66m/sec$

The general formula

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

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

But introducing here (Power of jet)

pressure head = 0

$Z = 0$

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

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

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

$P = 28314$ watts $= 28.314kW$

(ii) Power Supplied from reservoir at atmospheric pressure; $P = 0$ at $V = 0$

$\therefore$

$$P = \rho g Q Z$$

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

$$= 30607.2 \text{ watts}$$

$$\simeq 30.607 \text{ kW}$$

(iii) Power loss in transmission

= Power of reservoir − power of jet

$= (30607.2 - 28314) = 2293.2$ watts

$\simeq 2.29$ kW

Headloss in pipeline $= 2.29$ kW

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

$$h = \frac{2293.2}{1000 \times 9.81 \times 0.013} = \frac{2293.2}{127.53}$$

$$h = 17.98 \text{ m}$$

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

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

$$= 92.51\%$$

(5) Sg of oil = 0.84

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

$Q = 200l/sec = 0.22m^3/sec$

$V = 7m/sec$

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

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

but, $Sg = 0.84$

$S.g = \frac{x}{1000}$

$x = Sg \times 1000 = 0.84 \times 1000 = 890$

$\rho = x = 890$

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

$P = 4797.1$ watts

(ii) Power supplied from reservoir

$P = \rho g Q z$

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

$P = 576239.4$ watts

$\simeq 576.24$ KW

(iii) Power loss in transmission

= Power reservoir − Power of jet

~~= (5762344 − 4~~

$= (576.34 - 4.797)$ kw

$= 571.44$ KW

Head used to overcome losses

$$= \frac{571442.3}{890 \times 9.81 \times 0.22} = 297.51m$$

(iv) Efficiency $= \frac{\text{Power of Jet}}{\text{power of Reservior}} \times 100$

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

$= 0.83\%$

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

$z = 20m = h$

$\rho = 1000$

$g = 9.81$

$Q = VA$

$d = 100mm = 10^{-1}m$

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

But we need the velocity at the height of initial velocity using one of the equation of motion

$V = 0$

$V^2 = u^2 - 2gh$

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

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

$u = 19.804 \simeq 19.81 m/s$

The velocity $= 19.81 m/s$

$Q = VA$

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

$= 0.15558 m^3/s$

$\simeq 0.156 m^3/s$

Then;

$P = \rho g Q Z$

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

$P = 30510.7677$ watts

$\simeq 30.5 kW$

(7) $d_1 = 0.3m$ $A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.3^2}{4}$

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

$d_2 = 0.2m \quad A_2 = \frac{\pi d^2}{4} = \frac{\pi \times 0.2^2}{4}$

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

$C_d = 0.96$

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, $\rho g = 19.62$

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

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

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

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

for the manometer

$P_1 + P_g g Z_1 = P_2 + P_g g(Z_2 - R_p) + P_w g R_p$

$P_1 - P_2 = P_g g(Z_2 - R_p) + P_w g R_p - P_g g Z$

$P_1 - P_2 = 19.62(Z_2 - Z_1) + 587.423$ — (i)

for the ventrimeter

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

$P_1 - P_2 = 19.62(Z_2 - Z_1) + 0.803V_2^2$ — (ii)

$\{ \ Z_2 - Z_1 = 0.06m$

equating eqn (i) and eqn (ii)

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

$587.423 = 0.803V_2^2$

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

$V_2^2 = 731.538$

$V_2 = \sqrt{731.535}$

$V_2 = 27.0464 m/s \simeq 27.05 m/s$

$Q_{ideal} = A_2V_2$

$= 27.047 \times 0.0314$

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

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

$= 0.96 \times 0.85$

$= 0.816 m^3/s$

(8) D_2 = Throat diameter = 0.076m

D_1 = Vertical diameter = 0.152m

Relative density = 0.8

Throat being = 0.914m

$C_d = 0.91$

Bernoulli's ~~equatio~~ 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

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

$$A_2 = \frac{\pi d^2}{4} = \frac{\pi \times 0.076^2}{4} = 4.64 \times 10^{-3} m^2$$

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

$V_1 A_1 = V_2 A_2$

$$\therefore V_1 = \frac{V_2 A_2}{A_1} = \frac{V_2 \times 4.54 \times 10^{-3}}{0.0181}$$

$V_1 = 0.25 V_2$

Then it becomes for $P_1 = P_2$, $\rho = 800$

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

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

$\cancel{0.194}\ 0.914 + \frac{(V_2\ 0.251)^2}{2\times 9.81} = \frac{V_2^2}{2\times 9.81}$

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

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

$0.914 \times 19.62 = V_2^2 - 0.063V_2^2$

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

$V_2 = \sqrt{19.136} = 4.37\ m/sec$

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

$= C_d \times A_2V_2$

$= 0.96 \times 4.37 \times 4.64 \times 10^{-3}$

$= 0.0195 m^3/s$

(ii) Then $P_1 - P_2 = 15170$

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

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

Recall $Z_1 - Z_2 = 0.914$

$$\frac{P_1 - P_2}{\rho g} = \frac{V_2^2 - V_1^2}{2g} - 0.94$$

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

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

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

$$\frac{15170}{7848} = \frac{Q^2\left(\left(\frac{1}{A_2}\right)^2 - \left(\frac{1}{A_1}\right)^2\right)}{2g} - 0.94$$

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

$(1.932 + 0.9447)2g = Q^2(48516.36 - 3052.47)$

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

$Q^2 = 124 \times 10^{-3}$

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

$Q = 0.0352 m^3/s$

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

$d_2 = 150mm = 0.15m$

$\therefore A_1 = 0.07069m^2$

$A_2 = 0.0177m^2$

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

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

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

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

But $Q = A_1V_1$

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

$V_1 = 0.5658 \simeq 0.57m/s$

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

$V_2 = 2.2598 \simeq 2.26m/s$

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

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

$$40.77 + 4 + (-0.2438) = \frac{P_2}{9.81 \times 1 \times}$$

$$44.52 \times 9.81 = P_2$$

$$P_2 = 436.\cancel{7}4 \, kN/m^2$$

(10) Reading of manometer $= 170mm$

$= 0.17m$

Specific gravity of mercury $= 13.6$

" " seawater $= 1.026$

$y = 0.17m$

for $h = y\left[\frac{Sg_m}{Sg_o} - 1\right]$

$$h = 0.17\left[\frac{13.6}{1.026} - 1\right] = 0.17 \times 12.256$$

$$= 2.0834m$$

Recall $V = \sqrt{2gh}$

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

$$V = \sqrt{40.87}$$

$$V = 6.393 m/s$$