Name: Onwo Efeoghene David
Matric No: 18/ENG03/051
Dept: Civil Engineering

Flow rate Q = 10 dm^3/min
Pressure change = 12 bar
Speed = 1500 rpm
Nominal displacement = 10 cm^3/rev
Torque input = 12.5 N-m

Q1 Q = 10 dm^3/min

$\therefore (10 \times 10^{-3}) m^3 / 60 s$

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

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

Speed of rotation = $\frac{1500 \text{ rev}}{60 s}$

= 25 rev/sec

Nominal displacement = 10 cm^3/rev

= $(10 \times 10^{-6}) m^3$/rev = $1 \times 10^{-5} m^3$/rev

Torque input = 12.5Nm

Volumetric Efficiency = $\frac{\text{Actual flow rate}}{\text{Ideal flow rate}} \times 100$

Ideal flow rate = $25 \frac{rev}{sec} \times 10^{-5} \frac{m^3}{rev}$

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

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

= 66.8 %

II Fluid Power = $Q \times \delta P$

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

$= 200.4$ watts

III Shaft Power = Torque input × angular Speed

$\frac{25 \times 2 \times \pi}{1 sec} = 50\pi$ rad/sec which is 157.08 rad/sec

Shaft power = $12.5 Nm \times 157.08 \frac{rad}{sec}$

$= 1963.495$ watts.

~~Q2~~ Question 2

$Q = 35 dm^3/min$

$= \frac{35 \times 10^{-3}}{60} m^3/s$

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

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

Overall Efficiency = 87%

Note: Efficiency = $\frac{\text{fluid power}}{\text{shaft power}} \times 100$

fluid Power = $Q \times \delta P = (5.83 \times 10^{-4}) \times (100 \times 10^5)$

$= 5830$ watts

Question 3

Nominal displacement : $50cm^3/rev$, Pressure change : 100bar ,
Shaft power : 15KW , flow rate Q : $35dm^3/min$, Speed : 850rpm

Ideal flow rate : Nominal displacement x Speed
= $50cm^3$ (rev x 850rpm)
: $42500 cm^3/m$ ∴ $42.5dm^3/min$

Volumetric Efficiency : Actual flow / Ideal flow
: $35/42.5$ = 0.8235 or 82.35%

ii $Q : \frac{35 \times 10^{-3}}{60} m^3/sec : 58.3 \times 10^{-5} m^3/sec$

$= 58.3 \times 10^{-5} m^3/sec$

$\Delta P : 100 \times 10^5 N/m^2$

Fluid power : $\Delta P \times Q = 58.3 \times 10^{-5} m^3/sec \times 100 \times 10^5$
= 5830watts

Overall Efficiency : $\frac{\text{fluid power}}{\text{shaft power}}$: $5830/15000$ = 0.386 or 38.86%

Question 4

H : 240m
Q : $0.013m^3/sec$
V : 66m/sec

a Power of jet (P_{jet}) : $1/2 \, mv^2$ jet

= $1/2 \, \rho Q v^2$ jet

$^{1}/_{2} \times 1000 \times 0.013 \times 66^2$ watt

$= 28314$

$= 28.314$ kilo watts

b Power supplied by Pres = $\rho Q g h$

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

$= 30607.2$

$= 30.6072$ watt

c Head used to overcome losses

$H - v^2_{jet}/2g$

$= 240 - 66^2/2 \times 9.81 \quad = 17.98m$

d Efficiency of pipe line and nozzle = $P_{jet}/P_{res} \times 100$

$= \dfrac{28.314}{30.6072} \times 100 = 92.51\%$

Question 5

$Z_1 = 300m \quad Q_1 = 220 \, l/s = 220 \times 10^{-3} \, m^3/s, \quad V_2 = 7 m/s$

Power of Jet = $\rho g Q H \quad \rho = 0.89 \times 1000 = 890 kg/m^3$

$g = 9.81 m/s^2 \quad Q = (220 \times 10^{-3}) m^3/s$

$H = 0 + \dfrac{0}{\rho g} + \dfrac{(7)^2}{2 \times 9.81}$

$H = 49/19.62 = 2.4975$

Power $= 890 \times 9.81 \times 220 \times 10^{-3} \times 2.497 = 4797.1$ Watts

II Power supplied from reservoir

$$H = Z_1 + \frac{P}{\rho g} + \frac{v^2}{2g} = 300 + \frac{0}{\rho g} + \frac{0}{2g} = 300J$$

Power: $890 \times 9.81 \times 220 \times 10^{-3} \times 300 = 576239.4$ watts

III Heat used to overcome power loss   power loss/$\rho g Q$

$$\frac{576239.4 - 4797.1}{100 \times 9.81 \times 220 \times 10^{-3}} = 264.7772681$$

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

$$\frac{4797.1}{576239.4} \times 100 = 0.8324836\%$$

Question 6

Power = $\frac{\text{work done}}{\text{time}}$ And work done = $\frac{mgh}{s}$

V = Velocity of stream, ρ = density of water (1000kg/m³)

$\dot{m} = \rho \times v$

$V = \sqrt{2gh}$, $\sqrt{2 \times 9.8 \times 20} = 19.7989$ m/s

Power = $1000 \frac{kg}{m^3} \times \left(\frac{10 \times 10^{-2}}{2}\right) \times 19.7989 \, m/s \times 9.8 \, m/s^2 \times 20m$

$P = 30478.03 \, W$

Question 7

Diameter = 0.3 m

$A_1 = \pi/4 \times 0.3^2$

$A_1 = 0.070685 m^2$

Throat diameter $D_2 = 0.2m$

$A_2 = \pi/4 \times 0.2^2$.

$A_2 = 0.031416 m^2$

$Cd = 0.96$

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

Density of gas (ρg) = $19.62 / 9.81 = 2 Kg/m^3$

Piezometric head difference (h) $= 0.06 \times \left(\frac{Sm}{Sg} - 1\right)$

$= 0.06 \times \left(\frac{1000}{2} - 1\right)$

h = 29.94m

Volume flow rate (Q) $= \frac{A_1 \cdot A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$= \frac{0.96 \times 0.070685 \times 0.031416 \times \sqrt{2 \times 9.81 \times 29.94}}{\sqrt{(0.070685)^2 - ((0.031416))^2}}$

$Q = 0.81599 m^3/s$

Question 8

$A_1 = \frac{\pi}{4} D_1^2 = \frac{\pi}{4} (0.152)^2 = 0.018146 m^2$

$A_2 = \frac{\pi}{4} D_2^2 = \frac{\pi}{4} (0.076)^2 = 4.5365 \times 10^{-3} m^2$

i $Q = Cd \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$

$= \frac{0.97 \times 0.018146 \times 4.5365 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 0.914}}{\sqrt{(0.018146)^2 - (4.5365 \times 10^{-3})^2}}$

$Q = 0.01924 m^3/s$

ii $h = \left(\frac{P_1 - P_2}{\rho g}\right) = \frac{15170}{0.8 \times 10^3 \times 9.81} = 1.933 m$

$Q = Cd \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} (\sqrt{2gh})$

$Q = \frac{0.97 \times 0.018146 \times 4.5365 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 1.933}}{\sqrt{(0.018146)^2 - (4.5365 \times 10^{-3})^2}}$

$Q = 0.02798 m^3/s$

Question 9

$D_1 = 0.3m \quad A_1 = \frac{\pi d^2}{4} = \frac{\pi (0.3)^2}{4} = 0.0707m^2$

$D_2 = 0.15m \quad A_2 = \frac{\pi d^2}{4} = \frac{\pi (0.15)^2}{4} = 0.0177m^2$

$Q = 40 L/s \; (40 \times 10^{-3}) m^3/s$

$Z_1 = 10m \quad Z_2 = 6m \quad P_1 = ? \quad P_2 = 400{,}000 N/m^2 \quad , \quad Q = VA$

$V_1 A_1 = Q \qquad Q = V_2 A_2$

$V_1 = (40 \times 10^{-3}) / 0.0707 \qquad V_2 = (40 \times 10^{-3}) / 0.0177$

$V_1 = 0.5658 m/s \qquad V_2 = 2.2599 m/s$

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

$$10 + \frac{400{,}000}{9.81 \times 1000} + \frac{(0.5658)^2}{2(9.81)} = 6 + \frac{P_2}{9.81 \times 1000} + \frac{(2.2399)^2}{2 \times 9.81}$$

$P_2 / 9.81 \times 1000 = 50.79 - 6.26$

$P_2 = (9.81 \times 1000)(44.53)$

$P_2 = 436836.326 N/m^2$

Question 10

ρ_m = density of mercury $\quad \rho_f$ = density of flowing fluid

$y \rightarrow$ manometric reading

$$h = y \left[\frac{\rho_m}{\rho_f} - 1 \right]$$

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

$h = 2.0834$

Calculate velocity of submarine

$V = \sqrt{2gh}$

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

$= 6.393 m/sec$