NAME: ARIKPO DEBORAH KEDEAYE
MATRIC NO: 18/ENG06/012
DEPARTMENT: MECHANICAL ENGINEERING
ASSIGNMENT:

① $Q = 10 dm^3/min$
$SP = 12 bar \Rightarrow 12 \times 10^5 \ N/m^2$
Rotation speed $\Rightarrow$ 1500 rev/min
Nominal displacement $\Rightarrow 10 cm^3/rev$
Torque input = 12.5 Nm

$Q = 10 dm^3/min \Rightarrow m^3/s$
$\frac{10}{10^3} = 0.01 m^3/min \rightarrow \frac{0.01}{60} m^3/s$

Actual flow rate $\Rightarrow 1.67 \times 10^{-4} m^3/s$

Rotation speed $\Rightarrow$ 1500 rev/min
$\Rightarrow \frac{1500}{60}$ rev/s $\Rightarrow$ 25 rev/s

Nominal Displacement
$\Rightarrow 10 cm^3/rev$
$\frac{10}{100^3} m^3/rev$
$\Rightarrow 1 \times 10^{-5} m^3/rev$

Ideal flow rate = Rotation Speed x Nominal Displacement
$\Rightarrow 25 \times 1 \cdot 10^{-5}$
$= 2.5 \times 10^{-4} m^3/s$

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

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

$$\Rightarrow 0.67 \times 100 = 67\%$$

(ii) Fluid power = SP × Q(Actual)

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

$$= 200.4 \text{ watts or } 200.4 \text{ Nm/sec}$$

(iii) Shaft power = Torque input × angular speed

$$T = 12.5 \text{ N/m}$$

$$\omega = 2 \times \pi \times \text{Nominal displacement}$$

$$\Rightarrow 2 \times \frac{22}{7} \times 25 \Rightarrow 157.1 \text{ rad/s}$$

Shaft power = 12.5 × 157.1

$$\Rightarrow 1963.75 \text{ watts}$$

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

$$\Rightarrow \frac{200.4}{1963.75} \times 100$$

$$\Rightarrow 0.102 \times 100$$

$$= 10.2\%$$

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

$SP = 100 \, bar = 100 \times 10^5 \, N/m^2$

Overall Efficiency = 87%

Shaft Power = ?

Fluid power = Change in pressure × Q(actual)

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

$$= 5830 \text{ watts}$$

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

$87 = \frac{5830 \times 100}{\text{Shaft power}}$

$\text{Shaft power} = \frac{5830 \times 100}{87}$

Shaft power = 6701.15 watts

3) Nominal Displacement = $50 cm^3/rev$

$\Rightarrow \frac{50}{100m^3} m^3/rev \Rightarrow 5 \times 10^{-5} m^3/rev$

Change in pressure = 100 bar = $100 \times 10^5 N/m^2$

Shaft Power = 15 kW => 15,000 watts

Actual flowrate = $35 dm^3/min = \frac{35}{10^3 \times 60} = 5.83 \times 10^{-4} m^3/s$

Rotation Speed = 850 r.p.m = $\frac{850}{60}$ rev/s

~~= 14.17 r.p.s~~

= 14.17 r.p.s

(i) Overall Efficiency = $\frac{\text{fluid power}}{\text{Shaft power}} \times 100$

fluid power = SP × Q(actual)

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

=> 5830 Watts

$\frac{5830}{15000} \times 100 \Rightarrow 0.389 \times 100$

=> 38.9%

(ii) Volumetric Efficiency = $\frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100$

Ideal flowrate = Nominal Displacement x Rotation Speed

$= 5\times10^{-5} \times 14.17 = 7.085\times10^{-4}\ m^3/s$

Volumetric Efficiency $= \frac{5.83\times10^{-4}\times100}{7.085\times10^{-4}}$

$= 0.823\times100$

$= 82.3\%$

(4) $Z = 24000cm \Rightarrow 240m$

Volumetric flow rate = 13l/s

$\Rightarrow \frac{13}{1000}\ m^3/s \Rightarrow 0.013m^3/s$

Velocity of jet = 66m/s, ρ of water = $1000kg/m^3$

(a) Power of Jet

$P = PQ + \frac{\rho QV^2}{2} + \rho gQZ$ —— (-)

∵ The jet of water will leave the nozzle at datum level with atmospheric pressure.

∴ $P = 0$ & $Z = 0$

eqn (-) becomes

$P = 0\times Q + \frac{\rho QV^2}{2} + \rho gQ\times0$

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

Power of Jet = 28314 watts or 28.314kw

(b) Power supplied from Reservoir

The speed of water in Reservoir = 0 and it operates Atmospheric pressure ∴ $V = 0$, $P = 0$

eqn(x) becomes

$P = 0\times Q + \frac{\rho Q\times0^2}{2} + \rho gQZ$

$P = \rho g Q z$
$= 1000 \times 9.81 \times 0.013 \times 240$
$= 30,607.2$ watts or $30.6072$ kW

(iii) Head used to overcome losses

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

=> Power lost in transmission
= Power Supplied from reservoir - Power of Jet

$= 30607.2 - 28314$
$= 2293.2$ watts

$$h = \frac{2293.2}{1000 \times 9.81 \times 0.013} = 17.98\,m$$

(iv) Efficiency of pipeline and nozzle in transmitting operation:

$$= \frac{\text{Power of Jet}}{\text{Power from reservoir}} \times 100 \Rightarrow \frac{28314 \times 100}{30607.2} = 92.51\%$$

(3) Sg of oil $= 0.89$

$$\text{Sg of oil} = \frac{\text{density of oil}}{\text{density of water}}$$

$$0.89 = \frac{\rho \text{ of oil}}{1000}$$

$\rho$ of oil $= 0.89 \times 1000 \Rightarrow 890\,kg/m^3$
$z = 30,000\,cm = 300\,m$
$Q = 220\,l/s \Rightarrow \frac{220}{1000} \Rightarrow 0.22\,m^3/s$

Velocity of Jet = 7m/s

(i) Power of Jet

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

but $P = 0$ & $z = 0$

$P = \frac{\rho Q V^2}{2} = \frac{890 \times 0.22 \times 7^2}{2}$

Power of Jet => 4797.1 watts

(ii) Power Supplied from reservoir

$P = 0, \; V = 0$

Power supplied from Reservoir $= \rho g Q z$

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

$= 576239.4$ watts or 576 kW

(iii) Head used to overcome losses

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

Power lost in transmission = Power from reservoir – Power of Jet

$= 576239.4 - 4797.1$

$= 571442.3 W$

$h = \frac{571442.3}{890 \times 9.81 \times 0.22} \doteq 297.5 m$

(iv) Efficiency of pipeline and nozzle in transmitting operation

$= \frac{\text{Power of Jet}}{\text{Power from Reservoir}} \times 100$

$= \frac{4797.1}{570239.4} \times 100$

$= 0.83\%$

(b) $h = 20m$

base of stream = 10cm in diameter

$= 0.1m$

Area $= \frac{\pi d^2}{4} = \frac{3.142 \times 0.1^2}{4} = 7.855 \times 10^{-3} m^2$

from $v^2 = u^2 + 2as$, — ①

Since stream is moving against gravity to a height, eqn ① becomes

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

$v = 0$

$u^2 = +2gh$

$u = \sqrt{2gh}$

$u = \sqrt{2 \times 9.81 \times 20}$

$u = \sqrt{392.4}$

$u = 19.81 m/s$

from Continuity equation

$Q = VA$

where $V$ = Velocity (m/s)

$A$ = Area ($m^2$) $Q$ = flow rate ($m^3/s$)

$Q = 19.81 \times 7.855 \times 10^{-3}$

$= 0.156 m^3/s$

Power $= \rho g h Q$ [Pressure $= \rho g h$]

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

$= 30607.2$ Watts

Q) $d_1 = 0.3m$

$A_1 = \frac{\pi d_1^2}{4} = \frac{3.142 \times 0.3^2}{4} = 0.0707m^2$

$d_2 = 0.2m$

$A_2 = \frac{\pi d_2^2}{4} = \frac{3.142 \times 0.2^2}{4} = 0.0314m^2$

$cd = 0.98$

$h = 0.06m$

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

$Q = \frac{0.98 \times 0.0707 \times 0.0314 \times \sqrt{2 \times 9.81 \times 0.06}}{\sqrt{0.0707^2 - 0.0314^2}}$

$Q = \frac{2.22 \times 10^{-3} \times \sqrt{1.177}}{\sqrt{4.01 \times 10^{-3}}}$

$Q = \frac{2.408 \times 10^{-3}}{0.06332}$

$Q = 0.038 m^3/s$

∴ The volume of gas flowing per second is $= 0.038 m^3$

8) $d_1 = 0.152m$

$A_1 = \frac{\pi d_1^2}{4} = \frac{3.142 \times 0.152^2}{4} = 0.0181 m^2$

$d^2 = 0.076m$

$A_2 = \frac{\pi d_2^2}{4} = \frac{3.142 \times 0.076^2}{4} = 4.537 \times 10^{-3} m^2$

Relative Density of liquid = 0.8
$z_1 = 0.914m$, $z_2 = 0m$
$Cd = 0.97$

(a) $h = \left(\frac{P_1}{\omega} - \frac{P_2}{\omega}\right) + (z_1 - z_2)$
but $P_1 = P_2$
$h = 0 + (0.914 - 0)$
$h = 0.194 m$

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

$$Q = \frac{0.97 \times 0.0181 \times 4.537 \times 10^{-3} \sqrt{2 \times 9.81 \times 0.914}}{\sqrt{0.0181^2 - (4.537 \times 10^{-3})^2}}$$

$$Q = \frac{7.9656 \times 10^{-5} \times \sqrt{17.933}}{\sqrt{3.0702 \times 10^{-4}}}$$

$$Q = \frac{3.3732 \times 10^{-4}}{0.01752}$$

$= 0.0192 m^3/s$

(b) when $P_1 - P_2 = 15170 N/m^2$
$h = \frac{15170}{\omega} + (z_1 - z_2)$
R.D of liquid = 0.8

$$0.8 = \frac{\rho \text{ of liquid}}{\rho \text{ of water}}$$

$1000 \times 0.8 = \rho$

$\rho = 800 kg m^{-3}$

$\omega = \rho g = 800 \times 9.81$

$= 7848$

$h = \frac{15170}{7848} + 0.914$

$= 2.847 - 0.914$

$= 3.761$

$$Q = \frac{cd \times A_1 \times A_2 \times \sqrt{2 \times g \times h}}{\sqrt{A_1^2 - A_2^2}}$$

$$Q = \frac{0.97 \times 0.0181 \times 4.537 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 3.761}}{\sqrt{0.0181^2 - (4537 \times 10^{-3})^2}}$$

$$= \frac{7.9656 \times 10^{-5} \times \sqrt{73.79}}{\sqrt{3.0702 \times 10^{-4}}}$$

$$Q = \frac{6.842 \times 10^{-4}}{0.01752} = 0.039 m^3/s$$

8) $d_1 = 300 mm = 0.3 m$

$d_2 = 150 mm = 0.15 m$

$A_1 = \frac{\pi d_1^2}{4} = \frac{3.142 \times 0.3^2}{4} = 0.0707 m^2$

$A_2 = \frac{\pi d_2^2}{4} = \frac{3142 \times 0.15^2}{4} = 0.01767 m^2$

$Q = 40 l/s \rightarrow m^3/s$

$\frac{40}{1000} \Rightarrow 0.04 m^3/s$

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

$P_1 = 400 kN/m^2 \rightarrow 400{,}000 N/m^2$

$P_2 = ?$

Continuity of equation;

$Q = V_1 A_1$

$\frac{Q}{A} = V_1$

$V_1 = \frac{0.04}{0.0707} = 0.566 m/s$ //

$Q = V_2 A_2$

$\frac{Q}{A_2} = V_2 = \frac{0.04}{0.01767}$

$V_2 = 2.264 m/s$

from Bernoulli's equation

$$\frac{P_1}{\omega} + \frac{V^2}{2g} + z_1 = \frac{P_2}{\omega} + \frac{V^2}{2g} + z_2$$

$$\omega = \rho g = 1000 \times 9.81 = 9810$$

$$\frac{P_2}{\omega} = \frac{P_1}{\omega} + \left[\frac{V_1^2}{2g} - \frac{V_2^2}{2g}\right] + z_1 - z_2$$

$$\frac{P^2}{\omega} = \frac{400{,}000}{9810} + \frac{0.566^2 + 2.264^2}{19.62} + (10-6)$$

$$\frac{P^2}{\omega} = 40.77 - \frac{4.80534}{19.62} + 4$$

$$\frac{P^2}{\omega} = 40.77 - 0.2449 + 4$$

$\frac{P_2}{\omega} = 44.525\,m$

$P_2 = 44.525 \times 9810$
$P_2 = 436790.25\ N/m^2$

∴ The intensity of pressure at section 2 is = 436790.25 $N/m^2$

(i) Manometer Reading (y) = 120 mm → 0.17 m
S.g of sea water = 1.026

$h = y\left[\frac{\text{S.g of manometer liquid (heavier liquid)}}{\text{S.g of sea water}} - 1\right]$

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

$h = (12.2554) \times 0.17$
$h = 2.0834\,m$

$V = \sqrt{2gh}$
$V = \sqrt{2 \cdot 9.81 \times 2.0834}$
$= \sqrt{40.876}$
$V = 6.39\,m/s$

∴ The speed of the submarine is 6.39 m/s