ABIOYE FOLAWIYO ABDUL-AZEEM
18/ENG03/002
CIVIL ENGINEERING
FLUID MECHANICS <ENG 214>

(1) Rate of pump delivery = $10 dm^3/min$

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

Speed of rotation = 1500 rev/min = $\frac{1500 \text{ rev}}{1 \text{min}} \times \frac{1 \text{min}}{60 \text{sec}}$

Nominal displacement = $10 cm^3/rev$

Torque Input = 12.5 N/m

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

Actual flow rate = $10 dm^3/min = \frac{10 dm^3}{1 min} \times \frac{1 m^3}{1000 dm^3} \times \frac{1 min}{60 sec}$

$= 1.667 \times 10^{-4} m^3/sec$

Norminal displacement = $\frac{10 cm^3}{1 rev} \times \frac{1 m^3}{100^3 cm^3} = 1 \times 10^{-5} m^3/rev$

Ideal flow rate = nominal displacement × Speed.

$= 1 \times 10^{-5} \times 25$

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

Volumetric efficiency = $\frac{1.667 \times 10^{-4}}{2.5 \times 10^{-4}} \times 100 = 66.68\%$

(ii) Fluid Power = Actual flow rate × Pressure

$= 1.667 \times 10^{-4} \times 12 \times 10^5$

= 200.04 watts.

(iii) Shaft power = Torque Input × Angular Speed.

Torque input = 12.5 Nm

Angular Speed = $W = \frac{2\pi N}{60} = \frac{2 \times \pi \times 1500}{60}$

∴ Shaft power = $12.5 \times 2 \times \pi \times 25$ = 1963.5 watts.

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

$= \frac{200.4}{1963.5} \times 100\% = 10.21\%$

(2) Rate of delivery $= 35 dm^3/min = 35/60 = 0.55 dm^3/sec.$

Pressure change $= 100$ bar $= 100 \times 10^5 N/m^2$

Overall efficiency $= 87\%$

Shaft power $= ?$

(i) ∴ Rate of delivery $= 0.58 \times \frac{1}{1000} = 5.83 \times 10^{-4} m^3/sec.$

(ii) Fluid power = Actual flow rate × pressure change

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

$= 5833.33$ watts.

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

$87 = \frac{5833.33}{\text{Shaft power}} \times 100$

$\frac{0.87}{5833.33} = \frac{1}{\text{Shaft power}}$

∴ Shaft power $= 6704.977$ watts

(4)

(3) Nominal displacement $= 50 cm^3/rev = \frac{50 cm^3}{rev} \times \frac{1 m^3}{100 cm^3} = 5 \times 10^{-4} m^3/rev$

Pressure change $= 100$ bar $= 100 \times 10^5 N/m^2$

Shaft power $= 15 KW = 15{,}000 W$

Actual flow rate $= 35 dm^3/min = \frac{35 dm^3}{1 min} \times \frac{1 min}{60 sec} \times \frac{1 m^3}{1000 dm^3}$

$= 5.833 \times 10^{-4} m^3/sec.$

Speed of rotation $= 850$ rpm $= 14.2$ rps

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

fluid power = Actual flow rate × pressure change.

$= 5.883 \times 10^{-4} \times 100 \times 10^{5}$

$= 5833$ watts

Shaft power = Torque Input × Angular Speed

$= 15KW = 15000 W$

Overall efficiency = $\frac{5883}{15000} \times 100$

$= 388.7\%$

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

Ideal flow rate = nominal displacement × Speed.

$= 5 \times 10^{-4} \times 14.2$

$= 7.1 \times 10^{-3} m^3/sec.$

Volumetric efficiency = $\frac{5.883 \times 10^{-4}}{7.1 \times 10^{-3}} \times 100$

$= 8.22\%$

(4) $Z = 24,000 Cm = \frac{24,000}{100} = 240m$

Flow rate = 13 litres/Sec.

Since 1000 litres = $1m^3$

$\therefore$ 13 litres = $\frac{13 \times 1}{1000} = 0.013 m^3/sec.$

Velocity of Jet = 66m/sec.

Jet Issuing from Nozzle is at atmospheric pressure and at datum Level $\therefore$ $P = 0$; $Z = 0$

Density = $1000 Kg/m^3$

From equation; $P = \langle P + \rho g z + \rho v^2/2 \rangle Q$

$\therefore$ Since; $P = 0$, $Z = 0$

$P = p\langle Q \rangle + \rho \frac{\langle Q v^2 \rangle}{2} + \rho g \langle 0 \rangle$

$$P = \frac{\rho Q v^2}{2} = \frac{1000 \times 0.013 \times 66^2}{2}$$

$P = 28314\ W = 28.314\ KW$

(ii) At this point ; $P = 0$ while $v = 0$

$$P = (PQ + \rho Q g z + \frac{\rho Q v^2}{2})$$

$$P = \rho Q g z = 1000 \times 0.013 \times 9.8 \times 240$$

$= 30576\ W$

$= 30.576\ KW$

(iii) Power loss in transmission $= 30.576 - 28.314$

$= 2.262\ KW = 2262\ W$

Head loss in pipeline;

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

$$= \frac{2262}{1000 \times 9.81 \times 0.013} = 17.73\ m$$

(iv) Efficiency of the pipeline and Nozzle;

$$\Rightarrow \frac{\text{Power of Jet}}{\text{Power of reservoir}} \times 100 = \frac{28314}{30576} \times 100$$

$= 92.6\%$

5, Specific gravity of oil $= 0.89$

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

$Q = 220$ litres/sec.

∴ Since 1000 litres $= 1\ m^3$

∴ Then 220 litres $= \frac{220 \times 1}{1000} = 0.22\ m^3/sec.$

Velocity of Jet $= 7\ m/sec.$

(i) Specific gravity $= \frac{\text{Specific weight of Liquid}}{\text{Specific weight of water.}}$

$0.89 \times 9.81 =$ Specific weight of Liquid

$\Rightarrow 8.7309\ KN/m^3 = 8730.9\ N/m^3$

∴ density $\langle \rho \rangle = \frac{8730.9}{9.81} = 890\ Kg/m^3.$

if we recall;

At the point of Jet issuing from Nozzle; $P=0$; $z=0$

from eqn; $\langle PQ + \rho g z Q + \rho v^2 Q/2 \rangle$ = Power.

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

$= 4797.1 W \Rightarrow 4.7971 KW$

(ii) Power Supplied from reservoir; $P=0$; $v=0$

$$\text{Power} = \langle PQ + \rho z g Q + \frac{\rho v^2 Q}{2} \rangle$$

$$\text{Power} = \rho z g Q = 890 \times 300 \times 9.81 \times 0.22$$

$= 576239.4 W \Rightarrow 576.2394 KW$

(iii) Power loss in transmission = 576239.4 − 4797.1

= 571442.3 W

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

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

= 297.50m.

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

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

= 0.83%

(6) Power = Pressure × flow rate.

Pressure of water = $\rho g h$ = 1000 × 9.81 × 20

= 196200 N/m²

Area = $\pi \times \langle 0.05 \rangle^2 = 7.854 \times 10^{-3} m^2$

Volume = $7.854 \times 10^{-3} \times 20 = 0.1571 m^3$

$$Q = \text{flowrate} = \frac{0.1571}{60} = 2.62 m^3/s.$$

Power = 196200 × 2.62

= 514044W = 514.044KW

7, Inlet diameter $\langle D_1 \rangle = 0.3m \Rightarrow \frac{\pi \times 0.3^2}{4} = 0.071m^2$ = Inlet Area $\langle A_1 \rangle$

Throat diameter $\langle D_2 \rangle = 0.2m \Rightarrow \frac{\pi \times 0.2^2}{4} = 0.031m^2$ = Throat Area $\langle A_2 \rangle$

$C_D = 0.96$; $h = 0.06m$; Sp. gr of water = 1

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

Sp. gr of gas $= \frac{19.62 \div 1000}{9.81} = 0.002$

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

$$Q = \frac{0.96 \times 0.071 \times 0.031}{\sqrt{(0.071)^2 - (0.031)^2}} \times \sqrt{2 \times 9.81 \times 0.06}$$

$Q = 0.0359 m^3/s$

Volume flowing $= 0.0359 m^3$

8, Throat diameter $\langle D_2 \rangle = 0.076m$

Throat Area $\langle A_2 \rangle = \frac{\pi \times \langle 0.076 \rangle^2}{4} = 4.54 \times 10^{-3} m^2$

Relative density = 0.8

Pipe diameter = 0.152m = D_2

Pipe Area $\langle A_1 \rangle = 0.0181 m^2$

difference btw Inlet and throat = 0.914m

$Cd = 0.97$

Since $h = \left(\frac{P_1}{w} - \frac{P_2}{w}\right) + (z_1 - z_2)$

(a) When $P_1 = P_2$

$\therefore h = 0$

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

Since $h = 0$

$\therefore Q = 0.$

(b) When $P_1 - P_2 = 15170$; $0.8 \times 1000 = 800 Kg/m^3$ = density of liquid

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

$w = \rho g$

$w = 800 \times 9.81 = 7.848\ kN/m^3$

$h = 1.933m + 0.914m$

$\therefore h = 2.847m$

$\therefore$ discharge $\langle Q \rangle = \dfrac{C_d \times A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$

$Q = \dfrac{0.97 \times 0.0181 \times 4.54 \times 10^{-3}}{\sqrt{(0.0181)^2 - (4.54 \times 10^{-3})^2}} \times \sqrt{2 \times 9.81 \times 2.847}$

$Q = 0.034\ m^3/seconds$

9, Section 1 diameter $= 300mm = 0.3m$ $\langle D_1 \rangle$

Section 1 Area $= \dfrac{\pi \times 0.3^2}{4} = 0.071\ m^2$ $\langle A_1 \rangle$

Section 2 diameter $= 150mm = 0.15m$ $\langle D_2 \rangle$

Section 2 Area $= \dfrac{\pi \times 0.15^2}{4} = 0.018m^2$ $\langle A_2 \rangle$

$Q = 40$ litres/sec $= 0.04m^3/sec.$

$Z_1 = 10m$; $Z_2 = 6m$

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

$= 400kPa$

$V_1 = \dfrac{Q}{A_1} = \dfrac{0.04}{0.071} = 0.563m/s$

$V_2 = \dfrac{Q}{A_2} = \dfrac{0.04}{0.018} = 2.27m/s$

Using Bernoulli's Equ: $\dfrac{P_1}{w} + \dfrac{V_1^2}{2g} + Z_1 = \dfrac{P_2}{w} + \dfrac{V_2^2}{2g} + Z_2$

$= \dfrac{400}{9.81} + \dfrac{0.563^2}{2 \times 9.81} + 10 = \dfrac{P_2}{9.81} + \dfrac{2.27^2}{2 \times 9.81} + 6$

$\dfrac{P_2}{9.81} = 44.53$

$\therefore$ Intensity of Pressure at Section 2 $\Rightarrow 9.81 \times 44.53$

$P_2 = 436.82\ kN/m^2$

10, Axis = 12m below Sea-Level

y = 170mm = 0.17m of mercury

Sp. gravity of Hg = 13.6

Sp. gravity of Water = 1.026

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

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

$h = 2.08m$

∴ Velocity of Submarine (v) $= \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.08}$

$= 6.39 m/s$