RAJI UMMI-SALMA ONIZE
18/ENG08/020
BIOMEDICAL ENGINEERING

ASSIGNMENT

1.) $Q = 10 dm^3/min = 0.01 m^3/min$

$\Delta P = 12$ bar $= 12 \times 10^5$ pascal

$N = 1500$ RPM $= 1500$ RPM

displacement $= 10 cm^3/rev = 10 \times 10^{-6} m^3/rev$

$T_{in} = 12.5 Nm$ (Torque input)

a.) Volumetric Efficiency $= \frac{\text{Actual flow rate}}{\text{Ideal flow rate}}$

ideal flow rate $= 10 \times 10^{-6} \times 1500 \; m^3/min$

$= 0.015 m^3/min$

Volumetric efficiency $= \frac{0.01}{0.015} = 0.6666$

Volumetric efficiency $= 66.67\%$

b.) fluid power $= P_{fluid} = \rho g Q H = \Delta P Q$

$\frac{12 \times 10^5 \times 0.01}{60}$

$P = 200$

$P_f = 200$ watt

c) shaft power

$P = \frac{2\pi NT}{60} = \frac{2 \times \pi \times 1500 \times 125}{60}$

$P_{shaft} = 1963.4954$ watt

d) Overall efficiency = $\frac{\text{fluid power}}{\text{shaft power}}$

$= \frac{200}{1963.4954} = 0.1018$

Overall efficiency = 0.1018×100

$= 10.18\%$

2) $Q = 35 \, dm^3/min = 0.035 \, m^3/min$ ~~0.035kg~~

$= 0.035/60 = 5.83 \times 10^{-4} \, m/s$

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

Overall Efficiency = 87% = 0.87

Shaft power = ?

Overall efficiency = $\frac{\text{fluid power}}{\text{shaft power}}$

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

Fluid power = $P \times Q$

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

Fluid power = 5830 watts

Shaft power = $\frac{5830}{0.87} = 6701.15$

$= 67.01$ watts

3.] ND = $50 cm^3/rev$

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

Shaft power = 15kW

$Q = 35 dm^3/min = 0.035 m^3/min = 5.83 \times 10^{-4} m^3/s$

Speed = 850 rpm

Overall efficiency = ? , %V = ?

$\%V = \frac{\text{Actual flow rate}}{\text{Ideal flow rate}}$

Ideal flow rate = Nominal flow rate × Speed

$= 50 cm^3/rev \times 850\ rev/min$

$= 42500 cm^3/min$

Ideal flow rate $= \frac{42500}{1000000} = 0.0425 m^3/min$

∴ Volumetric efficiency $= \frac{0.035}{0.0425} = 0.824$

Volumetric efficiency = 0.824 × 100 = 82.4%

⇒ Overall efficiency $= \frac{\text{fluid power}}{\text{shaft power}}$

Fluid power = P × Q

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

Fluid power = 5830 watts

Shaft power $= 15 \times 10^3$ watts

$= \frac{5830}{15000} = 0.389$

0.389 × 100 = 38.9% [overall Efficiency].

4.] Water level, z = 2,4000cm = 240 m

Q = 13 litre/sec $= 13 \times 10^{-3} m^3/sec$

~~Q~~ Jet velocity, V = 66 m/s

I.) $P = z = 0$, $\rho = 1000 kg/m^3$

$$P = \frac{\rho \times Q \times v^2}{2} = \frac{1000 \times 13 \times 10^{-3} \times (66)^2}{2}$$

$P = 28314$ watts

ii.) $P = 0, v = 0$

$P = \rho g Q z = 1000 \times 9.81 \times 13 \times 10^{-3} \times 240$

$P = 30607.2$ watts

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

Power lost in transmission = Power of reservoir − Power of jet

$= 30607.2 - 28314 = 2293.2$ watts

$\therefore h = \frac{2293.2}{1000 \times 9.81 \times 13 \times 10^{-3}} = 17.981 m$

iv.] Efficiency $= \frac{\text{Power of jet}}{\text{Power of reservoir}}$ %

$= \frac{28314}{30607.2} = 0.925 \times 100$

$= 92.5\%$

5.] $\rho_o = 0.89 = 890$

$h = 30,000$ cm $= 300 m$

$Q = 220$ litres/sec $= 220 \times 10^{-3} m^3/s$

$v = 7 m/s$

a.] Power of jet, $P = \frac{\rho_o \times Q \times v^2}{2}$

$$= \frac{890 \times 220 \times 10^{-3} \times (7)^2}{2}$$

$P = 4797.1$ watts

b.] Power from reservoir, $P = wQh$

$= 890 \times 9.81 \times 220 \times 10^{-3} \times 300$

$P = 576239.4$ watts

c) $h = \frac{\text{Power lost in transmission}}{Q}$

Power of jet $= \frac{\rho Q V^2}{2g} = \frac{890 \times (7)^2 \times 220 \times 10^{-3}}{2 \times 9.81}$

$= 489.0$ kgm/s

Power of reservoir $= rQh = 890 \times 220 \times 10^{-3} \times 300$

$= 58740$ kgm/s

∴ Power lost in transmission $= 58740 - 489.0$

$= 58251$ kgm/s

∴ $h = \frac{58251}{890 \times 220 \times 10^{-3}} = 297.5$ m

d.) Efficiency of the pipeline & nozzle in transmitting operation

Efficiency $= \frac{\text{Power of jet}}{\text{Supply}} = \frac{489.0}{58740}$

$= 0.00832 \times 100$

Efficiency $= 0.832\%$

6.) $h = 20$ m

$d = 10$ cm $= 0.10$ m $\qquad \rho = 1000$ kg/m^3

$A = \frac{\pi d^2}{4} = \frac{\pi (0.10)^2}{4} = 7.85 \times 10^{-3}$ m^2

final speed, $V_f = 0$, Power, $W = ?$

$W = \rho g Q h$

$Q = VA$, but $V_f = ?$

$V_f = V_i^2 - 2gh$

$V_i = \sqrt{V_f^2 - 2gh}$

$V_i = \sqrt{0^2 + (2 \times 9.8 \times 20)} = 19.8$ m/s

$Q = 19.8 \times 7.85 \times 10^{-3} = 0.1555 m^3/s$

$W = 1000 \times 9.81 \times 0.1555 \times 20$

$W = 30478 kgm^2/s^3$

$W = 30 \times 10^3 W$

(7) $d_1 = 0.3m$, $Cd = 0.96$

$d_2 = 0.2m$ $P_g = 19.62 N/m^2$

$Q = ?$

Considering the manometer

$P_1 + \rho g z_1 = P + \rho g(z_2 - R) + \rho_w g R$

$\therefore P_1 - P_2 = 19.62(z_2 - z_1) + 587.423$ — (1)

Considering the venturimeter

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

$P_1 - P_2 = 19.62(z_2 - z_1) + 0.803V_2^2$ — (2)

Equating eqn 1 & 2

$19.62(z_2 - z_1) + 587.423 = 19.62(z_2 - z_1) + 0.803V_2^2$

$\therefore 587.423 = 0.803V_2^2$

$$V_2^2 = \frac{587.43}{0.803}$$

$V_2 = \sqrt{731.535} = 27.047 m/s$

$Q = V_2 \cdot A_2$

$$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi(0.2)^2}{4} = 0.0314 m^2$$

$Q = 27.047 \times 0.0314$

$= 0.85 m^3/s$

But $Q_0 = Cd\, Q_{ideal}$

$Q_0 = 0.96 \times 0.85$

$= 0.816 m^3/s$

Q.] $d_1 = 300\ mm = 0.3m$

$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi (0.3)^2}{4} = 0.0707 m^2$

$d_2 = 150\ mm = 0.15m$

$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi (0.15)^2}{4} = 0.01767 m^2$

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

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

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

$V_1 = ?$, $V_2 = ?$

Using continuity equations

$Q = A_1V_1 = A_2V_2$

$V_1 = \frac{Q}{A_1}$, $V_2 = \frac{Q}{A_2}$

$V_1 = \frac{0.04}{0.0707}$, $V_2 = \frac{0.04}{0.01767}$

$V_1 = 0.56 m/s$, $V_2 = 2.264 m/s$

Using Bernoulli's equation at ①

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

$$\frac{400}{9.81} + \frac{(0.566)^2}{2\times 9.81} + 10 = \frac{P_2}{w} + \frac{(2.264)^2}{2\times 9.81} + 6$$

$$\therefore \frac{P_2}{w} = \frac{400}{1000\times 981} + \left(\frac{1}{2\times 9.81} \times (0.566^2 - 2.264^2)\right) + 10 - 6$$

$$\frac{P_2}{w} = 40.77 - 0.245 + 4$$

$$\frac{P_2}{w} = 44.525$$

but $w = 1000 \times 9.81$

$P_2 = 44.525 \times 1000 \times 9.81 = 436790\ N/m^2$

$= 436.79\ kN/m^2$

10.] $S_{hg} = 13.6$

S.g of $o = 1.026$

$x = 170mm = 0.17m$

V_2 ?

$V = \sqrt{2gh}$

but $h = ?$

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

$$V = \sqrt{2g\left(x\left(\frac{13.6}{1.026} - 1\right)\right)}$$

$V = \sqrt{2 \times 9.81 \times (0.17(12.255))}$

$V = \sqrt{2 \times 9.81 \times 2.083}$

$V = 6.393\ m/s$

$V = 6.4\ m/s$