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FLUID MECH
COMPUTER ENGINEERING

1) $Q = 10 dm^3/min = 10/1000 \times 60$
$= 1.667 \times 10^{-4} m^3/s$
$\Delta P = 12 Bar = 12 \times 10^3 N/m^2$
Speed of Rotation = 1500rev/min
= 1500/60
= 25rev/s

Nominal displacement = $10cm^3/rev$
$= 10/1000000 = 1 \times 10^{-5} m^3/rev$

Torque Input = 12.5 Nm

(i) Volumetric Efficiency = Q/ideal flowrate

Ideal flow rate = Nominal displacement × speed = $1 \times 10^{-5} \times 25$
$= 2.5 \times 10^{-4} m^3/s$
∴ Volumetric Efficiency = $\frac{1.667 \times 10^{-4}}{2.5 \times 10^{-4}}$
$= 0.6668 \times 100\% = 66.68\%$

ii) Fluid Power = $Q \times \Delta P$
$= (1.667 \times 10^{-4}) \times (12 \times 10^{-3}) = 200.04 W$

iii) Shaft Power = $2\pi T \times speed$
$= 2 \times 3.14 \times 12.5 \times 25$
$= 1963.50 W$

iv) Overall Efficiency = $\frac{\text{Fluid Power}}{\text{Shaft Power}} = \frac{200.04}{1963.50} = 0.102 \times 100 =$

2) $Q = 35 dm^3/min = (35 \times 0.001)/60$
$= 5.83 \times 10^{-4} m^3/s$
$\Delta P = 100bar = 100 \times 10^3 N/m^2$
Overall Efficiency = 87%
Shaft Power = fluid Power / Overall Efficiency
$= \frac{Q \times \Delta P}{87 \div 100} = \frac{5.83 \times 10^{-4} \times 100 \times 10^5}{0.87} = 6701.15 W$

3.) $Q = 35\,dm^3/min = (35 \times 0.001)/60$
$= 5.83 \times 10^{-4}\, m^3/s$
$\Delta P = 100\, bar = 100 \times 10^5\, N/m^2$
Shaft Power = 15 KW
Speed Rotation = 880 rev/min
$= 880/60 = 14.167\, rev/s$

i) Volumetric Efficiency = $\frac{\text{Actual flowrate, } Q}{\text{Ideal flow rate}}$

Ideal flow R = Nominal displacement × speed
$= 50\, cm^3/rev \times 14.167$
$= 5 \times 10^{-5} \times 14.167$
$= 7.0835 \times 10^{-4}\, m^3/s$

∴ Volumetric $\mathcal{E} = \frac{5.83 \times 10^{-4}}{7.0835 \times 10^{-4}} = 82.3\%$
=

iii) Overall Efficiency = Fluid P / Shaft P = $\frac{Q \times \Delta P}{\text{Shaft power}}$

$= \frac{5.83 \times 10^{-4} \times (100 \times 10^5)}{(15 \times 10^3)} = \frac{5830}{15000} = 0.3887 \times 100$
$= 38.87\%$

No(10)

Difference of Mercury level, $x = 170\,mm = 0.17\,m$
Speed of submarine = ?
S.gravity of mercury = 13.6
S.gravity of sea water = 1.026

Differential Head, $h = x\left\{\frac{S_g}{S_o} - 1\right\}$
$= 0.17\left(\frac{13.6}{1.026} - 1\right)$
$= 2.0839\, m$ of water

Velocity/speed of Sub
$v = \sqrt{2gh}$
$= \sqrt{2 \times 9.81 \times 2.0834}$
$= 6.393\, m/s$

No(7)

Specific weight = 19.62 N/m²

$C_d = 0.96$

$d_1 = 0.3m$

$d_2 = 0.2m$

Calculate Q,

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

For the manometer

$P_1 + S_{ws} Z = P_a + S_{ng} (Z_2 - R_2) + S_{ng} R_p$

$P_1 - P_2 = 19.62 (Z_2 - Z_1) + 587.423$ — (1)

For the Venturimeter

$\frac{P_1}{S_g} + \frac{V_1^2}{2g} + Z_1 \Rightarrow \frac{P_2}{S_{ng}} + \frac{V_2^2}{2g} + Z_2$

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

Comb. (1) & (2) ⇒

$0.803 V_2^2 = 587.423$

V_2 ideal $= 27.047 m/s$

Q_1 ideal $= 27.047 \times \pi \times (\frac{0.2}{2})^2$

$= 0.85 m^3/s$

$Q = C_d \cdot Q_{ideal} = 0.96 \times 0.85 = 0.816 m^3$

No(6)

Power = $\frac{\text{Workdone}}{\text{Time}}$

workdone = mgh / time

V = Velocity of stream

ρ = density of water (1000kg/m³)

$m = \rho \times V$

$V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 20} = 19.7989m$

1.) $P \Rightarrow \rho \pi r^2 V g h$

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

Power = 30478.63W ≡ 30.5 KW //

No. 8

$d_1 = 0.152m \Rightarrow A_1 = \frac{\pi}{4}(0.152)^2$
$= 0.01814 m^2$

$d_2 = 0.076m \Rightarrow A_2 = \frac{\pi}{4}(0.076)^2 = 0.00464 m^2$

$\rho = 0.8 \times 1000 = 800 kg/m^3$

$Cd = 0.97$

$\Rightarrow$ Apply Bernoulli

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

(a) $P_1 = P_2$

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

By continuity =

$Q = V_1 A_1 = V_2 A_2$

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

$$\frac{V_1^2}{2g} = 0.314 = \frac{16(V_1^2)}{2g}$$

$$V_1 = \sqrt{\frac{0.314 \times 2 \times 9.81}{15}} = 1.0734 m/s$$

$Q = Cd\, A_1 V_1 = 0.37 \times (0.01814) \times (1.0939)$

b) $P_1 - P_2 = 15170$

$$\Rightarrow \frac{P_1 - P_2}{\rho g} = \frac{V_2^2 - V_1^2}{2g} - 0.914$$

$$\frac{15170}{800 \times 9.81} = \frac{Q^2[(220.43)^2 - (55.11)^2]}{2 \times 9.81} - 0.914$$

$\Rightarrow Q = 0.035 m^3/s$

No (3)

⇒ At section 1

$P_1 = 0.3m$, Area $= \pi/4 \times (0.3)^2 = 0.07068 m^2$, Pressure, $P_1 = 400 kN/m^2$

Height of upper end above the datum, $(Z_1) = 10m$

⇒ At section 2,

$P_2 = 150m = 0.15m$, Area $= \pi/4 \, (0.15)^2 \doteq 0.01767 m^2$

Height of lower end of datum = 6

⇒ Rate of flow, $Q = 0.04 m^3/sec$

⇒ As the flow is continuous,

$Q = A_1 V_1 = A_2 V_2$ (continuity Eqn)

$$V_1 = Q/A_1 = \frac{0.04}{0.07068} = 0.5658 m/s$$

$$V_2 \; Q/A_2 = \frac{0.04}{0.01767} = 2.2635 m/s$$

⇒ Apply Bernoullis equation at section 1 & 2

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

$$\frac{P_2}{\rho g} = \frac{400 \times 10^3}{1000 \times 9.81} + \frac{(0.5658^2 - 2.2635^2)}{2 \times 9.81} + (10 - 6)$$

$$\therefore \frac{P_2}{\rho g} = 44.53$$

$P_2 = 486.838 \; kN/m^2$

No. (4)

$Z = 240m$

Volumetric flow rate $= 13 L/sec$

$= \frac{13}{1000} m^3/sec = 13 \times 10^{-3} m^3/sec$

Jet Velocity $= 60 m/s$

Water Density $= 1000 kg/m^3$

Since $P = 0$ and $Z = 0$

$$P = (0 \cdot Q) + \frac{\rho \cdot Q \cdot V^2}{2} + \rho g Q (0)$$

$\Rightarrow P = \rho Q \cdot V^2$

$= 1000 \times \frac{13\times10^{-3}}{2} \times 66^2$

$P = 28314$ watts ; Power of Jets

=> Power Supplied from reservoir

Since $P=0$ & $V=0$;

$P = (0\times P) + \frac{\rho (0)^2 Q}{2} + \rho g Q z$

$\Rightarrow P = \rho g Q z$

$= 1000 \times 9.81 \times 13\times10^{-3} \times 240$

$= 30607.2$ Watts

=> Power lost in transmission = Power of reservoir − Jet Pow

$= 30607.2 - 28314 = 2293.$

Head loss in Pipeline => $\frac{2293.2}{1000\times9.81\times13\times10^{-3}} = 17.982m$ //

> Efficiency $= \frac{\text{Jet P}}{\text{Reservoir P}} \times 100\%$

$= \frac{28314}{30607.2} \times 100\% = 92.5\%$

No.(5)

S.g of oil $= 0.89$

$L = 30000\,cm = 300m$

$Q = 200L/sec = 0.22\,m^3/sec$

$V = 7m/sec$

Introductory $Z=0$, and $P=0$,

$\Rightarrow P = \rho Q V^2/2$ − Jet power

Recall, $S_g = 0.89$

$S_g = x/1000 \therefore x = 890$

$P = \frac{890\times0.22\times7^2}{2} = 4797.1$ watts.

=> Power Supplied from resovoir;

$P = \rho g Q x$

$= 890 \times 9.81 \times 0.22 \times 300 = 576239.4$ watts ≈ 576.24 Kwatts.

=> Power loss

$= (576.24 - 4.7971)$ Kwatts

$= 571.4423$ KW $= 571442.3$ watts

=> Head used to over come losses

$$= \frac{571442.3}{590 \times 9.81 \times 0.22} = 297.51 m$$

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