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18/ENG02/025

Solutions

1) Rate - 10 dm^3/min, P = 12 bar
Shaft speed - 1500 rev/min
Norminal displacement - 10 cm^3/rev
Torque input - 12.5 Nm

i) To find volumetric efficiency
Ideal flowrate = Norminal d × speed
= 10 × 1500
= 15000 cm^3/min
= 15.0 dm^3/min

Volumetric efficiency = $\frac{\text{Actual flow}}{\text{Ideal flow}} = \frac{10}{15}$
= 0.66 or 66 %

ii) $Q = \frac{10 \times 10^{-3}}{60} m^3/s = 16.7 \times 10^{-6} m^3/s$

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

Fluid power = Qp
= $16.7 \times 10^{-6} \times 12 \times 10^5$
= 20.04 watts

iii) Shaft power = $2\pi NT/60$
= $\frac{2 \times 1500 \times 12.5 \times 3.142}{60}$
= 1963.75 Watts

Overall efficiency = $\frac{\text{Fluid Power}}{\text{Shaft power}}$
= 0.010 or 1%

2) Rate - 35 dm^3/min P = 100 bar
Overall efficiency - 87%
Shaft power = $\frac{2\pi NT}{60}$

$Q = \frac{35 \times 10^{-3}}{60} = 5.83 \times 10^{-4} m^3/s$

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

Fluid power = QP
= $5.83 \times 10^{-4} \times 100 \times 10^5$
= 5833.3 watts

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

$\frac{87}{100} = \frac{5833.3}{S.P}$

Shaft power = 6704.9 watts

3) Norminal displacement - 50 cm^3/rev
Pressure - 100 bar S.P = 15 kW
Actual flow = 35 dm^3/min
Speed - 850 rev/min
Ideal flowrate = Norminal d × speed
= 50 × 850
= 42500 cm^3/m
= 42.5 dm^3/[illegible]

Volumetric efficiency = $\frac{\text{Actual flow}}{\text{Ideal flow}} = \frac{35}{42.5}$

$= 0.82$ or 82%

$Q = \frac{35 \times 10^{-3}}{60} = 5.83 \times 10^{-4}$

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

Fluid power = QP

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

$= 5833.3$ watts.

Shaft power = $\frac{2\pi NT}{60}$ = ~~2×3.142×850×~~

Shaft power = 15 kW = 15000.

Overall efficiency = $\frac{5833.3}{15000}$

$= 0.38$ or 38%

7)- Entrance diameter - 0.3m d_1

Throat diameter - 0.2m. d_2

$C_d = 0.96$. Specific weight - 19.62 N/m³

For the manometer.

$P_1 + \rho_g g z_2 = P_2 + \rho_g g(z_1 - R) + \rho_w g R_y$

$P_1 - P_2 = 19.62(z_2 - z_1) + 587.423$.

For the venturimeter

$\frac{P_1}{\rho g} + \frac{u_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{u_2^2}{2g} + z_2$

$P_1 - P_2 = 19.62(z_2 - z_1) + 0.803 u_2^2$

Combining (1) and (2).

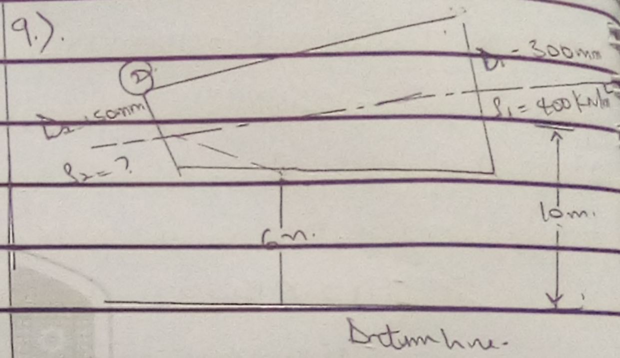
$0.803 u_2^2 = 587.423$

u_2 ideal = 27.047 m/s

$Q_{ideal} = 27.047 \times \pi \left(\frac{0.2}{2}\right)^2 = 0.85 \, m^3/s$

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

9.)



At section (1).

$D_1 = 300\,mm = 0.3m$, Area $a_1 = \frac{\pi}{4} \times 0.3^2$

$P_1 = 400\,kN/m^2$ $= 0.0707\,m^2$

Height of upper end above the datum, Z_1=

$Z_1 = 10m$

At section (2)

$D_2 = 150\,mm = 0.15m$, $A_2 = \frac{\pi}{4} \times 0.15^2$

$= 0.0176\,m^2$

Height of lower end above the datum, $Z_2 = 6m$.

Rate of flow (that is discharge)

$Q = 40$ lit/sec $= 40/1000$

1 litre = 1m³/sec = 0.04 m³/sec

Intensity of pressure at section 2, P_2

As the flow is continuous,

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

Therefore, $V_1 = Q/A_1 = \frac{0.04}{0.0707} = 0.56\,m/sec$

And, $V_2 = Q/A_2 = \frac{0.04}{0.01767} = 2.264 m/s$

Applying bernoulli's equation at section 1 & 2

We get, $P_1/w + V_1^2/2g + Z_1 = P_2/w + V_2^2/2g + Z_2$

And, $P_2/w = P_1/w + (V_1^2 - V_2^2/2g) + Z_1 - Z_2$

$= (400/9.81) + 1/(2 \times 9.81) \times (0.566^2 - 2.264^2) + (10-6)$

$= 40.77 - 0.245 + 4$ (as $w = \rho g = 1000 \times 9.81 N/m^3$)

$= 44.525 m = 9.81 kN/m^3$

$P_2 = 44.525 \times w = 44.525 \times 9.81$

$= 436.8 kN/m^2$

6). Data

$h = 20m$, $d = 10cm = 0.10m$

$A = \frac{\pi}{4} d^2$

$V_f = 0$

$W = ?$

The initial speed will be defined by: $V_f^2 = V_i^2 - 2gh$.

$v_i = \sqrt{V_f^2 + 2gh}$

$v_i = \sqrt{0^2 + 2(9.8m/s^2)(20m)} = 1$

The flow rate = Speed through the area.

$Q = vA = (19.80m/s)(7.854 \times 10^{-3} m^2)$

$= 0.1555 m^3/s$

The hydraulic power required to drive water to a hight h.

$W = \rho g Q h$

$= (1000 kg/m^3)(9.8 m/s^2)(0.1555 m^3/s)(20m)$

$= 30478 kg m^2/s^2$

$= 30 \times 10^3 W$

The power required is;

$W = 30 \times 10^3 W$

10) Difference of the level

$X = 170mm = 0.17m$.

Specific gravity of Hg, $S_g = 13.6$

Sp gr of sea water $S_0 = 1.026$

$h = x\left[\frac{S_g}{S_0} - 1\right] = 0.17\left[\frac{13.6}{1.026} - 1\right]$

$= 2.0834m$

$V = \sqrt{2gh} = 6.393 m/s$

$V = 6.393 \times$ ~~[illegible]~~

Speed of submarine.

$V = 6.395 \times 60 \times \frac{60}{100}$

$V = 23.01 km/hr$

4) $Z = 2,4000cm \times 10^{-2} = 240m$

Jet velocity $= 6.6 m/sec$

Vol flow rate $\doteq 13 L/s$

$Q = 13/1000 = 13 \times 10^{-3} m^2/sec$

Where $P = 2 = 0$

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

$= 28314$ watts

ii) $\rho = 0$, $V = 0$

$P = \rho g Q z = 1000 \times 9.81 \times 13\times10^{-3} \times 240$

$= 30607.2$ watts

$P = 30.6072$ Kwatts

iii) Power in transmission

Power of reservoir − power of jet

$= 30607.2 - 28314$

$= 2293.2$ watts

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

$h = \frac{2293.2}{1000 \times 9.81 \times 13\times10^{-3}} = 17.982\,m$

v) Efficiency $= \frac{\text{Power of jet}}{\text{Power of reservoir}} \times 100\%$

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

$= 92.5 \simeq 93\%$

6) $V = 7m/s$, $Q = 0.22\,m^3/s$, $s = 300m$

- ~~Power of jet~~ $= 0.22\,m^3/s$
- Power of jet − $P = \frac{1}{2} \times r a v^3$

$= \frac{1}{2} \times 890 \times 0.22 \times 7^2$

$P = 4797.1$ watts

- Power from reservoir

$P = w Q.A$

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

$= 576239.4\,W$

Power $= \gamma Q_A = 890 \times 0.22 \times 300$

$= 58740$ kgm/s

$= \frac{1}{2} \rho v^2 Q = \frac{1}{2} \times \frac{890}{9.81} \times 7^2 \times 0.22$

$= 489$ kgm/s

Power lost in transmission $= \gamma Q h$

$= 58740 - 489$

$= 58251$ kgm/s

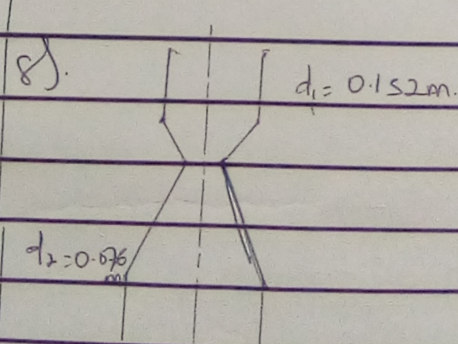
$h = \frac{58251}{890 \times 0.22} = 297.5\,m$

Efficiency $= \frac{\text{Power of jet}}{\text{Supply}} = \frac{489}{58700}$

$= 0.083 \times 100$

$= 0.83\%$

8)



From the question

$d = 0.152m$ $A_1 = 0.01814\,m$

$d_2 = 0.076m$ $A_2 = 0.00454\,m$

$S = 800\,kg/m^3$ $C_d = 0.97$

Apply Bernoulli:

$$\frac{P_1}{\rho g} + \frac{U_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{U_2^2}{2g} + z_2$$

By continuity,

$$Q = U_1 A_1 = U_2 A_2$$

$$U_2 = U_1 \frac{A_1}{A_2} = U_1 4$$

$$\frac{U_1^2}{2g} + 0.914 = \frac{16U_1^2}{2g}$$

$$U_1 = \sqrt{\frac{0.914 \times 2 \times 9.81}{15}} = 10934 \text{ m/s}$$

$$Q = C_d A_1 U_1$$

$$Q = 0.96 \times 0.01814 \times 10934 = 0.019 \text{ m}^3/\text{s}$$

b) $P_1 - P_2 = 15170$

$$\frac{P_1 - P_2}{\rho g} = \frac{U_2^2 - U_1^2}{2g} = 0.914$$

$$\frac{15170}{\rho g} = \frac{Q^2 (220.43^2 - 55.11^2)}{2g} - 0.914$$

$$55.8577 = Q^2 (220.43^2 - 55.11^2)$$

$$Q = 0.035 \text{ m}^3/\text{s}$$