1/20 - NWOSU ADAEZE 18/ENG05/065

NUMBER ONE

1. Flow rate = $10 dm^3/min$ ΔPressure = 12 bar

Nominal displace = $10 cm^3/rev$ speed = 1500 rpm

Torque input = 12.5 N-m

Ideal flow rate = Nominal Disp. x speed = $10 \times 1500 = 15000 cm^3/min$

$= 15 dm^3/min$

Volumetric efficiency = $\frac{\text{Actual flow}}{\text{Ideal flow}} = \frac{10}{15} = 0.667$ or 66.7%

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$Q = \frac{10 \times 10^{-3}}{60} m^3/sec = 16.7 \times 10^{-5} m^3/sec$

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

Fluid Power $= \Delta P \times Q = 16.7 \times 10^{-5} m^3/sec \times 12 \times 10^5 = 200$ watt

Shaft power $= \frac{2\pi NT}{60} = \frac{2\pi \times 1500 \times 12.5}{60} = 1963.5$ watt

Overall Efficiency $= F.P / S.P = \frac{200}{1963.5} = 0.102$ or 10.2%.

2. Overall Efficiency = 87% $= \frac{F.P}{S.P}$

$S.P = \frac{F.P}{87\%} = \frac{\Delta P \times Q}{87\%} = \frac{100 \times 10^5 \times 5.833 \times 10^{-7}}{0.87}$

$= 6.7$ watt

3 nominal displacement = $50 cm^3 \times rev$

ΔP = 100 bar

Shaft power = 15 KW = 15000 watt

Actual flow rate = $36 dm^3/min$

Speed rotation = 800 r.p.m

Volumetric Efficiency = $\frac{\text{Actual flow}}{\text{Ideal flow}} = \frac{\text{Actual flow}}{\text{nominal disp.} \times \text{speed}}$

$= \frac{35 \ dm^3/min}{850 \times 50 \ cm^3/min}$

$\frac{35}{42.5} = 0.82$ or 82%

Overall Efficiency = $\frac{F.P}{S.P} = \frac{\Delta P \times Q}{S.P} = \frac{100 \times 10^5 \times 35 \times 10^{-3}}{60 \times 15000}$

$= 0.389$ or 38.7%

4. Power of jet $= \frac{1}{2} \rho v^2 Q$

$= \frac{1 \times 1000}{2 \times 9.81} \times 66^2 \times 0.13 = 28862 \ Kgm/sec$

$= 28862 \times 9.81 = 283140$ watt

ii At reservoir, pressure is atmospheric and velocity of jet surface equals zero ; P = 0 , v = 0

Power supplied from reservoir = $\rho Q g z = \gamma Q z$

$= 1000 \times 0.13 \times 240$

$= 31200 \ Kgm/sec$

$= 31200 \times 9.81 = 306072 W$

$= 306.072 KW$

iii If H_r = Total head at the reservoir

H_j = Total head at the jet

h = head loss in transmission

a_1 = Power supplied from reservoir = rQH_1 = 31200 kgm/sec

b Power of issuing jet = rQH_2 = 28862 kgm/sec

Power lost in transmission = rQh = a − b = 2338 kgm/sec

Head loss in pipe = h = Power lost / rQ

h = 2338 / (1000 × 0.13)

= 17.98 m

$40000 = 416.67Q + 0.0625Q^2$

$0.0625Q^2 + 416.67Q - 40000 = 0$

$Q^2 + 6666.72Q - 640,000 = 0$

Q = 94.65 ft/day

5. ρ = 890 kg/m³

h = 300 m

Q = 220 L/s = 0.22 m³/s

V = 7 m/s

1 Power Jet = $\frac{1}{2}\rho QV^2 = \frac{1}{2} \times 890 \times 0.22 \times 7^2$

= 4797.1 watt

ii Power supplied from reservoir = $P = WQH$

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

= 576239.4 W

Power supplied from reservoir = $\gamma Q H_1$

$= 890 \times 0.22 \times 300 = 58740 \, kgm/sec$

Power issuing jet = $\frac{1}{2} \rho v^2 Q = \frac{1}{2} \times \frac{890}{9.81} \times 7^2 \times 0.22 = 489 \, kgm/s.$

Power loss during transmission = $\gamma Q h = 58740 - 489 = 58251 \, kgm/s.$

or $h = \frac{58251}{890 \cdot 022} = 297.50 \, m$

$\eta = \frac{\text{Power of jet}}{\text{Power supplied}} = \frac{489}{58740} = 0.0083 = 0.8324 = 0.8324\%$

6. $P = \frac{W}{t} = \frac{mgh}{t}$

$= \frac{\rho \pi r^2 v g h}{t}$

$v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 20} = 19.798 \, m/s$

$(1000 \, kg/m^3) \pi \times \left(\frac{10 \times 10^{-2}}{2}\right)^2 \times 19.798 \, m/s \times 9.8 \times 20$

$= 1000 \times \pi \times 2.5 \times 10^{-3} \times 19.798 \times 9.8 \times 20$

$= 30478.03 \, W$

7 $P_g = 19.62 \, N/m^2$

$C_d = 0.96$

$d_1 = 0.3m$

$d_2 = 0.2m$

We know that continuity equation

$a_1 v_1 = a_2 v_2$

$Q = a_1 v_1$ $\quad$ $Q = a_2 v_2$

$a_1 = \frac{\pi}{4} d_1^2$ $\quad$ $a_2 = \frac{\pi}{4} d_2^2$

$a_1 = \frac{\pi (0.3)^2}{4}$ $\quad$ $a_2 = \frac{\pi}{4} \times (0.2)^2$

$a_1 = 0.0700$ $\quad$ $a_2 = 0.0319$

$V_1 = \frac{Q_1}{0.07}$ $\quad$ $V_2 = \frac{Q}{0.0310}$

For manometer

For the above fig

we get

$P_1 + \rho_g g Z = P_2 + \rho_g g (z_2 - R) + P_w g R$

we know that

$\rho_g g = 19.62 N/m^2$ $\quad$ For $\rho_w = 1000$ (water)

By simplifying the eqn. $\quad = 9810 N/m^2$

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

For venturimeter:-

By Bernoullis equation.

$\frac{P_1}{\rho_g g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho_g g} + \frac{v_2^2}{2g} + z_2$.

we know that v_1

$v_1 = \frac{Q}{0.07}$

then $\frac{P_1}{19.6} + \frac{\left(\frac{Q}{0.07}\right)^2}{2 \times 9.81} + z_1 = \frac{P_2}{19.6} + \frac{V_2^2}{2 \times 9.81} + z_2$

$P_1 - P_2 = 19.2(z_2 - z_1) + 0.803 V_2^2$

Now comparing equation (1) & (2)

$0.803 V_2^2 = 587.423$

$V_2 = 27.047 m/s$

$Q_{ideal} = a_2 V_2$

$= 27.047 \times \frac{\pi}{4} (d_2)^2$

$= 27.047 \times \frac{\pi}{4} (0.2)^2$

$= 0.85 m^3/sec$

$Q = C_d \, Q_{ideal}$

$= 0.96 \times 0.85$

$= 0.816 m^3/sec$

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

$d_2 = 0.076 m$

$A_2 = \pi/4 (0.076)^2 = 0.00454 m^2$

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

$C_d = 0.97$

Apply Bernoulli :-

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

$P_1 = P_2$

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

By continuity

$Q = V_1 A_1 = V_2 A_2$

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

$$\frac{V_1^2}{2g} = 0.314 = \frac{1.6\,(V_1)^2}{2g}$$

$$V_1 = \sqrt{\frac{0.314 \times 2 \times 9.81}{15}} = 1.0934 \text{ m/s}$$

$$Q = C_d A_1 V_1 = 0.97 \times (0.01814) \times (1.0934)$$

$$Q = 0.0192 \text{ m}^3/\text{s}$$

(b) $P_1 - P_2 = 15170$

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

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

$$1.933 = 2321.7 Q^2 - 0.914$$

$$2.847 = 2321.7 Q^2$$

$$0.0012262566 = Q^2$$

$$Q = 0.035$$

9. At section 1

$D_1 = 300\text{mm} = 0.3\text{m}$ $\quad A_1 = \frac{\pi}{4} \times 0.3^2 = 0.07068\text{m}^2$

Pressure $P_1 = 400 \text{ KN/m}^2$

Height of upper end above the datum $(Z_1) = 10\text{m}$

At section 2 -

$D_2 = 150\text{mm} = 0.15\text{m}$ $\quad A_2 = \frac{\pi}{4} \times 0.15^2 = 0.01767\text{m}^2$

Height of lower end above the datum $(z_2) = 6m$

Rate of flow C

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

As the flow is continuous.

$Q = A_1 V_1 = A_2 V_2$

$V_1 = Q/A_1 = 0.04/0.07068 = 0.5658 m/s$

$V_2 = Q/A_2 = 0.04/0.0177 = 2.2635 m/s$

Apply Bernoulli's equation at section 1 & 2.

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

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

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

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

$P_2 = 44.53 \times 9.81 \times 1000 = 436.838 KN/m^2$

10. Specific gravity of mercury $(S_m) = 13.6$

Specific gravity of sea water $(S_{sw}) = 1.026$

Difference of Hg level, $x = 170mm = 0.17m$

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

$h = 2.0534\ m$

Speed of Submarine

$v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.0834}$

$v = 6.39347\ m/s^2$

$v = 6.39347 \times \frac{3600}{100}\ km/hr$

$v = 23.0163\ km/hr$