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18/ENG05/052
Pump delivers at

~~flow~~ rate = 10 dm³/min

$\frac{10 \times 10}{60 \times}$ = 0.277 m/hr

ΔP = 12 bar
rotation speed = 1000 rev/min
nominal displacement = 10 cm³/rev
10 cm³/rev
torque input = 12.5 Nm

flow rate = 1.

10 dm — 1 m
100 dm² — 1 m²
1000 dm³ — 1 m³
10 dm³ — ?
$\frac{10}{1000}$
0.01 m³/min
= $\frac{0.01}{60}$
Q = 1.67×10^{-4} m³/sec
Speed = 1500 rev/min
$\frac{1500}{60}$ = 25 rev/sec

torque (constant pressure) = 12 bar
= 12×10^5 N/m²
ΔP = 12×10^5 N/m²
nominal displacement = ~~cm~~ rev
$\frac{10}{1000000}$ = 1×10^{-5} m³/rev
~~Ideal flowrate~~ =

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volumetric efficiency
= $\frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100\%$

$\frac{1.67 \times 10^5}{2.5 \times 10^5} \times 100$

= 66.8%

fluid power = discharge × change in pressure
= $1.67 \times 10^{-4} \times 12 \times 10^5$
= 200.4 Nm sec⁻¹

(ii) shaft power = T·ω
T = Torque
ω = angular velocity
T = 12.5 Nm
ω = 2πN for rps
2 × 3.14 × 12.5
where N = nominal displacement
= 157.14
Shaft power = 12.5 × 157.14
= 1964.25 watts

Overall efficiency
~~Actual flowrate~~
= $\frac{\text{fluid Power}}{\text{Shaft Power}} \times 100$

= $\frac{200.4}{1965} \times 100$ = 10.2%

2.) $\Delta P = 100\ bar$

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

Actual flow rate

$= 35\ dm^3/min$

$= \frac{35}{1000 \times 60} = 5.83 \times 10^{-4}$

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

$= 5830$ watts

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

Shaft power $= \frac{5830 \times 100}{87}$

$= 6.701 \times 10^3$ watts

3 nominal ~~speed~~ displacement

$= 50\ cm^3/rev$

$x = \frac{50}{1000,000}$

$= 5 \times 10^{-5}\ m^3/rev$

Actual flowrate

$= 35\ dm^3/min$

$= \frac{35}{1000 \times 60}$ ~~$= 5.83 \times 10^{-4}$~~

$5.83 \times 10^{-4}\ m^3/sec$

$dP = 100\ bar$

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

$P = Q \times \Delta P$

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

$= 5830\ W$

Overall efficiency $=$

$\frac{\text{fluid power}}{\text{shaft power}} \times 100$

$= \frac{5830}{15,000} \times 100$

Overall eff $= 38.87\%$

Ideal flow rate

$=$ nominal displacement $\times$ speed

Speed: $850\ rpm$

$\frac{850}{60} = 14.17$

$= 5 \times 10^{-5} \times 14.17$

$= 7.085 \times 10^{-4}\ m^3/sec$

V efficiency $= \frac{\text{Actual flowrate}}{\text{Ideal flow}} \times 100$

$= \frac{5.83 \times 10^{-4}}{7.085 \times 10^{-4}} \times 100$

$= 82.29\ \%$

4) $Z = 2,4000$ cm

[redacted] $= 240$ m

volumetric flow rate

$=$ ~~18 liters/sec~~ 18 liters/sec

$1000 l = 1m^3$

$= \frac{18}{1000} = 18 \times 10^{-3} m/s$

velocity of jet $= 66 m sec^{-1}$

Due to atmospheric level

$P = 0, \quad Z = 0$

$P = 0 \cdot Q + \frac{\rho Q v^2}{2} + \rho g Q 0$

$P = \frac{\rho Q \cdot v^2}{2}$

When $\rho = 1000$

$= \frac{1000 \times 18 \times 10^{-3} \times (66)^2}{2}$

$P = 28.314$ KW

ii) Power supplied from the reservoir

The reservoir operates at an atmospheric pressure,

$P = 0, \quad v = 0$

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

$P = \rho g Q z$

$1000 \times 9.81 \times 18 \times 10^{-3} \times 240$

$= 30607.2$ watts

iii) Power loss in transmission

$=$ Power of reservoir $-$ power of jet

$= 30607.2 - 28314$

$= 2,293.2$ W

Head loss in Pipeline

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

$= \frac{2293.2}{100 \times 9.81 \times 18 \times 10^{-3}}$

$= 17.982$ m

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

$= \frac{28314}{30607} \times 100\%$

$= 92.5\%$

5) $Z = 30,000$ cm $= 300$ m

volumetric flow rate $= 220$ lit/sec

$\frac{220}{1000} = 22 \times 10^{-3}$ m/s.

velocity of the jet $= 7$ m/sec

$P = 0 \cdot Q + \frac{\rho Q v^2}{2} + \rho g Q 0$

when $\rho = 0.89$

$0.89 \times \frac{22\times10^{-3} \times (7)^2}{2}$

$= 4.7971$ w

ii) Power supplied for the reservoir

when $p = 0$ $v = 0$

substituting into the equation

$p = \rho g Q z$

$= 0.89 \times 9.81 \times 22\times10^{-3} \times 300$

$= 576.23$ watts

iii) power loss in transmission

$= 576.23 - 4.7971$

$= 571.43$ w

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

$= \frac{571.43}{0.89 \times 9.81 \times 22\times10^{-3}}$

$= \frac{571.43}{1.92}$

$= 297.61$ m

iv) Efficiency =

$\frac{\text{power of jet}}{\text{power of reservoir}} \times 100$

$= \frac{4.7971}{576.23} \times 100$

$= 8324\times10^{-4}$ %

6)

$h = 20$ m

$d = 10$ cm $= 0.1$

$A = \frac{\pi d^2}{4}$ $= 0.7854$ m^2

$W = ?$

$v_f^2 = v_1^2 - 2gh$

$v_1 = \sqrt{v_f^2 + 2gh}$

$v_1 = \sqrt{0^2 + 2(9.8)(20)}$

$= 19.80$ ms^{-1}

The flow rate = the speed through the area

$Q = vA = 19.80 \times 7.854\times10^{-3}$ m

$= 0.155$ m^2s^{-1}

$W = \rho g Q h$

$= 1000 \times 9.8 \times (0.155) \times 20$

$= 30478$ kgm^2s^{-2}

7) $P_{1g} = 19.62$ N/m^2

$C_d = 0.96$

$d_1 = 0.3$m

$d_2 = 0.2m$

$d_1 = 0.0707$

$P_1 + \rho g \, ?\, z = P_2 + \rho g z$

$(z_2 + P_7) + P_w g P_{HG}$

$P_1 - P_2 = 19.62(z_2 - z_1) + 587.$

for the venturimeter

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

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

compare Q_1 and Q_2

~~Combine Q_1 and Q_2~~

~~$P_1 - P_2 = 15170$~~

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

~~$\frac{15170}{\rho g} = Q_2 \frac{(220.43^2 - 55.11^2)}{2g} - 0.914$~~

~~$Q = 0.035 m^3/s$~~

$0.803V_2^2 = 387.423$

$V^2_{ideal} = 27.047 m/s$

$Q_{ideal} = 27.047 \times \pi \left(\frac{0.2}{2}\right)^2$

$= 0.85 m^3 s^{-1}$

$Q = C_d Q_{ideal} = 0.96 \times 0.85$

$= 0.816 m^3/s$

8) $d_1 = 0.152m$ $A_1 = 0.0184m$

$d_2 = 0.076m$ $A_2 = 0.00454$

$\rho = 800kg/m^2$

$C_d = 0.91$

Apply Bernoulli's method

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

a) $P_1 = P_2$

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

$Q_1 = V_1 A_1 = V_2 A_2$

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

$V_1 = \sqrt{\frac{0.94 \times 2 \times 9.81}{15}}$

$= 1.0734 m/s$

$Q = C_d A_1 V_1$

$Q = 0.96 \times 0.018m \times 1.0734$

$= 0.019 m^3 s^{-1}$

$P_1 - P_2 = 15170$

$\frac{P_1 - P_2}{\rho g} = \frac{V_2^2 - V_1^2}{2g} = 0.944$

$\frac{15170}{\rho g} = Q_2 \frac{(220.43^2 - 55.11^2)}{2g} - 0.9$

$Q = 0.085 m^3 s^{-1}$

9 At Section 1

$D_1 = 0.5m$

$A = \frac{\pi D^2}{4} = \frac{\pi (0.3)^2}{4}$

$= 0.0706$

$Z_1 = 10m$

$V_1 = ?$

$P_1 = 400 \times 10^3 \, Nm^{-2}$

$D_2 = 0.15m$

$A = \frac{3.14 \times (0.15)^2}{4}$

$= 0.0176 \, m^2$

$Z_2 = 6m$

$V_2 = ?$

$P_2 = ?$

$A_1 V_1 = A_2 V_2 = 40 \times 10^{-3} \, m/sec$

$V_1 = \frac{40 \times 10^{-3}}{0.0706}$

$= 0.5665 \, ms^{-1}$

$V_2 = \frac{40 \times 10^{-3}}{0.0176}$

$= 2.264 \, ms^{-1}$

Apply bernoulli theorem

$\frac{40 \times 10^{-3}}{9800} + \frac{(0.556)^2}{2 \times 9.8} + 10 = \frac{P_2}{W} + \frac{(2.274)^2}{2 \times 9.8} + 6$

$P_2 = 436.8 \, KNm^{-2}$

(b) Reading of manometer

$= 170mm = 0.17 \, mHg$

S.g of mercury $= 13.6$

S.g of water $= 1.026$

$h = y \left(\frac{\text{S.g of mercury}}{\text{S.g of sea water}} - 1 \right)$

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

$h = 0.17 (12.255)$

$h = 2.083$

∴ velocity of submarine

$V = \sqrt{2gh}$

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

$V = 6.393 \, ms^{-1}$