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CIVIL ENGINEERING

1. Actual flow rate = $10 dm^3/min$
$= 0.000167 m^3 s^{-1}$

Pressure = 12 bar = $12 \times 10^5 Nm^{-2}$
Speed = 1500 rpm = 25 rps
Displacement = $10 cm^3/rev = 10^{-5} m^3/rev$
Torque input = $12.5 Nm^{-2}$
~~Speed = 1500 rpm = 25 rps~~
~~Displacement = $10 cm^3/rev = 10^{-5} m^3/rev$~~

i) Volumetric ~~Efficiency~~ Efficiency (VE);

$VE = \frac{\text{Actual flowrate}}{\text{Ideal flow rate}} \times 100\%$

Ideal flow rate = speed x Displ.
$= 25 \times 10^{-5} m^3 s^{-1}$

$VE = \frac{0.000167}{25 \times 10^{-5}} \times 100\%$

$\simeq 66.67\%$

ii) Fluid power (Pf);
Pf = Pressure x Actual flow rate

$= \frac{12 \times 10^5 \times 10}{60000}$

$P_f = 200 W$

(iii) shaft power = $T \times W$
$W = 2\pi \times$ speed
$= 2\pi \times 25$
$= 50\pi$ rad/sec

T = 12.5 Nm

Shaft power = $12.5 \times 50\pi$
$= 1963.495 W$

iv) Overall Efficiency
$= \frac{\text{Fluid Power}}{\text{Shaft power}} \times 100\%$

$= \frac{200}{1963.495} \times \frac{100}{1}$

$= 10.19\%$

2) Actual flow rate = $35 dm^3/min$
$= \left(\frac{35}{60000}\right) m^3/sec$

$\simeq 5.833 \times 10^{-4} m^3/sec$

Pressure = 100 bar = $100 \times 10^5 Nm^{-2}$
Overall Efficiency = 87%

Overall Efficiency = $\frac{\text{Fluid power}}{\text{Shaft power}} \times 100$

~~[illegible]~~

$\therefore$ Shaft power = $\frac{\text{Fluid power} \times 100\%}{\text{Overall Eff.}}$

$= \frac{100 \times 10^5 \times 5.833 \times 10^{-4} \times 100\%}{87\%}$

Shaft power = 6704.98 w
= 6.705 kw

3) Displacement = $50 cm^3/rev$
$= 5 \times 10^{-5} m^3/rev$

P = 100 bar = $100 \times 10^5 Nm^{-2}$

Shaft power = 15 kw

Actual flowrate = $35\,dm^3/min = \left(\frac{35}{60000}\right) m^3/sec$

$= 5.833 \times 10^{-4}\ m^3/sec$

Speed = 850 rpm = $850/60$

$= 14.167$ rps

(i) Overall efficiency

$= \frac{\text{Fluid Power}}{\text{Shaft power}} \times 100\%$

P_F = Pressure × Actual flowrate

$\therefore E = \frac{\text{Pressure} \times \text{Actual flow rate}}{\text{shaft power}} \times 100\%$

$= \frac{10.3 \times 10^7 \times 5.833 \times 10^{-4}}{15000}$

$E = 38.89\%$

(ii) Volumetric Efficiency

$VE = \frac{AF}{IF} \times 100\%$

IF = Disp × Speed

$= 5 \times 10^{-5} \times 14.167$

$= 7.083 \times 10^{-4}\ m^3/s$

$VE = \frac{5.833 \times 10^{-4}}{7.083 \times 10^{-4}} \times 100\%$

$= 82.35\%$

(4) Water level (z) = 24000 cm

= 240 m

Volumetric flowrate (Q)

= 13 l/sec

$= 1.3 \times 10^{-2}\ m^3/s$

Jet velocity = 66 m/s

$\rho_{water} = 1000\ kg/m^3$

(i) Since the jet is issuing from the nozzle, it is considered to be at datum level

$\therefore$ p = 0, and z = 0

recall,

$P = p.Q + \frac{\rho.Q.V^2}{2} + \rho g Q z$

Since p = z = 0

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

$= \frac{1000 \times 1.3 \times 10^{-2} \times 66^2}{2}$

P = 28.314 kw

(iii) Power supplied from reservoir

This implies that p = v = 0

recall,

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

substitute for p and V

$$P = \rho g Q z$$

$$= 1000 \times 9.81 \times 1.3 \times 10^{-2} \times 240$$

$$= 30607.2 w$$

$$= 30.6072 kw$$

(iii) Power loss in transmission

= Power of reservoir − Power of jet

$(30.6072 - 28.314) kw$

$= 2.2932 kw$

Head used to overcome losses (h)

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

$h = 17.982 m$

(iv) Efficiency ------

$$E = \frac{\text{Power of Jet}}{\text{Power of reservoir}} \times 100\%$$

$$= \frac{28.314 \times 100}{30.6072}$$

$$= 92.5\%$$

5) $S_{oil} = 0.89$
$z = 30000 cm = 300 m$
$Q = 220 ls^{-1} = 0.22 m^3 s^{-1}$
$v = 7 ms^{-1}$

i) Power of jet
from jet, $P = z = 0$
$$P = \frac{\rho Q v^2}{2}$$

$$\frac{890 \times 0.22 \times 7^2}{2}$$
$= 4797.1 W = 4.7971 kW$

ii) Power supplied from reservoir,
This implies that $P = v = 0$
$P = \rho g Q z$
$= 890 \times 9.81 \times 0.22 \times 300$
$= 576239.4 W$
$= 576.2394 kW$

(iii) Head used to overcome losses (m)

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

$$= \frac{\text{Power of reservoir} - \text{Power of Jet}}{\rho g Q}$$

$$h = \frac{571442.3}{1920.798} = 297.503 m$$

iv) Efficiency in pipeline and nozzle in transmitting operation (E);

$$E = \frac{\text{Power of jet}}{\text{Power of reservoir}} \times 100\%$$

$$= \frac{4797.1 \times 100}{576239.4}$$

$$E = 0.832\%$$

6. $V = ?$

$d = 10cm = 0.1m$; $h = 20m$

$A = \pi/4 (d)^2 = \pi/4 (0.1)^2 = 0.00785m^2$

Assuming pipe is cylindrical

$Q = Av$

$= 0.00785 \times v$

$v^2 = 2gh$

$v = \sqrt{2gh}$

$Q = 0.00785 \times 19.809$

$Q = 0.1556 m^3 s^{-1}$

$P = \rho g Q h$

$= 1000 \times 9.81 \times 0.1156 \times 70$

$P = 30524.859 w$

$= 30.525 kw$

7) $d_1 = 0.3m$
$d_2 = 0.2m$

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

$A_2 = \pi/4\ d_2^2 = 0.0314 m^2$

$y = 0.06m$

$$h = y\left(1 - \frac{S_{water}}{S_{gas}}\right)$$

$$= 0.06\left(1 - \frac{1}{19.62}\right)$$

$h = 0.05694$ of gas

$$Q = \frac{C_d \cdot A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$$

$$= \frac{0.96 \times 0.0707 \times 0.0314 \sqrt{2 \times 9.81 \times 0.0}}{\sqrt{(0.0707)^2 - (0.0314)^2}}$$

$Q = 0.036 m^3 s^{-1}$

8) $S_L = 0.8 = 0.8 \times 1000$

$= 800 kg m^{-3}$

$d_1 = 0.152 m$

$A_1 = \pi/4 (0.152)^2 \simeq 0.01815 m^2$

$d_2 = 0.076 m$

$A_2 = 0.00454 m^2$

$\Delta z = 0.914 m$

(i) $P_1 = P_2$

$P_2 - P_1 = 0 N m^{-2}$

From Bernoulli's Eqn

$$\frac{P_1 - P_2}{\rho g} + \Delta z = \frac{V_2^2 - V_1^2}{2g}$$

$$\Delta z = \frac{V_2^2 - V_1^2}{2g}$$

$$0.914 = \frac{V_2^2 - V_1^2}{2g} \quad \text{---} (1)$$

recall,

$A_1 V_1 = A_2 V_2$

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

$V_2 = 4V_1$ ---(2)

Subs for V_2 in (1)

$$0.914 = \frac{(4V_1)^2 - V_1^2}{2g}$$

recall from Continuity eqn,

$A_1V_1 = A_2V_2$

$V_2 = 4V_1$

$15V_1^2 = 2.846974 \cdot V2g$

$V_1^2 = 3.72385$

$V_1 = 1.92973\ ms^{-1}$

$Q = A_1V_1$

$= 0.1815 \times 1.92973\ m$

$Q = 0.03502\ m^3/s$

9) $d_1 = 300mm = 0.3m$

$A_1 = 0.0707m^2$

$d_2 = 0.15m$

$A_2 = 0.0177m^2$

$P_1 = 400kN/m^2$

$Q = 40Ls^{-1} = 0.04m^3/s$

From CE,

$Q = A_1V_1 = A_2V_2$

$V_1 = Q/A_1$

$V_1 = \frac{0.04}{0.0707}$

$V_1 = 0.5658 ms^{-1}$

$V_2 = Q/A_2 = \frac{0.04}{0.0177}$

$V_2 = 2.2599 m/s$

Recall from Bernoulli's,

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

$$\frac{P_2}{\rho g} = \frac{P_1}{\rho g} + \frac{V_1^2 - V_2^2}{2g} + \Delta Z$$

$$P_2 = \rho g\left(P_1/\rho g + \frac{V_1^2 - V_2^2}{2g} + \Delta Z\right)$$

$$P_2 = 1000 \times 9.81\left(\frac{400000}{1000 \times 9.81} + \frac{0.3201 - 5.1071}{2 \times 9.81} + (10 - 6)\right)$$

$= 400000 - 2393.45 + 39240$

$P_2 = 436846.55 N/m^2$

$= 436.847 KN/m^2$

10) Manometer reading = 170mm Hg
= 0.17m Hg

$S_{Hg} = 13.6$, $S_{seawater} = 1.026$

$$h = y\left(\frac{S_{Hg}}{S_{seawater}} - 1\right)$$

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

$$= 0.17 \times 12.26$$

$$h = 2.08\ cm$$

$$\frac{V^2}{2g} = h$$

$$V = \sqrt{2gh}$$

$$V = \sqrt{2 \times 9.81 \times 2.084}$$

$$V = 6.39 m/s$$

$$0.914 = \frac{16V_1^2 - V_1^2}{2g}$$

$V_1^2 = 1.95312$

$V_1 = 1.0934 ms^{-1}$

Solve for V_2 from (2)

$V_2 = 4 \times 1.0934$

$V_2 = 4.3736 ms^{-1}$

$Q = A_1 V_1$

$= 0.018115 \times 1.00934$

$= 0.0198 m^3 s^{-1}$

(ii) when $P_1 > P_2$

$P_1 = P_2 + 15170 Nm^{-2}$

$P_1 - P_2 = 15170 Nm^{-2}$

from BE,

$$\frac{P_1 - P_2}{\rho g} + \Delta Z = \frac{V_2^2 - V_1^2}{2g}$$

$$\frac{15170}{800 \times 9.81} + 0.914 = \frac{V_2^2 - V_1^2}{2g}$$

$$1.93298 + 0.914 = \frac{V_2^2 - V^2}{2g}$$

$$\frac{V_2^2 - V_1^2}{2g} = 2.846977$$