Egbuwe Kelvin Olamide
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Elect-Elect

Fluid mechanics
ENG 214

1) actual rate = $10 dm^3/min = 0.01 m^3/min = 1.67 \times 10^{-4} m^3/s$
pressure = 12 bar $= 12 \times 10^5 N/m^2$
Speed = 1500 rev/min $= 25$ rev/s
Nominal displacement = $10 cm^3/rev = 1 \times 10^{-5} m^3/rev$
Torque = $12.5 Nm$

Volumetric efficiency = $\frac{\text{actual flowrate}}{\text{ideal flowrate}} \times 100\%$

ideal flowrate = displacement × speed
ideal flowrate = $1 \times 10^{-5} \times 25 = 2.5 \times 10^{-4} m^3/s$
Volumetric efficiency = $\frac{1.67 \times 10^{-4}}{2.5 \times 10^{-4}} \times 100\%$
Volumetric efficiency = 66.8%

Fluid power = actual rate × pressure
fluid power = $1.67 \times 10^{-4} \times 12 \times 10^5$
Fluid power = 200.4 watts

Shaft power = Torque × Angular speed

Angular speed = $2 \times \pi \times$ speed

$= 2 \times \pi \times 25 = 157.08$ rad/s

Shaft power = 12.5×157.08

Shaft power = 1963.5 Watts

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

overall efficiency $= \frac{200.4}{1963.5} \times 100\%$

overall efficiency $= 10.21\%$

(2) rate: $35 dm^3/min = 0.035 m^3/min = 5.83 \times 10^{-4} m^3/s$

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

Overall efficiency = 87%

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

Fluid power = actual flow rate × pressure

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

Fluid power = 5830 Watts

Overall efficiency = $\frac{\text{Fluid power}}{\text{Shaft power}} \times 100\%$ ~~5830~~

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

$0.87 = \frac{5830}{\text{Shaft power}}$

Shaft power $\times 0.87 = 5830$

Shaft power $= \frac{5830}{0.87} = 6701.15$ Watt

(3) nominal displacement = $50 cm^3/rev = 5 \times 10^{-5} m^3/rev$
pressure = $100 bar = 100 \times 10^5 N/m^2$
Shaft power = $15 KW = 15 \times 10^3 W$
Actual flowrate = $35 dm^3/min = 0.035 m^3/min = 5.83 \times 10^{-4} m^3/s$
speed = $850 rev/min = 14.17 rev/s$

Volumetric efficiency = $\frac{\text{Actual rate}}{\text{ideal rate}} \times 100\%$

ideal rate = nominal displacement × speed
ideal flowrate = $5 \times 10^{-5} \times 14.17$
ideal flowrate = $7.085 \times 10^{-4} m^3/s$

Volumetric efficiency = $\frac{\text{actual flowrate}}{\text{ideal flowrate}} \times 100\%$

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

Volumetric efficiency $= 82.29\%$

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

Fluid power = actual rate × pressure

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

Fluid power $= 5830$ Watts

Overall efficiency $= \frac{5830}{15 \times 10^3} \times 100$

Overall efficiency $= 38.87\%$

1c) depth = 15m

manometer reading $y = 170mm = 0.17m$

Specific gravity mercury $S_{Hg} = 13.6$

Specific gravity sea water $S_{swater} = 1.026$

Differential head: $y\left[\frac{S_{Hg}}{S_{swater}} - 1\right]$

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

$h = 0.17(12.255)$

$h = 2.08335m$

velocity $= \sqrt{2gh}$

$V = \sqrt{2 \times 9.81 \times 2.08335}$

velocity $= 6.3934 m/s$

(9) $d_1 = 300mm = 0.3m$

$A_1 = \frac{\pi (d_1)^2}{4} = \frac{\pi \times 0.3^3}{4} = 0.0707m^3$

$d_2 = 150mm = 0.15m$

$A_2 = \frac{\pi (d_2)^3}{4} = \frac{\pi \times (0.15)^2}{4} = 0.0177m^3$

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

$Z_1 = 10m$

$Z_2 = 6m$

$P_1 = 400 kN/m^2 = 400 \times 10^3 N/m^2$

$P_2 = ?$

From continuity equation

$Q = AV$

$Q = A_1 V_1 = A_2 V_2$

For section 1

$Q = A_1 V_1$

$0.04 = 0.0707 \times V_1$

$V_1 = 0.5658 m/s$

For section 2

$Q = A_2 V_2$

$0.04 = 0.0177 \times V_2$

$V_2 = 2.2599 m/s$

Applying Bernoulli's equation

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

$$\frac{400 \times 10^3}{1000 \times 9.81} + \frac{(0.5658)^2}{2 \times 9.81} + 10 = \frac{P_2}{w} + \frac{(2.2599)^2}{2 \times 9.81} + 6$$

$$40.7747 + 0.0163 + 10 = \frac{P_2}{w} + 0.2603 + 6$$

$$50.791 = \frac{P_2}{w} + 6.2603$$

$$\frac{P_2}{w} = 50.791 - 6.2603$$

$$\frac{P_2}{w} = 44.5307$$

$$P_2 = 44.5307 \times w$$

$$P_2 = 44.5307 \times \rho \times g$$

$$P_2 = 44.5307 \times 1000 \times 9.81$$

$$P_2 = 436846.167 \ N/m^2$$

8) $d_1 = 0.152m$

$$A_1 = \frac{\pi (d_1)^2}{4} = \frac{\pi \times (0.152)^2}{4} = 0.0181 \ m^2$$

$d_2 = 0.076m$

$$A_2 = \frac{\pi (d_2)^2}{4} = \frac{\pi \times (0.076)^2}{4} = 4.536 \times 10^{-3} \ m^2$$

$C_d = 0.97$

Relative density = 0.8

i) For $P_1 = P_2$

$$h \text{ (differential head)} = \frac{P_1 - P_2}{w} = \frac{0}{w} = 0m$$

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

$$Q = \frac{0.97 \times 0.0181 \times 4.536 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 0}}{\sqrt{0.0181^2 - (4.536 \times 10^{-3})^2}}$$

$Q = 0 m^3/s$

Fr, $P_1 > P_2$

$h = \frac{P_1 - P_2}{w} = \frac{15170}{w} = \frac{15170}{1000 \times 9.81 \times 0.8}$

$h = 1.933 m$

$Q = \frac{C_d \times A_1 A_2 \times \sqrt{2gh}}{\sqrt{A_1^2 - A_2^3}}$

$Q = \frac{0.97 \times 0.0181 \times 4.536 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 1.933}}{\sqrt{0.0181^2 - (4.536 \times 10^{-3})^3}}$

$Q = \frac{4.9044 \times 10^{-4}}{0.0175}$

$Q = 0.028 m^3/s$

4) $Z = 24{,}000 cm = 240 m$

Volumetric flow rate = 13 lit/s = $0.013 m^3/s$

jet velocity = 66 m/s Since $p = 0$, $z = 0$

$Power = \frac{\rho \times Q . v^2}{2}$

$$power = \frac{1000 \times 0.013 \times (66)^2}{2}$$

Power = 28314 Watts

power supplied from reservoir

$p = 0, v = 0$

$P = \rho g Q z$

Power $= 1000 \times 9.81 \times 0.013 \times 240$

Power supplied from reservoir = 30607.2 Watts

Power loss in transmission = Power of reservoir − Power of jet

Power loss in transmission = 30607.2 − 28314

Power loss = 2293.2 Watts

head loss in pipeline

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

$$h = \frac{2293.2}{1000 \times 9.81 \times 0.013}$$

$h = 17.982m$

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

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

Efficiency = 92.5%

Scanned with CamScanner

5) Specific gravity of oil = 0.89
$Z = 30{,}000cm = 300m$
$Q = 220$ litre/s $= 0.22 m^3/s$
Velocity = 7m/s

i) Power of Jet
If $p = 0, z = 0$

$$Power = \frac{\rho \times Q \times v^3}{2}$$

$$Power = \frac{1000 \times 0.89 \times 0.22 \times (7)^3}{2}$$

Power of Jet = 4797.1 Watts.

ii) Power supplied from reservoir
$P = 0, v = 0$

$P = \rho g Q z$

Power supplied from reservoir = $1000 \times 0.89 \times 9.81 \times 0.22 \times 300$

Power supplied from reservoir = 576239.4 Watts

iii) Head loss in pipeline = $\frac{\text{Power loss in transmission}}{\rho g Q}$

Power loss in transmission = Power at reservoir - Power at Jet
Power loss = 576239.4 - 4797.1

power loss = 571442.3

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

Head loss = $\frac{571442.3}{1000 \times 0.89 \times 9.81 \times 0.22}$

Head loss = 297.50 m

Efficiency = $\frac{\text{Power at Jet}}{\text{Power at reservoir}} \times 100\%$

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

Efficiency = 0.83%

7) $d_1 = 0.3m$
$A_1 = \frac{\pi (d_1)^2}{4} = \frac{\pi \times (0.3)^2}{4} = 0.0707 m^2$

$d_2 = 0.2m$
$A_2 = \frac{\pi (d_2)^2}{4} = \frac{\pi \times (0.2)^2}{4} = 0.0314 m^2$

$C_d = 0.96$

Specific weight
S weight gas = 19.62 N/m³
S weight water = 9807 N/m³
y = 0.06 m

Differential head (h) = $y \left[\frac{\text{S weight gas}}{\text{S weight water}} - 1 \right]$

$$h = 0.06\left[\frac{\sout{19.62}\ 9807}{\sout{9807}\ 19.62} - 1\right]$$

$h = 0.06(498.84)$

$h = 29.93\,m$

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

$$Q = \frac{0.96 \times 0.0707^2 \times 0.0314^2 \times \sqrt{2 \times 9.81 \times 29.93}}{\sqrt{0.0707^2 - 0.0314^2}}$$

$$Q = \frac{0.0516}{0.0633}$$

$Q = 0.815\,m^3/s$

(6) $z = 20m$

$d = 10cm = 0.1m$

$$A = \frac{\pi (d)^2}{4} = \frac{\pi \times (0.1)^2}{4} = 0.0079m^2$$

$\rho = 1000\,kg/m^3$ $g = 9.81\,m/s^2$

At the highest point, final velocity = 0

To obtain maximum height at height Z

$V^2 = u^2 - 2gh$

$0 = u^2 - 2 \times 9.81 \times 20$

$0 = u^2 - 392.4$

$u^2 = 392.4$

$u = 19.81 m/s$

$\therefore Q = AV$

$Q = 0.0079 \times 19.81$

$Q = 0.1565 m^3/s.$

$Power = \rho g Q z$

$= 1000 \times 9.81 \times 0.1565 \times 20$

$Power = 30705.3$