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Course: FLUID MECHANICS
Course title: ENG 214
Matric No: 18/ENG01/012
Dept: CHEMICAL ENGINEERING.

Assignment.

1 sol.

Real flowrate = $10 dm^3/min$ $T = 12.5 Nm$

$= \frac{10 \times 10^{-3}}{60} = 1.67 \times 10^{-4} m^3/s$

Pressure = 12 bar = $12 \times 10^{+5} Nm^{-2}$

Speed = 1500 rev/min = $\frac{1500 rev}{60}$ = 25 rev/sec

Nominal displacement = $\frac{10 cm^3}{rev} = 1 \times 10^{-5} m^3/rev$

Ideal flowrate = Nominal displacement × Speed

$= \frac{25 rev}{sec} \times \frac{1 \times 10^{-5} m^3}{rev}$

$= 2.5 \times 10^{-4} m^3/sec$

i Volumetric efficiency = $\frac{\text{Real flowrate}}{\text{Ideal flowrate}} \times 100\%$

$= \frac{1.67 \times 10^{-4}}{2.5 \times 10^{-4}} \times 100\% = 66.8\%$

ii Fluid Power = Q · dP

$= 1.67 \times 10^{-4} \times 12 \times 10^{5}$

= 200.4 watts

iii Shaft Power = T · ω

$\omega = 2\pi N = 2 \times \pi \times 25$

= 157.07

Shaft power = 12.5 × 157.07

= 1963.49 watts

iv) Overall Efficiency

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

$= \frac{200.4}{1963.49} \times 100\% = 10.2$

2) sol.

pump delivery = $35 dm^3/min$

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

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

Overall eff = 87%

Fluid power = Q · dP

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

= 5830 watts.

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

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

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

= ~~6701~~ 6701.149 watts

Shaft Power = 6701.149 watts

3. Nominal displacement = $50 cm^3/rev$

$= 50 \times 10^{-6} m^3/rev$

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

Shaft power = $15 Kw = 15000$ watts

Actual flowrate = $35 dm^3/min = \frac{35 \times 10^{-3} m^3}{60}$

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

Speed = $850 r/m = \frac{850 r}{60} = 14.17 rev/s$

Ideal flowrate = Nominal displacement × Speed

$= 50 \times 10^{-6} \frac{m^3}{rev} \times 14.17 rev/s$

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

i. Volumetric efficiency = $\frac{Real}{Ideal} \times 100\%$

$= \frac{5.83 \times 10^{-4} m^3/s}{7.083 \times 10^{-4} m^3/s} \times 100\%$

$= 82.31\%$

ii. Fluid Power = $Q \cdot dP$

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

$= 5830$ watts.

Overall eff = $\frac{5830}{15000} \times 100$

$= 38.867\%$

4. sol

$z = 2400 cm = 24 cm$

Volumetric flow rate, $Q = 13 litres/sec$

$0.013 m^3/sec$

Velocity = $66 m/sec$

The general formula

$P = \rho g Q\left(\frac{P}{\rho g} + \frac{v^2}{2g} + z\right)$

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

but introducing here (Power of jet)

pressure head = 0

$z = 0$

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

and $Q = 0.013$, $\rho = 1000$, $v = 66 m/s$

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

$P = 28314$ watts = 28.314 Kwatts.

ii) Power supplied from reservoir

At atmospheric pressure, $P = 0$ and $v = 0$

so the formula becomes

$P = \rho g Q z$

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

$= 30607.2$ watts

$= 30.672$ Kwatts

iii) Power loss in transmission

= Power of reservoir − Power of jet

$= (30607.2 - 28314)$

$= 2293.2$ watts

$= 2.293$ Kwatts

Head loss in pipeline ?

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

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

$h = 17.9816 \simeq \underline{17.982m}$

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

$= \frac{28314}{306072} \times 100 = \underline{92.51\%}$

5 S_g of oil $= 0.89$

$z = 30,000cm = 300m$

$Q = 220l/sec = 0.22m^3/sec.$

$v = 7m/sec.$

introducing ; $z = 0$; Pressure head $= 0$.

i $P = \frac{\rho Q v^2}{2}$ (Power of jet)

but $S_g = 0.89$.

$S_g = \frac{x}{1000}$ $\therefore x = 0.89 \times 1000$

$= 890$

$\therefore \rho = 890.$

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

$P = 4797.1 watts = \underline{4.7971Kw}$.

ii) Power supplied from reservoir

$P = \rho g Q z$

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

$P = 576239.4 watts = \underline{576.2394Kwatts}$

iii) Power loss in transmission;

= Power reservoir − Power of jet

= (576.2394Kwatts − 4.7971Kw)

= 571442.3watts

= 571.4423Kw.

Head used to overcome losses.

$= \frac{571442.3}{890 \times 9.81 \times 0.22}$

$= \underline{297.51m}$

iv) $Eff = \frac{\text{Power of jet}}{\text{Power of reservoir}} \times 100$

$= \frac{4797.1}{571442.3} \times 100$

$= \underline{0.83\%}$

6) $P = \rho g Q z$ $z = 20m = h.$

here; $\rho = 1000$

$g = 9.81$

$Q = vA.$

$d = 10cm = 10 \times 10^{-2} m.$

$A = \frac{\pi d^2}{4} = 7.85 \times 10^{-3} m^2$

but we need the velocity at height of 20m (initial velocity); using 1 of the equations of motion;   v here = 0.

$v^2 = u^2 - 2gh.$

$u = \sqrt{v^2 + 2gh}$

$u = \sqrt{0^2 + 2 \times 9.81 \times 20}$

$u = \sqrt{392.4}$

$u = 19.809 \simeq \underline{19.81m/s}$

$\therefore$ The velocity $= 19.81$

$\therefore Q = vA$

$= 19.81 \times 7.85 \times 10^{-3}$

$= 0.15558m^3/s \simeq 0.156m^3/s.$

Then;

$P = \rho g Q_z$

$= 1000 \times 9.81 \times 0.156 \times 20$

$P = 30510.7677$ watts

$\simeq 30.5$ Kwatts

7 $d_1 = 0.3m$

$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.3^2}{4} = 0.07068 m^2 \simeq 0.0707 m^2$

$d_2 = 0.2m$

$A_2 = \frac{\pi d^2}{4} = \frac{\pi \times 0.2^2}{4} = 0.031415 m^2 \simeq 0.0314 m^2$

$Cd = 0.96$ Specific weight of gas $= 19.62 N/m^3$

$\gamma = \frac{mg}{V} = \rho g$

$\frac{19.62}{9.81} = \frac{\rho \times 9.81}{9.81}$ so, $\rho g = 19.62$

ρ (density) $= 2 Kg/m^3$

Calculating Q. $Q = A_1 V_1$ & $Q = A_2 V_2$

$V_1 = Q/0.0707$ $V_2 = Q/0.0314$

For the manometer,

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

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

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

For the venturimeter,

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

$P_1 - P_2 = 19.62(z_2 - z_1) + 0.803 V_2^2$ — 2

& $z_2 - z_1 = 0.06m$

equating them

$19.62(z_2 - z_1) + 587.423 = 19.62(z_2 - z_1) + 0.803 V_2^2$

$587.423 = V_2^2$

$\therefore V_2 = 27.047 m/s$

Q ideal $= A_2 V_2$

$\therefore 27.047 \times 0.0314$

Q ideal $= 0.8493 \simeq 0.85$

$\therefore$ Q real $= Cd \times Q_{ideal}$

$= 0.96 \times 0.85$

$= 0.816 m^3/s$

8) Throat diameter $= 0.076m$ $= d_2$

Vertical diameter $= 0.152m$ $= d_1$

relative density $= 0.8$

Throat height $= 0.914m$

$Cd = 0.97$

Bernoulli's equ:

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

& $Q = V_1 A_1$; $Q = V_2 A_2$

$A_2 = \frac{\pi d^2}{4} = \frac{\pi \times 0.076^2}{4} = 4.54 \times 10^{-3} m^2$

$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.152^2}{4} = 0.0181 m^2$

$\therefore V_1 A_1 = V_2 A_2$

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

$\therefore V_1 = \frac{V_2 \times 4.54 \times 10^{-3} m^2}{0.0181}$

$V_1 = V_2 0.251$

Then it becomes, For $P_1 = P_2$ & $\rho = 800$

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

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

& $z_1 - z_2 = 0.914$

$0.914 + \frac{(V_2 0.251)^2}{2 \times 9.81} = \frac{V_2^2}{2 \times 9.81}$

$$0.914 = \frac{V_2^2}{19.62} - \frac{0.063V_2^2}{19.62}$$

$$0.914 = \frac{0.9369 V_2^2}{19.62}$$

$$\frac{17.932}{0.9369} = \frac{0.9369 v_2^2}{0.9369}$$

$$\sqrt{19.14} = \sqrt{v_2^2}$$

$\therefore v_2 = 4.37 m/s$

$Q_{real} = Cd \times Q$

$Q_{ideal} = A_2 V_2$

$= 4.37 \times$ ~~0.0181~~ 4.54×10^{-3}

$= 0.0193$

$Q_{real} = 0.96 \times 0.0193$

$Q_{real} = 0.01906 m^3/s \simeq \underline{0.0191 m^3/s}$

ii Then, $P_1 - P_2 = 15170$

$$\left(\frac{P_1}{\rho g} + z_1\right) - \left(\frac{P_2}{\rho g} + z_2\right) = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

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

$z_1 - z_2 = 0.914$

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

& $\rho = 800$ $g = 9.81$ & $V_1 = Q/A_1$, $V_2 = Q/A_2$.

$$\frac{15170}{\rho g} = \frac{\left(\left(\frac{Q}{A_2}\right)^2 - \left(\frac{Q}{A_1}\right)^2\right)}{2g} - 0.914$$

$$\frac{15170}{\rho g} = \frac{Q^2\left(\left(\frac{1}{A_2}\right)^2 - \left(\frac{1}{A_1}\right)^2\right)}{2g} - 0.914$$

$$\frac{15170}{800 \times 9.81} = \frac{Q^2(48516.36 - 3052.41)}{2g} - 0.914$$

$$(1.932 + 0.94)2g = Q^2(48516.36 - 3052.41)$$

$$\frac{56.3678}{45463.95} = \frac{Q^2(45463.95)}{45463.95}$$

$$\sqrt{1.23 \times 10^{-3}} = \sqrt{Q^2}$$

$Q = 0.0352 m^3/s$

$\simeq \underline{0.035 m^3/s}$

a) $d_1 = 300mm$ $\therefore A_1 = 0.07069 m^2$

$d_2 = 150mm$ $A_2 = 0.0177 m^2$

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

$z_1 = 10m$; $z_2 = 6m$

$P_1 = 400 kN/m^2$ $P_2 = ?$

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

but $Q = A_1 V_1$

$$\therefore V_1 = \frac{Q}{A_1} = \frac{0.04 m^3/sec}{0.07069}$$

$V_1 = 0.5658 \simeq 0.57 m/s$

Then $V_2 = \frac{Q}{A_2} = \frac{0.04 m^3/sec}{0.0177 m^2} = 2.2598$

$V_2 = 2.2598 \simeq 2.26 m/s$

$$\frac{P_1}{\rho g} + (z_1 - z_2) + \left(\frac{V_1^2}{2g} - \frac{V_2^2}{2g}\right) = \frac{P_2}{\rho g}$$

$$\frac{400kN}{9.81kN} + (10-6) + \left(\frac{0.57^2 - 2.259^2}{2 \times 9.81}\right) = \frac{P_2}{9.81kN}$$

$$40.77 + 4 + (-0.2438) = \frac{P_2}{9.81 kN}$$

$(44.52 \times 9.81 \times 10^3) N = P_2$

$P_2 = 436802.35 N$

$P_2 = \underline{436 kN}$

10 Reading of manometer = 170mm

$= 0.17m$

Specific gravity of mercury = 13.6

" " " seawater = 1.026

$y = 0.17m$

For $h = y\left(\frac{S_{hg}}{S_o} - 1\right)$

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

$= 0.17 \times 12.255$

$= 2.0834m.$

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

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

$v = \sqrt{40.87}$

$v = 6.393 m/s \simeq \underline{6.4 m/s}$