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19/ENG05/063
Mechatronics
Fluid mechanics

i; vol efficiency $= \frac{\text{actual flowrate}}{\text{Ideal flow rate}} \times 100$

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

$= 66.8\%$

ii; Fluid power $= Q \cdot dp$

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

$= 200.4$ Nm/sec

iii Shaft power $= T\omega_i$

$\omega_i = 2\pi N_i$ = ~~$2 \times \frac{22}{7} \times 25 = 157.14$~~

$2 \times \frac{22}{7} \times 25 = 157.14$ rad s/sec

$\therefore$ Shaft power $= 12.5 \times 157.4$

$= 1964.25$N

$$\frac{200.4}{1964.25} \times 100 = 10.2\%$$

2. Pump delivery $= 35\ dm^3/min$

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

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

overall efficiency $= 87\%$

fluid power $= Q \cdot dp$

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

$= 5830$ watts

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

$$= \frac{5830 \times 100}{87} = 6701.149 \text{ watts}$$

3 Nominal displacement of 50cm³/rev

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

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

Shaft power $= 15 Kw = 15000$ watts

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

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

speed $= 850 rev/min = \frac{850}{60} = 14.17 rev/sec$

~~differential head $h_i = y\left(\frac{Sh}{S_0} - 1\right)$~~

~~$SL = 13.6$~~

~~$y = 50 \times 10^{-2}$~~

~~$h = 50 \times 10^{-2}$~~

4 $z = 2400 cm = 24 m$

volumetric flowrate $Q = 13 L/sec$

$= 0.013 m^3/sec$

velocity $= 66 m/sec$

The general formula

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

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

Pressure head = 0

z = 0

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

and Q = 0.013, ρ = 1000, v = 66 m/s

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

P = 28314 watts = 28.314 kW

ii Power supplied from reservoir

P = ρ g Q z

= 1000 × 9.81 × 0.013 × 240

= ~~306072~~ 30607.2 watts

≃ 2.2932 Kilowatts

Head loss in pipeline = 2.2932 Kwatts

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

$= \frac{2293.2}{1000 \times 9.81 \times 0.013} = 17.98 m$

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

$$= \frac{28314}{30607.2} \times 100 = 92.51\%$$

3 Sg of oil = 0.89

$z = 30,000 cm = 300 m$

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

$v = 7 m/sec$

Introducing, $z = 0$, pressure $= 0$

1 $P = \frac{\rho Q v^2}{2}$

$Sg = \frac{x}{1000}$

$x = 0.89 \times 1000 = 890$

$\rho = x = 890$

$P = \frac{890 \times 0.22 \times (7)^2}{2} = 4797.1 w$

ii Power supplied from reservior

$P = \rho g Q z$

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

$P = 576239.4$ watts

$\simeq 576.2394$ ~~K~~watts

iii Power loss in transmission

= Power reservior − Power of jet

= (576239.4 − 47971)

= 571442.3 watts

= 571.4423 kwatts

Head used to over come losses

$= \frac{571442.3}{890 \times 9.81 \times 0.22} = 297.51m$

iv Efficiency $= \frac{\text{Power of jet}}{\text{" " reservior}} \times 100\%$

$= \frac{47971.1}{571442.3} \times 100 = 0.83\%$

c $P = \rho g Q z$

$z = 20m^2h$

$\rho = 1000$

$g = 9.81$

$Q = VA$

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

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

$v = ?$

$v^2 = v^2 - 2gh$

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

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

$v = \sqrt{392.4}$

$v = 19.81 m/s$

The velocity = 19.81

$Q = VA$

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

= 30.5 kilowatts

~~equating both equations~~
~~19.62 (z_2 + z_1) + 58(7.4Ht)~~

$d_1 = $ ~~0.2m~~ $0.3m$

$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.3^2}{4}$

$= 0.07068 m^2$

$d_2 = 0.2$

$A_2 = \frac{\pi d^2}{4} = \frac{\pi \times 0.2^2}{4}$

$= 0.031415 m^2 \simeq 0.0314 m^3$

$C_d = 0.96$

Specific weight of gas = 19.62 N/m

$\left( = \frac{mg}{v} = \rho g = \frac{19.62}{9.81} = \frac{\rho \times 9.81}{9.81}\right.$

$\rho g = 19.62$

$\rho = 2\ kg/m^2$

So $v_1 = \frac{Q_1}{A_1} = \frac{Q}{0.0707}$  $v_2 = \frac{Q}{0.0314}$

For manometer

~~$P_1 + \rho_g g (z_2$~~

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

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

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

For venturimeter

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

$P_1 - P_2 = 19.62 (z_2 - z_1) + 0.803 v_2^2$

$z_2 - z_1 = 0.06 m$

equating equ 1 and 2

~~$19.62$~~ $(z_2 - z_1) + 587.423 =$ ~~$19.62 (z_2 - z_1)$~~

$+ 0.803 v_2^2$

$0.803 v_2^2 = 587.423$

$V_2^2 = \frac{587.423}{0.803}$

$V_2^2 = 731.535$

$V_2 = \sqrt{731.535}$

$V_2 = 27.047 m/s$

$Q_{ideal} = A_2 V_2$

$= 27.047 \times 0.0314 = 0.85 m^3/s$

$Q_{real} = C_d \times Q_{ideal}$

$= 0.96 \times 0.85 = 0.816 m^3/s$

Using Bernoulli's eqn

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

Recall

~~$A_2 =$~~ $Q = V_1 A_1$, $Q = V_2 A_2$

$A_2 = \frac{\pi d^2}{4} = \frac{\pi \times 0.076^2}{4}$

$= 4.64 \times 10^{-3} m^2$

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

$v_1 A_1 = v_2 A_2$

$v_1 = \frac{v_2 A_2}{A_1}$ $\quad v_1 = \frac{v_2 \times 4.64 \times 10^{-3}}{0.0181}$

$v_1 = 0.251 v_2$

then

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

$z_1 - z_2 + \frac{v_1^2}{2g} = \frac{v_2^2}{2g}$ , $z_1 - z_2 = 0.914$

$0.914 + \frac{(v_2\ 0.251)^2}{2 \times 9.81} = \frac{v_2^2}{2 \times 9.81}$

$0.914 = \frac{v^2}{19.62} - \frac{0.063 v_2^2}{19.61}$

$V_2^2 = \frac{19.\ }{0.937}$

$V_2^2 = 19.136$

$V_2 = \sqrt{19.136}$

$V_2 = 4.37$

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

$Q_{ideal} = A_2 V_2$

$4.37 \times 4.64 \times 10^{-3} = 0.0202$

$Q_{real} = 0.96 \times 0.0202$

$Q_{real} = 0.195 m^3/s$

Then $P_1 - P_2 = 15170$

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

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

Recall $z_1 - z_2 = 0.914$

Recall; $Q = VA$, $V = \frac{Q}{A}$

$\rho = 800$, $g = 9.81$

$\frac{15,720}{800 \times 9.81} = \left(\frac{Q}{A_2}\right)^2 - \left(\frac{Q}{A_1}\right)^2 - 0.914$

$\frac{15,720}{7848} = Q^2\left(\left(\frac{1}{A_2}\right)^2 - \left(\frac{1}{A_1}\right)^2\right) - 0.914$

Recall $Q = VA$, $V = \frac{Q}{A}$

$\rho = 800$, $g = 9.81$

$\frac{15170}{9.81 \times 800} = \frac{\left(\frac{Q}{A_2}\right)^2 - \left(\frac{Q}{A_1}\right)^2}{2g} - 0.914$

$\frac{15,720}{7848} = \frac{Q^2\left(\left(\frac{1}{A_2}\right)^2 - \left(\frac{1}{A_1}\right)^2\right)}{2g} - 0.914$

$1.932 = \frac{Q^2(48516.38 - 3052.4)}{2g} - 0.9$

$Q^2 = 1.24 \times 10^{-3}$

$Q = 0.0352 m^2/s$

9 $\frac{P_1}{\rho g} + z_1 + \frac{v_1^2}{2g} = \frac{P_2}{\rho g} + z_2 + \frac{v_2^2}{2g}$

Sub $Q = A_1 v_1$

$v_1 = \frac{Q_1}{A_1} = \frac{0.04}{0.07059} = 0.57 m/s$

Then $v_2 = \frac{Q}{A_2} = \frac{0.04}{0.0177} = 2.26 m/s$

$\frac{P_1}{\rho g} (z_1 - z_2) + \left(\frac{v_1^2}{2g} - \frac{v_2^2}{2g}\right) = \frac{P_2}{\rho g}$

$\frac{400kN}{9.81} + (10 - 6) + \left(\frac{0.57^2 - 2.26^2}{2 \times 9.81}\right) =$

$\frac{P_2}{9.81}$ kN

~~4~~ $44.52 \times 9.81 = P_2$

$P_2 = 436.74 kN$

Reading of manometer = 170mm = 0.17m
Specific gravity of mercury = 13.6
Seawater = 1.026

y = 0.17m/s
for $h = y\left(\frac{S_{hl}}{S_l} - 1\right)$
$= 0.17\left(\frac{13.6}{1.026} - 1\right)$
$= 0.17 \times 12.255$
$= 2.0834m$

where $v = \sqrt{2gh}$
$v = \sqrt{2 \times 9.81 \times 2.0834}$
$v = \sqrt{40.87}$
$v = 6.393m/s$