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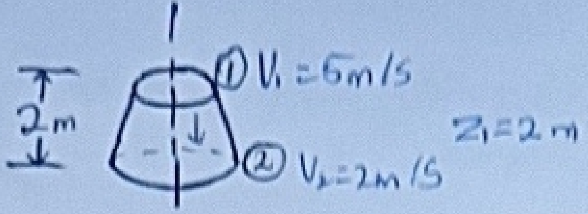
BIOMEDICAL ENGINEERING 15/ENG07/087

ENG 214 ASSIGNMENT

①



$\frac{P_1}{\rho\omega} = 2.5m$, Head loss, $H_L = \frac{0.35(V_1 - V_2)^2}{2g}$

$H_L = \frac{0.35(5-2)^2}{2 \times 9.81} = 0.16m$

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

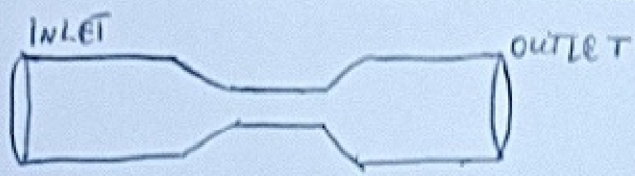
$2.5 + 1.27 + 2 = P_2/\omega + 0.203 + 0 + 0.16$

$P_2/\omega = 2.5 + 1.27 + 2 - (0.203 + 0.16)$

$P_2/\omega = 5.77 - 0.363$

$= 5.407m$ of liquid

②



Inlet;

$D_1 = 20cm = 0.2m$

$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.2^2}{4} = 0.0314m^2$

$P_1 = 17.658 N/cm^2 = 176580 N/m$

Throat diameter,

$d_2 = 10cm = 0.1m$

$A_2 = \frac{\pi d^2}{4} = \frac{\pi \times 0.1^2}{4} = 7.85 \times 10^{-3} m^2$

$h = \frac{P_1}{\omega} - \frac{P_2}{\omega}$

$P_1 = 176580 N/m^2$, $\omega = 9.81 \times 1000$

$P_2/\omega = 30cm\ Hg = 0.3m\ Hg$

$= 0.3 \times 13.6 = 4.08$

$P_2/\omega = -4.08$

$P_1/\omega = \frac{176580}{9.81 \times 1000} = 18.0$

$\frac{P_1}{\omega} - \frac{P_2}{\omega} = 18.0 - -4.08 = 22.08$

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

$Q = 0.98 \times 0.0314 \times 7.85 \times 10^{-3} \times \sqrt{\frac{2 \times 9.81 \times 22.08}{(0.0314^2 - (7.85 \times 10^{-3})^2)}}$

$Q = 0.1653 m^3/s$

③ $d_o = 15cm = 0.15m$

$A_o = \frac{\pi \times 0.15^2}{4} = 0.01767m^2$

$d_P = 30cm = 0.3m$

$A_P = \frac{\pi \times 0.3^2}{4} = 0.07069m^2$

S.P.G of oil $= 0.9$

$C_d = 0.64$

Reading of differential $= 60cmHg$

Differential head $h = y\left[\frac{S_{hl}}{S_0} - 1\right]$

$S_{hl} = 13.6$

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

$h = 50 \times 10^{-2}\left[\frac{13.6}{0.9} - 1\right]$

$h = 0.5 \times 14.11 = 7.055m$

$Q = \frac{C_d A_o A_P \sqrt{2gh}}{\sqrt{A_P^2 - A_o^2}}$

$= \frac{0.64 \times 0.01767 \times 0.07069 \times \sqrt{2 \times 9.81 \times 7.055}}{\sqrt{(0.07069^2) - (0.01767^2)}}$

$= 0.1374 m^3/s$

④ $y = 170 mmHg = 0.17 m Hg$

$S.g_{Hg} = 13.6, \; S.g_{sw} = 1.026$

$$\Delta h = y\left(\frac{S.g_{Hg}}{S.g_{sw}} - 1\right)$$

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

$\Delta h = 2.08 m$

$V = \sqrt{2g\Delta h}$

$V = \sqrt{2 \times 9.81 \times 2.08}$

$V = 6.388 m/s$

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⑤

$Q = 0.05 dm^3/min = 8.33 \times 10^{-5} m^3/sec$

Speed of rotation $= 1700 Rev/min = 28.3 Rev/sec$

Nominal Displacement $= 10 cm^3/rev = 10^{-5} m^3/rev$

Torque Input $= 15 Nm$

Pressure Change $= 15 bar = 15 \times 10^5 N/m^2$

- Ideal Flowrate = Nominal displacement × Speed Rotation

$= 10^{-5} \times 28.3 = 283 \times 10^{-4} m^3/sec$

ⓐ Volumetric Efficiency

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

$$= \frac{8.33 \times 10^{-5}}{2.83 \times 10^{-4}} \times 100 = 29.45\%$$

ⓑ Fluid Power,

$P_F = Q \times \Delta P = 8.33 \times 10^{-5} \times 15 \times 10^5$

$= 124.95$ watts

ⓒ Shaft power

$\Rightarrow T \times \omega$

$\omega = 2 \times \pi \times$ speed of rotation.

$\omega = 2 \times \pi \times 28.3 = 177.81 rad/sec$

Shaft power $= 15 \times 177.81$

$= 2667.2$ watts

ⓓ Overall efficiency

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

$$= \frac{124.95}{2667.2} \times 100 = 4.68\%$$