Harding-Udoh Titania B.
18/ENG08/007
BIOMEDICAL ENGINEERING
FLUID MECHANICS

① Length of tube, $l = 2.0m$

$V_1 = 5m/s$

$V_2 = 2m/s$

Loss of head in tube $= \frac{0.35(V_1-V_2)^2}{2g}$

Pressure head at smaller end $= 2.5m$ of liquid

determine pressure head of lower end

$\frac{P_1}{w} = 2.5m$ of liquid

Loss of head $= \frac{0.35(V_1-V_2)^2}{2g}$

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

$= \frac{3.15}{19.62} = 0.16m$

Applying Bernoulli's equation

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

Then, $z_2 = 0$, $z_1 = 2.0m$

$$\therefore 2.5 + \frac{5^2}{2g} + 2.0 = \frac{P_2}{w} + \frac{2^2}{2g} + 0 + 0.16$$

$$(2.5 + 1.274 + 2.0) = \frac{P_2}{w} + 0.204 + 0.16$$

$$5.774 = \frac{P_2}{w} + 0.364$$

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$$\frac{P_2}{w} = 5.774 - 0.364$$

$\frac{P_2}{w} = 5.41m$ of Liquid.

② Inlet diameter $= 20cm = 0.2m$

throat diameter $= 10cm = 0.1m$

$$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi \times (0.2)^2}{4} = 0.0314m^2$$

$$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi \times (0.1)^2}{4} = 7.853\times10^{-3} m^2$$

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

$= 17.658 \times 10^4 N/m^2$

vacuum pressure at the throat

$= 30 cmHg = 300 mmHg$

$= 0.3 mHg$.

$C_d = 0.64$

To get h;

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

$P_1 = 17.658 \times 10^4 N/m^2$

$w = 9.81 \times 10^3 N/m^2$

at throat vacuum pressure $= 0.3 \times 13.6$

$= 4.08$

$$\therefore \frac{P_2}{w} = -4.08$$

$$\frac{P_1}{w} = \frac{17.658 \times 10^4}{9.81 \times 10^3} = 18$$

$$\therefore \frac{P_1}{w} - \frac{P_2}{w},\ 18 - -4.08 = 22.08$$

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

$$Q_{actual} = \frac{0.98 \times 0.0314 \times 7.815 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 22.08}}{\sqrt{(0.0314^2) - (7.85 \times 10^{-3})^2}}$$

$Q_{actual} = 2.4156 \times 10^{-4} \times 684.59$
$= 0.1653$

$\therefore Q_{actual} = 0.1653\ m^3/s$

3) Orifice meter; Given that

$d_o = 15cm = 15 \times 10^{-2} m$

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

$d_p = 30 cm = 30 \times 10^{-2} m$

$A_p = \frac{\pi \times d^2}{4} = 0.07069 m^2$

SG of oil $= 0.9$ (S_o)

$C_d = 0.64$

Reading of differential $= 50 cmHg$

Differential head, $h_1 = y\left[\frac{S_{hl}}{S_o} - 1\right]$

$S_{hl} = 13.6$

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

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

$h = 50 \times 10^{-2} \times 14.11$
$= 7.055 m$

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

$$Q = \frac{0.64 \times 0.1767 \times 0.07069 \times \sqrt{2 \times 9.81 \times 7.055}}{\sqrt{(0.1769)^2 - (0.01767)^2}}$$

$$Q = \frac{7.994 \times 10^{-4} \times 11.765}{\sqrt{4.68 \times 10^{-3}}}$$

$Q = 0.1374\ m^3/s$

4) $y = 170 mmHg = 0.17 mHg$,

S.g of mercury $= 13.6$

S.g of water $= 1.026$

$$\Delta h = y\left(\frac{\text{Sg of mercury}}{\text{Sg of water}} - 1\right)$$

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

$\Delta h = 2.08 mm$

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

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

$v = \sqrt{40.8096}$

$v = 6.388 m/s$

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 (ND) $= 10 cm^3/rev = 10^{-5} m^3/rev$

Torque Input $= 15 Nm$

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

Ideal flow rate $=$ ND $\times$ Speed rotation
$= 10^{-5} \times 28.3$
$= 2.83 \times 10^{-4} m^3/sec$

a) Volumetric Efficiency $= \frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100$

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

$= 29.45\%$

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(b) Fluid Power, $P_f = Q \times \Delta P$

$= 8.33 \times 10^{-5} \times 15 \times 10^{5}$

$= 124.95$ Watts

(c) Shaft Power $= T \times w$

$w = 2 \times \pi \times$ speed of rotation

$w = 2 \times \pi \times 28.3$

$w = 177.81$ rad/sec

$\therefore$ Shaft power $= 15 \times 177.81$

$= 2667.2$ watts

(d) Overall efficiency

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

$= \frac{124.75}{2667.2} \times 100$

$= 4.68\%$