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18/ENG06/007
MECHANICAL ENGINEERING
ENG 214

Assignment

1) $Z_1 = 0$, $Z_2 = 2.0m$
$V_1 = 5m/s$ $V_2 = 2m/s$

The pressure, h, $\frac{P_1}{w} = 2.5m$, $\frac{P_2}{w} = ??$

$$h_f = 0.35 \frac{(V_1 - V_2)^2}{2g}$$

$$= \frac{0.35(5-2)^2}{2 \times 9.81} = \frac{0.35 \times 9}{2 \times 9.81}$$

$$= 0.1606m$$

Applying Bernoulli's Equation

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

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

$$= 2.5 + \frac{5^2}{2 \times 9.81} + 0 - \frac{2^2}{2 \times 9.81} - 2.0 - 0.1606$$

$$= 2.5 + 1.274 - 0.204 - 0.1606 - 2.0$$

$$= 1.4094m$$

$$= 1.41m$$

$\therefore h_2, \frac{P_2}{w} = 1.41m$

$= 1.41m$

2) $d_1 = 20cm = \frac{20}{100} = 0.20m$, $d_2 = 10cm = \frac{10}{100} = 0.10m$

$$A_1 = \frac{\pi d^2}{4} = \frac{\pi(0.2)^2}{4}$$

$$= 0.0314m^2$$

$$A_2 = \frac{\pi d^2}{4} = \frac{\pi(0.10)^2}{4} = 0.00785m^2$$

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$P_1 = 17.658 N/cm^2$
$= 17.658 \times 10^4$
$= 176510 N/m^2$
$P_2 = 30cm$ of Hg
$= -0.3m$ of Hg
$= -0.3 \times 13.6 = -4.08m$
$h_2 = -4.08m$
$h_1 = \frac{P_1}{w} = \frac{176580}{1000 \times 9.81}$
$= 18m$
$\therefore h = h_1 - h_2$
$h = 18 - (-4.08) = 18 + 4.08$
$= 22.08$
$\therefore Q = \frac{C_d \times A_1 \times A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$
$= \frac{0.98 \times 0.0314 \times 0.00785 \times \sqrt{2 \times 9.81 \times 22.08}}{\sqrt{(0.0314)^2 - (0.00786)^2}}$
$Q = \frac{0.00503}{0.0304}$
$Q = 0.1654 m^3/s$

3) Orifice diameter, $d_o = 15cm = 0.15m$, $C_d = 0.6$
Pipe diameter, $d_1 = 30cm = 0.30m$
$A_o = \frac{\pi d_o^2}{4} = \frac{\pi (0.15)^2}{4} = 0.01767 m^2$
$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi (0.30)^2}{4} = 0.070686 m^2$
Differential head;
$y = 50cm = 0.5m$
$h = \frac{P}{w} = y \left(\frac{S.G \text{ of Hg}}{S.G \text{ of oil}} - 1 \right)$
$= 0.5 \left(\frac{13.6}{0.9} - 1 \right)$

$= 0.5(14.11)$

$= 7.06m$

$\therefore h = 7.06m$

$\therefore Q = \frac{C_d \times A_1 \times A_2}{\sqrt{A_1^2 - A_0^2}} \times \sqrt{2gh}$

$= \frac{0.64 \times 0.01767 \times 0.07068}{\sqrt{(0.070686)^2 - (0.01767)^2}} \times \sqrt{2 \times 9.81 \times 7.08}$

$= \frac{0.009407}{0.06844}$

$Q = 0.1374 m^3/s$

$Q = 0.137 m^3/s$

$\therefore Q = 0.137 m^3/s$,,

4) Difference of Hg (y)

$y = 170mm = \frac{170}{1000} = 0.17m$

S.G of Mercury = 13.6, S.G of Sea water = 1.026

$\therefore h = y\left(\frac{S.G \text{ of } Hg}{S.G \text{ of sea water}} - 1\right)$

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

$= 0.17(12.255)$

$= 2.08m$

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

$= \sqrt{2gh}$

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

$V = 6.39 m/s$,,

5) Actual flow rate $= 0.05 m^3/min = 8.33 \times 10^{-4} m^3/sec$

Change in pressure, $\delta p = 15 bar = 15 \times 10^5 N/m^2$

Speed of rotation, $N = 1700 rev/min$

$= \frac{1700}{60}$

$= 28.33 rev/sec$

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Norminal Displacement $= 10cm^3/rev = \frac{10}{10^6} m^3/rev$

$= 1\times10^{-5} m^3/rev$

Torque input, $T = 15Nm$

i) Volumentric Efficiency

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

Actual flowrate $= 8.33\times10^{-4} m^3/sec$

Ideal flowrate = Speed of rotation $\times$ Normal Displacement

$= 28.33 \times 1\times10^{-5}$

$= 2.833\times10^{-4}$

$\therefore$ Volumetric Efficiency

$= \frac{8.33\times10^{-4}}{2.833\times10^{-4}} \times 100\%$

$= 2.94\times100\%$

$= 294\%$

ii) Fluid Power, $P_f = Q\times\delta p$

$= 8.33\times10^{-4} \times 15\times10^5$

$= 1249.5$ watts.

iii) Shaft Power $= T.w$

$T = 15Nm$

$w = 2\pi N$ rad/s

$= 2\times\frac{22}{7}\times 28.33$

$= 178.07$ rad/s

$\therefore$ Shaft Power $= 15\times178.07$

$= 2671.11$ watts

iv) Overall efficiency $= \frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100\%$

$$= \frac{1249.5}{2671.11} \times 100\%$$

$$= 0.468 \times 100\%$$

$$= 46.8\%$$

$\therefore$ The overall efficiency is 46.8%

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