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18/ENG05/012

MECHATRONICS

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1. $z_1 = 0$

$z_2 = 2.0m$

$v_1 = 5m/s$

$v_2 = 2m/s$

Pressure; $p_1/w = 2.5m$

$p_2/w = ?$

$h_f = 0.35(v_1 – v_2)^2/2g$

= 0.35(5 – 2)2/19.62 = 0.1606m

Applying Bernaulli's equation

$p_1/w + v_1^2/2g + z_1 = p_2/w + v_2^2/2g + z_2 + h_f$

$p_2/w = p_1/w + v_1^2/2g + z_1 – v_2^2/2g – z_2 – h_f$

= 2.5 + 52/19.62 + 0 – 22/19.62 – 2 – 0.1606

p_2/w = 2.5 + 1.274 – 0.204 – 0.1606 – 2.0

= 1.4094m =1.41m.

2. d_1 = 20cm = 0.2m

d_2 = 10cm = 0.1m

$A_1 = \pi d_1^2/4 = \pi(0.2)^2/4 = 0.0314m^2$

$A_2 = \pi d_2^2/4 = \pi(0.1)^2/4 = 0.00985m^2$

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

P_2 = 30cm of mercury = 0.3mofHg

0.3mmHg x 13.6m = 4.08

h_2 = 408m

$h_1 = p_1/w$ = (176580)/(1000x9.81) = 18m

$h = h_2 - h_1$

$h = 18-(-4.08) = 22.08$

using $Q = (Cd\ A_1\ A_2 / \sqrt{A_1^2 - A_2^2}) \times \sqrt{2gh}$

$Q = (0.98 \times 0.0314 \times 0.00985) / \sqrt{(0.0314)^2-(0.00985)^2} \times \sqrt{2 \times 9.81 \times 22.08}$

$Q = 0.00503/0.0304$

$Q = 0.1654 m^3/s$

3. $d_1 = 30cm = 0.3m$

$d_2 = 15cm = 0.15m$

$A_1 = \pi(d_1)^3/ 4 = \pi(0.3)^3/ 4 = 0.0707m^3$

$A_2 = \pi(d_2)^3/ 4 = \pi(0.15)^3/ 4 = 0.0177m^3$

Cd = 0.64

Differential readings(y) = 50cm = 0.5m

Specific gravity of mercury(sgm) = 13.6

Specific gravity of oil(sgoil) = 0.9

Differential head = y ((sgm/sgoil) – 1)

= 0.5((13.6/0.9) – 1)

= 0.5 (14.11)

= 7.055

$Q = (Cd.A_2.A_1 \times \sqrt{2gh}) / (\sqrt{A_1^2 - A_2^2})$

$Q = (0.64 \times 0.0177 \times 0.0707 \times \sqrt{2 \times 9.81 \times 7.055}) / (\sqrt{0.0707^2 - 0.0177^2})$

$Q = (9.4226 \times 10^{-3}) / (0.0684)$

$Q = 0.1378 m^3/s$

4. Depth = 15m

Manometer reading = 170mm = 0.17m

Sp.gr = 13.6

Sp.gr seawater = 1.026

h = y(hg/(seawater) – 1)

h = 0.17(13.6/(1.026) – 1)

h = 0.17(12.255)

h = 2.08335m

velocity $v = \sqrt{2 x g x h}$

$v = \sqrt{2 \times 9.87 \times 2.08335}$

v= 6.3934m/s

5. i). volumetric efficiency = (actual flowrate)/ (ideal flowrate) x 100

actual flowrate = $(0.05m^3/min)/(60) = 0.000833m^3/s$

ideal flowrate = (nominal displacement x speed)

nominal displacement = $10cm^2/rev/1{,}000{,}000 = 0.00001m^3/rev$

speed = 1700rev/min/ 60 = 28.33rev/s

.'. ideal flowrate = $0.00001m^3/rev \times 28.33rev/s$

$= 0.0002833m^3/s$

Volumetric efficiency = 0.000833/ 0.0002833) x 100

= 294.03%

ii). Fluid power= actual rate x pressure

$= 8.33 \times 10^{-4} \times 15 \times 10^5$

= 1249.5watts

iii). Shaft power = torque x angular speed

angular speed = 2 x π x speed

= 2 x π x 28.33

= 178.0026rad/s

Shaft power = 15 x 178.0026

= 2670.039watts.

iv). Overall efficiency = (fluid power/shaft power) x 100%

= (1249.5/2670.039) x 100%

= 0.468 x 100%

= 46.8%.