Chidi Milestone Miracle
18/engo1/005
Chemical Engineering
Fluid Mechanics

1) q_v (pump flow (m^3/s)) = $10 dm^3/min$
n (rotational velocity (r/s)) = 1500 r/min
V_g (displacement, geometric (m^3/r)) = $10 cm^3/rev$
Torque input = 12.5Nm
Change in pressure = 12bar

I) volumetric Efficiency (h_v)
$10 dm^3/min = 0.01 m^3/min$
$10 cm^3/rev = 0.00001 m^3/rev$
$q_v = n V_g h_v$
$0.01 = 1500 \times 0.00001 \times h_v$
$\frac{0.01}{1500 \times 0.00001} = h_v$
$h_v = 0.67 \simeq 67\%$

II) fluid power = $q_v \times$ change in pressure
$12 bar = 12 \times 10^5 = 1200000$
$= q_v = 10 dm^3/min = 1.67 \times 10^{-4}$
$= 1.67 \times 10^{-4} \times 1200000 = 200.04W$

III) Shaft Power = $\frac{2\pi nT}{60}$
$= \frac{2 \times \pi \times 1500 \times 12.5}{60} = 1963.75$ Watts

IV) Overall efficiency = $\frac{\text{fluid power}}{\text{Shaft power}}$
$= \frac{200.04}{1963.7}$
$= 0.1018 = 10.2\%$

2) fluid power = $q_v \times$ change pressure
$q_v = 35 dm^3/min = 0.035 m^3/min$
$fP = 0.035 \times 10000000 = 350000W$
Shaft power = $\frac{\text{fluid power}}{\text{overall power}}$
$\frac{87}{100} = \frac{350000}{\text{Shaft power}}$
Shaft power = $\frac{35000000}{87}$
Shaft power = 402298.9 Watts

3) Actual flow rate = $35 dm^3/min = 0.035 m^3/min$
Nominal displacement = $0.00005 m^3/rev$
Volumetric efficiency [rotation speed = 850
$0.035 = 850 \times 0.00005 \times h_v$
$\frac{0.035}{850 \times 0.00005} = h_v = 0.82 \simeq 82\%$
fluid power = $q_v \times$ pressure change
$= 0.00058 \times 10000000$
$= 35000W$
overall efficiency = $\frac{5800 w}{1500}$
overall efficiency = ~~2.233~~ = $0.386 \simeq 39\%$

4)

5)

6) height : 20m , diameter : 10cm : 0.1m

$Area = \frac{\pi d^2}{4} : 0.7854$

$V_f = 0 \quad w = ?$

$V_f^2 = V_1^2 - 2gh$

$V_1 = \sqrt{V_f^2 + 2gh}$

$V_1 = \sqrt{0^2 + 2(9.8)(20)} = 19.80 m/s$

Since flow rate is equal to the speed through the area

$Q = VA = 19.80 \times 7.854 \times 10^{-3} = 0.155 m^3/s$

$W = \rho g Q h = 1000 \times 9.8 \times 0.155 \times 20$

$= 30478 kgm^2/s^3$

$=$ 30478 Watts

7) $P_g = 19.62 N/m^2$

$C_d = 0.96$

$d_1 = 0.3$

$d_2 = 0.2$

$u_1 = 0.0707 \quad U_2 = 0.0314$

$P_1 + P_g g z = P_2 + P_g g(z_2 + A) + P_w g P$

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

For the venturimeter

$\frac{P_1}{P_g g} + \frac{u_1^2}{2g} + z_1 = \frac{P_2}{P_g g} + \frac{V_2^2}{2g} + z_2 \quad \therefore Q_1$

$P_1 - P_2 = 19.62(z_2 - z_1) + 0.803 V_2^2 \quad \therefore Q_2$

Combine Q_1 and Q_2

$0.8034 V_2^2 = 587.428$

U^2 ideal $= 27.047 m/s$

Q ideal $= 27.047 \times \pi\left(\frac{0.2}{2}\right)^2 = 0.85 m^3/s$

$Q = C_d Q_{ideal} = 0.96 \times 0.85 = 0.816 m^3/s$

8) $d_1 = 0.152$, $d_2 = 0.076$

$d_1 = 0.152 \quad A_1 = 0.0189 m$

$d_2 = 0.076 \quad A_2 = 0.00434 m$

$P = 300 kg/m^3$

$C_d = 0.97$

Applying Bernoulli method

$\frac{P_1}{\rho g} + \frac{U_1^2}{2g} + z = \frac{P_2}{\rho g} + \frac{U_2^2}{2g} + z_2$

a) $P_1 = P_2 \quad \frac{U_1^2}{2g} + z_1 = \frac{U_2^2}{2g} + z_2$

$Q = U_1 A_1 = U_2 A_2$

$V_2 = V_1 \frac{A_1}{A_2} = U_1 4$

$U_1 = \sqrt{\frac{0.94 \times 2 \times 9.81}{15}}$

$= 1.0934 m/s$

$q = C_d A_1 U_1$

$q = 0.96 \times 0.01814 \times 1.0934$

$= 0.019 m^3/s$

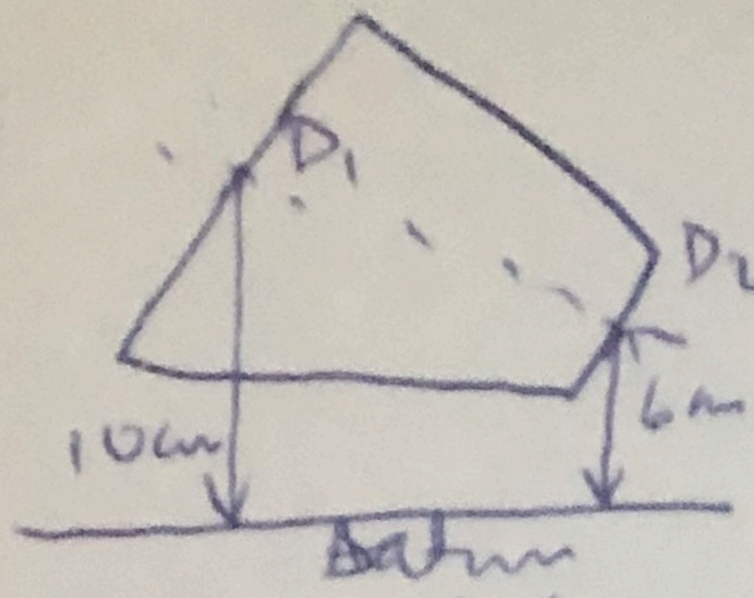
$P_1 - P_2 = 15.70$

$\frac{P_1 - P_2}{\rho g} = \frac{U_2^2 - U_1^2}{2g} - 0.914$

$\frac{15.70}{\rho g} = \frac{Q_2(220.43^2 - 55.11^2)}{2g} - 0.914$

$Q = 0.035 m^3/s$

9)



At section 1

$D_1 = 0.3m$

$A = \frac{\pi}{4}(0.3)^2 = 0.707m^2$

$Z_1 = 10m$

$P_1 = 400 \times 10^3 N/m^2$

At section 2

$D_2 = 0.15$

Area $= \frac{\pi \times (0.15)^2}{4} = 0.1367m^2$

5)

$Z_2 = 6m$

$V_2 = ?$

$P_2 = ?$

$A_1V_1 = A_2V_2 = 40lit/sec = 40 \times 10^{-3}$

$V_1 = \frac{40 \times 10^{-3}}{0.707} = 0.366m/s$

$V_2 = \frac{40 \times 10^{-3}}{0.01767} = 2.264m/s$

Apply Bernoulli's method

$\frac{400 \times 10^3}{9800} + \frac{(0.556)^2}{2 \times 9.8} + 10 = \frac{P_2}{w} + \frac{(1.274)^2}{2 \times 9.8} + 6$

$P_2 = 436.8 KN/m^2$

10) reading of the manometer (y) 170mm

specific gravity of mercury $(S_h) = 13.6$

" " water $= (S_1) = 1.026$

$h = y\left(\frac{S_h}{S_1} - 1\right)$

$h = 0.17\left[\frac{13.6}{1.026} - 1\right]$

$h = 2.083$

Velocity of Submarine

$V = \sqrt{2gh}$

$= \sqrt{2 \times 9.8 \times 2.083}$

velocity of submarine $= 6.39m/s$