OBE CORNELIUS MBA
18/ENG06/049
MECHANICAL ENGINEERING
FLUID MECHANICS (ENG 214)

1.) Flow rate $Q = 10 dm^3/min$
Pressure Change $(\Delta P) = 12 bar$
Normal Displacement $= 10 cm^3/rev$
Torque Input $T = 12.5 N\text{-}m$

Solution

Flow rate = Normal Displacement × Speed = $10 cm^3/rev \times 1500 rpm$
$= 15000 cm^3/min = 15 dm^3/min$

i) Volumetric efficiency $= \frac{\text{Actual flow}}{\text{Ideal flow}}$

$= \frac{10}{15} = 0.6667$

ii) $Q = \frac{10 \times 10^{-03}}{60} m/sec = 16.7 \times 10^{-05}$ m^3/sec, $\Delta P = 12 \times 10^5 N/m^2$

Fluid power $= \Delta P \times Q = 16.7 \times 10^{-05} m^3/sec \times 12 \times 10^5 N/m^2 = 200$ Watts

Shaft power $= \frac{2\pi NT}{60} = \frac{2\pi \times 1500 \times 12.5}{60}$
$= 1963.5$ watts

Overall Efficiency = F.P/S.P
$= \frac{200}{1963.5}$
$= 0.102$ or 10.2%

2.) Q_{actual} = Volume flow rate from the pump
$= 35 dm^3/min$
$= \frac{35 \times 10^{-3}}{60} m^3/sec = 5.8333 \times 10^{-4}$ m^3/s

Pressure change $= \Delta P = 100 bar$
$= 100 \times 10^5 Pa = 100 \times 10^5 N/m^2$

Overall efficiency of pump is given as
$\% = \frac{S_g Q H}{P}$
P = Shaft power
$S_g H = \Delta P$
$\Rightarrow P = \frac{Q \Delta P}{\%} \Rightarrow P =$

$= \frac{5.8333 \times 10^{-4} \times 100 \times 10^5}{0.87}$

P = Shaft power = 6704.98
P = 6.705 watts

3.) Nominal displacement of pump $= 50 cm^3/rev$
Speed of rotation $= 850 rev/min$
(Q) theory = theoritical displacement
= Nominal displacement × Speed of rotation
$= 50 \times 850$
$= 42500 cm^3/min = 42.5 dm^3/min$

Volumetric efficiency $= \frac{Q_{act}}{Q_m}$

$= \frac{35 dm^3/min}{42.5 dm^3/min} \times 100$
$= 82.353\%$

Overall efficiency of the pump is given as $\% = \frac{S_g Q H}{P_{shaft}}$

$S_g H = \Delta P = 100 bar = 100 \times 10^5 N/m^2$
$Q = Q_{actual} = 35 dm^3/min$
$= \frac{35 \times 10^{-3}}{60} = 5.8333 \times 10^{-4} m^3/sec$

(P) shaft $= 15 Kwatts = 15 \times 10^3$ watts

OBI CORNELIUS MOA
18/ENG06/049

$\% = \frac{100\times10^3 \times 5.8333\times10^4}{15\times10^3}\times 100$

$\% = 38.88\%$

4.i) Power of jet $= \frac{1}{2}\rho v^2 Q$

$= \frac{1}{2}\times\frac{1000}{9.81}\times 66^2\times0.13$

$= 28862$ Kgm/sec

$= 28862\times9.81$

$= 283140W = 283.14kW$

ii) At the reservoir, pressure is atmospheric and velocity of free surface is zero, $\rho=0, v=0$

Power supplied from reservoir

$= \rho Q g z = \gamma Q Z$

$= 1000\times0.13\times240$

$= 31200$ kgm/sec

$= 31200\times9.81 = 306072W$

$= 306.072$ KW

iii) If H_1 = Total head at the reservoir

H_2 = Total head at the jet

h = Head loss in transmission

a, power supplied from reservoir

$= \gamma Q H_1 = 31200$ kgm/s

b, = Power of issuing jet $= \gamma Q H_2$

$= 28862$ kgm/sec

a − b = c Power lost in transmission $= \gamma Q h = 2338$ kgm/sec

Head loss in pipe = hz

(power lost) / γQ

$= h = 2338/1000\times0.13$

$h = 17.98m$

$40000 = 416.67Q + 0.0625Q^2$

$\Rightarrow Q = 94.65$ ft/day

5.) $\rho = 890$ Kg/m³

$H = 300m$

$Q = 220L/s = 0.22m^3/s$

$V = 7m/s$

(a) Power of jet P =

$\frac{1}{2}\times\rho Q V^2 = \frac{1}{2}\times890\times0.22\times7^2$

$P = 4797.1$ Watt $= 4.797$ Kw.

b.) Power supplied from reservoir $= \gamma Q H$

$= 890\times0.22\times300$

$= 58740$ Kgm/sec

Power issuing jet $= \frac{1}{2}\rho v^2 Q$

$= \frac{1}{2}\times\frac{890}{9.81}\times7^2\times0.22$

$= 489$ Kgm/s

Power lost in transmission

$= \gamma Q h = 58740 - 489$

$= 58251$ Kgm/s

Or $h = \frac{58251}{890\times0.22} = 297.50m$

d.) $\eta = \frac{\text{power of jet}}{\text{Power supplied}}$

$= \frac{489}{58740} = 0.00832$

$= 0.8324\%$

6.) Power = $\frac{\text{Workdone}}{\text{time}}$

Workdone $= \frac{mgh}{\text{time}}$

OBE CORNELIUS MBA
18/ENG06/049

V = Velocity of stream
ρ = Density of water (1000 kg/m³)
$M = \rho \times V$
$V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 20}$
$= 19.7989 m/s$
$P = \rho \pi M^2 \frac{Vgh}{t}$
$Power = 1000 \times \left(\frac{10 \times 10^{-2}}{2}\right)$
$\times 19.7987 \times 9.8 \times 20$
$= 1000 \times \pi \times 2.5 \times 10^{-3} \times 19.7957$
$\times 20$
$= 30478.03W$
Power = 30478.03W

7.) $\rho_g g = 19.62 N/m^2$
$Cd = 0.96$
$d_1 = 0.3m$
$d_2 = 0.2 m$
Calculate Q
$V_1 = Q/0.0707$, $V_2 = Q/0.0314$
For the Manometer
$P + \rho_g g z = P_2 + P_2 g(z_2 - Rf) +$
$P_w g Rf$
$P_1 - P_2 = 19.62(z_2 - z_1) +$
587.423 —(1)
For the Manometer.
$\frac{P_1}{\rho g g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g g} + \frac{V_2^2}{2g} + z_2$
$P_1 - P_2 = 19.62(z_2 - z_1) +$
$0.803 V_2^2$ — (2)
Combining eqn (1) and (2)
$0.803 V_2^2 =$ ~~5.87~~ 587.423
$V = Ideal = 27.047 m/s$

$Q_{ideal} = 27.047 \times \pi \times \left(\frac{0.2}{2}\right)^2$
$= 0.85 m^3/s$
$Q = Cd\ Q_{ideal} = 0.96 \times 0.85$
$= 0.816 m^3/s$

8.)
$d_1 = 0.152m \Rightarrow A_1 = \frac{\pi}{4}(0.152)^2$
$= 0.01814 m^2$
$d_2 = 0.076m \Rightarrow A_2 = \frac{\pi}{4}(0.076)^2$
$= 0.00454 m$
$\rho = 0.8 \times 1000 = 800 kg/m^3$
$Cd = 0.97$
Applying Bernoullis
$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$
a) $P_1 = P_2$
$\frac{V_1^2}{2g} + z_1 = \frac{V_2^2}{2g} + z_2$
By Continuity
$Q = V_1 A_1 = V_2 A_2$
$V_2 = V_1 \frac{A_1}{A_2} = V_1 4$
$\frac{V_1^2}{2g} + 0.914 = \pm \frac{16(V_1^2)}{2g}$
$V_1 = \sqrt{\frac{0.914 \times 2 \times 9.81}{15}}$
$= 1.0934 m/s$
$Q = Cd\ A_1 V_1 = 0.97 \times (0.01814)$
$\times (1.0934)$
$Q = 0.0192 m^3/s$
b) $P - P_2 = 15170$
$\frac{P_1 - P_2}{\rho g} = \frac{V_2^2 - V_1^2}{2g} - 0.914$
$\frac{15170}{800 \times 9.81}$

OBG CORNELIUS MBA
18/ENG06/047

$= \frac{Q^2(220.43^2 - 55.11^2)}{2 \times 9.8}$

-0.914

$Q = 0.035 m^3/s$

9.) In Section 1

$D_1 = 300mm = 0.3m$

$A_1 = \frac{\pi}{4}(0.3)^2 = 0.070675m^2$

$P_1 = 400 kN/m^2 = 400000 N/m^2$

$Z_1 = 10m$

At Section 2

$D_1 = 0.15m$

$A_2 = \frac{\pi}{4}(0.15)^2 = 0.0177m^2$

$Z_2 = 6m$

$P_2 = ?$

Rate Of Flow Or Discharge

$Q = 40 lit/sec = \frac{40}{1000}$

$= 0.040 m^3/sec$

Now $Q = A_1V_1 = A_2V_2$

$V_1 = \frac{Q}{A_1} = \frac{0.040}{0.070675} = 0.566m/s$

$V_2 = Q/A_2 = \frac{0.040}{0.0177} = 2.2599m/s$

Applying Bernoulli's equation at Section 1 and 2 we get

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

$\frac{400000}{1000 \times 9.81} + \frac{0.566}{2 \times 9.81} + 10$

$= \frac{P_2}{1000 \times 9.81} + \frac{2.2599}{2 \times 9.81} +$

$= 40.77 + 0.0288 + 10 = \frac{P_2}{1000 \times 9.81}$

$+ 6.115$

$\Rightarrow 50.7988 = \frac{P_2}{9810} + 6.115$

$\frac{P_2}{9810} = 50.7988 - 6.115$

$= 44.6838$

$P_2 = 44.6838 \times 9810$

$P_2 = 438348.078 N/m^2$

10.)

Diff Of Mercury level

$x = 170mm = 0.17m$

Sp.gr Of Mercury $S_g = 13.6$

Sp.gr Of Sea water $S_0 = 1.026$

$h = x\left[\frac{S_g}{S_0} - 1\right] = 0.17\left[\frac{13.6}{1.026} - 1\right]$

$= 2.0834m$

$V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.0834}$

$= 6.393m/s$

$= \frac{6.393 \times 60 \times 6}{1000} Km/hr$

$= 23.01 Km/hr$

$$Q = Cd \times \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$$

$$Q = \frac{0.64 \times 0.0176 \times 0.0706 \times \sqrt{2 \times 9.81 \times 9.05}}{\sqrt{(0.0706)^2 - (0.0176)^2}}$$

$$Q = \frac{9.35 \times 10^{-3}}{4.0112}$$

$$Q = 2.33 \times 10^{-3} m/s$$

4) Axis = 15m

170mm Of Mercury (0.17m)

S.G Of Mercury = 13.6

S.G Of Sea Water = 1.026

$V = ?$

$$h = y\left(\frac{Sh_1}{S_L} - 1\right)$$

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

$$h = 2.083m$$

$$V = \sqrt{2gh}$$

$$V = \sqrt{2 \times 9.81 \times 2.083}$$

$$V = 6.39ms^{-1}$$

5) $0.05m^3/min$

$\Delta P = 15 bar$

speed Of rotation = 1700 rev/min

displacement = 100m³/rev

Torque Input = 15N/m

i) Volumetric efficiency

Flow rate = Normal Displacement × 1700

Flow rate = 0.05 × 1700

= $85m^3/min$

ii) Volumetric efficiency

$$= \frac{\text{Actual Flow}}{\text{Ideal Flow}} = \frac{10}{85} = 0.117$$

iii) $Q = \frac{0.05 \times 10^{-3}}{60} = 8.35 \times 10^{-7} m^3/sec$

$\Delta P = 15 \times 10^5 N/m^3$

Fluid power = $\Delta P \times Q$

$= 15 \times 10^5 \times 8.33 \times 10^{-7}$

= 1.249 Watts

iv) Shaft power = $\frac{2\pi NT}{60}$

$$= \frac{2\pi \times 1700 \times 15}{60} = 2670.35W$$

v.) Overall efficiency = $\frac{\text{Fluid power}}{\text{Shaft power}}$

$$\frac{1.2495}{2670.35} = 0.046\%$$