LAWAL MUHAMMAD ABDULAZEEZ 18/ENG03/036
CIVIL ENGINEERING

1. Flowrate (Q) = 10 dm^3/min
Pressure change (ΔP) = 12 bar
Speed (N) = 1500 rpm
Nominal displacement = 10 cm^3/rev
Torque Input (T) = 12.5 Nm

Ideal flowrate = Nominal Displacement x Speed
= 10 cm^3/rev x 1500 rpm
= 15000 cm^3/min = 15 dm^3/min
Volumetric efficiency = Actual flow / Ideal flow
= 10/15 = 0.6667 or 66.67%

$Q = \frac{10 \times 10^{-3}}{60} m^3/sec = 16.7 \times 10^{-5} m^3/sec$

$\Delta P = 12 \times 10^5 N/m^2$
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 = 200/1963.5 = 0.102 or 10.2%

Q = 35 dm^3/min, ΔP = 100 bar = $100 \times 10^5 N/m^2$
Overall Efficiency = 87%,
Shaft power = $\frac{2\pi NT}{60}$

Fluid power = $\Delta P \times Q$
$Q = \frac{35 \times 10^{-3}}{60} = 58.3 \times 10^{-5} m^3/sec$

Fluid power = $58.3 \times 10^{-5} \times 100 \times 10^5$
= 5830 watts

Overall Efficiency = fluid power / Shaft power

$0.87 = \frac{5830}{\text{Shaft power}}$

Shaft power = $\frac{5830}{0.87}$ = 6701.14 watts

3. Nominal Displacement = 50 cm^3/rev
Pressure change (ΔP) = 100 bar
Shaft power = 15 kilowatts = 15000
Overall Efficiency = ?
Volumetric Efficiency = ?
Flowrate (Q) = 35 dm^3/min
Speed (N) = 850 rpm
Ideal flowrate = Nominal displacement x Speed
= 50 cm^3/rev x 850 rpm
= 42500 cm^3/min = 42.5 dm^3/min
Volumetric efficiency = Actual flow / Ideal flow
= 35/42.5 = 0.8235 or 82.35%

$Q = \frac{35 \times 10^{-3}}{60} m^3/sec = 58.3 \times 10^{-5} m^3$

$\Delta P = 100 \times 10^5 N/m^2$
Fluid power = $\Delta P \times Q$ =
= $58.3 \times 10^{-5} m^3/sec \times 100 \times 10^5$
= 5830 watts

Shaft power = 15000 watts
Overall Efficiency = fluid power / Shaft power

= $\frac{5830}{15000}$ = 0.3881 or 38.8[illegible]

4. H = 240m, Q = 0.013 m^3/s, V = 66m[illegible]
a. Power of jet (P_{jet}) = $\frac{1}{2} m v_{jet}^2$
= $\frac{1}{2} \rho Q v_{jet}^2$
= $\frac{1}{2} \times 1000 \times 0.013 \times 66^2$ Watt
= 28314 or 28.314 Kilowatts

b. Power Supplied by (P_{s}) reservoir = [illegible]
= $\rho Q g h$ = 1000 x 0.013 x 9.8[illegible]
= 30607.2 or 30.607K[illegible]

3. Nominal displacement = 50 cm^3/rev
Pressure change (ΔP) = 100 bar
Shaft power = 15 Kilowatts = 15000
Overall Efficiency = ?
Volumetric Efficiency = ?
Flowrate (Q) = 35 dm^3/min
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= 50 cm^3/rev × 850 rpm
= 42500 cm^3/min = 42.5 dm^3/min
Volumetric efficiency = Actual flow / Ideal flow
= 35 / 42.5 = 0.8235 or 82.35%

ii. $Q = \frac{35 \times 10^{-3}}{60} m^3/sec = 58.3 \times 10^{-5} m^3/sec$

$\Delta P = 100 \times 10^5 N/m^2$
Fluid power = $\Delta P \times Q$ =
= $58.3 \times 10^{-5} m^3/sec \times 100 \times 10^5$
= 5830 watts

Shaft power = 15000 watts
Overall Efficiency = $\frac{\text{fluid power}}{\text{Shaft power}}$

$= \frac{5830}{15000} = 0.3886$ or 38.86%

4. H = 240m, Q = 0.013 m^3/s, V = 66m/sec
a. Power of jet (P_{jet}) = $\frac{1}{2} m v_{jet}^2$
= $\frac{1}{2} \rho Q V_{jet}^2$
= $\frac{1}{2} \times 1000 \times 0.013 \times 66^2$ Watt
= 28314 or 28.314 Kilowatts

b. Power Supplied by (P_{in}) reservoir = mgh
= $\rho Q g h$ = 1000 × 0.013 × 9.81 × 240
= 30607.2 or 30.6072 Kilowatts

c) Head need to overcome losses (H_L)
$= H - \frac{V_{jet}^2}{2g}$

$= 240 - \frac{66^2}{2 \times 9.81} = 17.98m$

d) Efficiency of pipeline & nozzle = $\frac{P_{jet} \times 100}{P_{in}}$

$= \frac{28.314}{30.6072} \times 100 = 92.51\%$

5) Z_1 = 35,000 cm = 300m, V_2 = 7m/s
Q = 220 litres/s = $(220 \times 10^{-3}) m^3/s$

Power of Jet = $\rho g Q H$
where $\rho = 0.89 \times 1000 = 890 Kg/m^3$
$g = 9.81 m/s^2$
$Q = (220 \times 10^{-3}) m^3/s$

$H = Z_2 + \frac{P}{\rho g} + \frac{V^2}{2g}$

$H = 0 + \frac{0}{\rho g} + \frac{(7)^2}{2 \times 9.81}$

$H = 49/19.62 = 2.497$

$890 \times 9.81 \times 220 \times 10^{-3} \times 2.497$
= 4797.1 watts

Power supplied from reservoir

$H = Z_1 + \frac{P}{\rho g} + \frac{V^2}{2g} = 300 + \frac{0}{\rho g} + \frac{0}{2g}$

= 300 J
Power = $890 \times 9.81 \times 220 \times 10^{-3} \times 300$
= 576239.4 Kgm/sec

iii) Head need to overcome the loss
= Power loss / $\rho g Q$
= $(576239.4 - 4797.1) / 1000 \times 9.81 \times 220 \times 10^{-3}$
= 571442.3 / 2158.2 = 264.7772681

8) $A_1 = \pi/4\, D_1^2 = \pi/4\,(0.152)^2 = 0.018146\, m^2$

$A_2 = \pi/4\, D_2^2 = \pi/4\,(0.076)^2 = 4.5365 \times 10^{-3}\, m^2$

$\Rightarrow Q = \frac{C_d A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$= \frac{0.97 \times 0.018146 \times 4.5365 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 0.19}}{(0.018146)^2 - (4.5365 \times 10^{-3})^2}$

$Q = 0.0193\, m^3/s$

9) $h = \left(\frac{P_1 - P_2}{\rho g}\right) = \frac{15170}{0.8 \times 10^3 \times 9.81} = 1.933\, m$

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

$= \frac{0.97 \times 0.018146 \times 4.5365 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 1.933}}{\sqrt{(0.018146)^2 - (4.5365 \times 10^{-3})^2}}$

$= 0.02798\, m^3/$

7) $d_1 = 300mm = 0.3m$, $d_2 = 150mm = 0.15m$

$A_1 = \pi d_1^2/4 = 0.0707 m^2$ $A_2 = \pi d_2^2/4$

$= 0.177 m^2$

$Q = 40 L/s = (40 \times 10^{-3}) m^3/s$

$Z_1 = 10m$, $Z_2 = 6m$, $P_2 = ?$, $P_1 = 400 KN/m^2$

$Q = VA$

$V_1 A_1 = Q = 40 \times 10^{-3} = V_1 (0.0707)$

$V_1 = 0.5658\, m/s$

$V_2 = (40 \times 10^{-3}) / 0.0177 = 2.2599\, m/s$

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

$10 + \frac{400000}{9.81 \times 1000} + \frac{(0.5658)^2}{2(9.81)} = 6 + \frac{P_2}{9810000} + \frac{(2.2599)^2}{2 \times 9.81}$

$50.79 = \frac{P_2}{\ldots} + 6.260303$

10) $h = y\left[\frac{S_m}{S_f} - 1\right]$

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

$h = 2.0834$

$V = \sqrt{2gh}$

$= 2 \times 9.81 \times 2.0834$

$= 6.393\ m/sec$

5. Efficiency = Power of jet / Power of pressure × 100

$= \frac{4797.1 \times 100}{576225.4} = 0.8325$

6. $P_{max} = \frac{\text{work done}}{\text{time}}$

work done $= \frac{mgh}{\text{time}}$

V = Velocity of stream

ρ = density of water (1020kg/m³)

$m = \rho \times V$

$v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 20} = 19.7989\,m/s$

$P = \frac{\rho \pi r^2 v g h}{t}$

$P_{max} = \frac{1020\,kg}{m^3} \times \left(\frac{10 \times 10^{-2}}{2}\right) \times 19.7989\,m/s \times 9.81\,m/s^2 \times 20\,m$

$= 1020 \times \pi \times 2.5 \times 10^{-3} \times 19.7989 \times 9.81 \times 20$

$= 30475.03\,W$

7. Diameter $(D_1) = 0.3\,m$, $C_d = 0.96$, $\gamma = 19.62\,kN/m^3$

$A_1 = \pi/4 \times 0.3^2 = 0.070685\,m^2$

Throat diameter $(D_2) = 0.2\,m$

$\therefore A_2 = \pi/4 = (0.2)^2 = 0.031416\,m^2$

$S_g = \frac{19.62}{9.81} = 2\,kg/m^3$

$h = x\left(\frac{S_m}{S_g} - \right) = 0.06 \times \left(\frac{1000}{2} - 1\right)$

$h = 29.94\,m$

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

$= \frac{0.96 \times 0.070685 \times 0.031416 \sqrt{2 \times 9.81 \times 29.94}}{\sqrt{(0.070685)^2 - (0.031416)^2}}$

$Q = 0.81599\,m^3/s$

8) $A_1 = \pi/4\,D^2 = \pi/4 (0.152)^2 = 0.018146\,m^2$

$A_2 = \pi/4\,D_2^2 = \pi/4 (0.076)^2 = 4.5365 \times 10^{-3}\,m^2$

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

$= \frac{0.97 \times 0.018146 \times 4.5365 \times 10^{-3} \times \sqrt{2 \times 9.81 \times [illegible]}}{(0.018146)^2 - (4.5365 \times 10^{-3})^2}$

$Q = 0.0192\,m^3/s$

ii) $h = \left(\frac{P_1 - P_2}{\rho g}\right) = \frac{15170}{0.88 \times 10^3 \times 9.81} = 1.757\,m$

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

$= \frac{0.97 \times 0.018146 \times 4.5365 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 1.757}}{\sqrt{(0.018146)^2 - (4.5365 \times 10^{-3})^2}}$

$= 0.02798\,m^3/$

9) $d_1 = 300\,mm = 0.3\,m$, $d_2 = 150\,mm = 0.15\,m$

$A_1 = \pi d_1^2/4 = 0.0707\,m^2$, $A_2 = \pi d_2^2/4$

$= 0.177\,m^2$

$Q = 40\,l/s = (40 \times 10^{-3})\,m^3/s$

$Z_1 = 10\,m$, $Z_2 = 6\,m$, $P_2 = ?$, $P_1 = 400\,kN/m^2$

$Q = VA$

$V_1 A_1 = Q = 40 \times 10^{-3} = V_1 (0.0707)$

$V_1 = 0.5658\,m/s$

$V_2 = (40 \times 10^{-3}) / 0.0177 = 2.2599\,m/s$

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

$10 + \frac{400000}{9.81 \times 1000} + \frac{(0.5658)^2}{2(9.81)} = 6 + \frac{P_2}{9.81 \times 1000} + \frac{(2.259)^2}{2 \times 9.81}$

$50.79 = \frac{P_2}{9.81 \times 1000} + 6.260303$

$P_2 = (9.81 \times 1000)(44.53$

$P_2 = 436.836\,kN/m^2$

10) $h = y\left[\frac{S_m}{S_f} - 1\right]$

$= 0.17\left[\frac{13.6}{1.026}\right.$

$h = 2.0534$

$v = \sqrt{2gh}$

$= 2 \times 9.81$

$= 6.353$