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DEPARTMENT: CHEMICAL ENGINEERING

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

Ideal flowrate = Normal 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%

ii. $Q = \frac{12 \times 10^{-3}}{60} m^3/sec = 16.7 \times 10^{-5} m^3/sec$
$\Delta P = 12 \times 10^5 N/m^2$
Fluid power = $\Delta p \times Q$ = $16.7 \times 10^{-5} m^3/sec \times 12 \times 10^5 N/m^2$ = 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%

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

3. Normal Displacement =
Pressure change (ΔP) =
Shaft power = 15 kilowatts
Overall Efficiency = ?
Volumetric Efficiency = ?
Flowrate (Q) = 35 dm
Speed (N) = 850 rpm
Ideal flowrate = Norm
= 50 cm^3/rev
= 42500 cm^3
Volumetric efficiency =
= 35/42.5 =

ii. $Q = \frac{35 \times 10^{-3}}{60}$
$\Delta P = 100 \times 10^5$
Fluid power = ΔP
= $58.3 \times 10^{-5} m^3$
= 5830 watts

Shaft power = 150
Overall Efficiency =
= $\frac{5830}{15000}$ = 0.

4. H = 240m, Q = 0.
a. Power of jet
= ½ PQV^2
= ½ x 1000 x 0.
= 28314

b. Power Supplied by
= $PQgh$
= 30607.

5. Nominal displacement = 50 cm³/rev
Pressure drop (ΔP) = 100 bar
Shaft power = 15 Kilowatts = 15000
Overall efficiency = ?
Volumetric Efficiency = ?
Flowrate (Q) = 35 dm³/min
Speed (N) = 850 rpm
Ideal flowrate = Nominal displacement × Speed
= 50 cm³/rev × 850 rpm
= 42500 cm³/min = 42.5 dm³/min
Volumetric efficiency = Actual flow / Ideal flow
= 35 / 42.5 = 0.8235 or 82.35%

ii) $Q = \frac{35 \times 10^{-3}}{60}$ m³/sec = 58.3 × 10⁻⁵ m³/sec

ΔP = 100 × 10⁵ N/m²
Fluid power = ΔP × Q =
= 58.3 × 10⁻⁵ m³/sec × 100 × 10⁵
= 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 = 240 m, Q = 0.013 m³/s, V = 66 m/sec
a. Power of jet (P_{jet}) = ½ m v^2_{jet}
= ½ ρ Q V^2_{jet}
= ½ × 1000 × 0.013 × 66² Watt
= 28314 or 28.314 Kilowatts

b. Power Supplied by (P_{in}) reservoir = mgh
= ρQgh = 1000 × 0.013 × 9.81 × 240
= 30607.2 or 30.6072 Kilowatts

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

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

d) Efficiency of pipeline of nozzle = $\frac{P_{jet\ loss}}{P_{in}}$

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

5) Z_1 = 30,000 cm = 300 m, V_2 = 7 m/s
Q = 220 l/s = (220 × 10⁻³) m³/s

Power of Jet = ρgQH
where ρ = 0.89 × 1000 = 890 kg/m³
g = 9.81 m/s²
Q = (220 × 10⁻³) m³/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 = 2.4974

890 × 9.81 × 220 × 10⁻³ × 2.497
= 4797.1 watts

Power supplied from reservoir
$H = Z + \frac{P}{\rho g} + \frac{V^2}{2g} = 300 + \frac{0}{\rho g} + \frac{0}{2g}$
= 300 J
Power = 890 × 9.81 × 220 × 10⁻³ × 300
= 576239.4 kgm/sec

m) Head used to overcome the loss
= Power loss / ρgQ
= (576239.4 − 4797.1) / 1000 × 9.81 × 220 × 10⁻³
= 571442.3 / 2158.2 = 264.7772681

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

$= \frac{4797.1 \times 100}{576239.4} = 0.8325$

6. Power = work done / time

work done = mgh / time

V = Velocity of stream

ρ = density of water (1000 kg/m³)

m = ρ × V

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

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

Power $= \frac{1000\ kg}{m^3} \times \left(\frac{10 \times 10^{-3}}{2}\right) \times 19.7989\ m/s \times 9.81\ m/s^2 \times 20\ m$

$= 1000 \times \pi \times 2.5 \times 10^{-5} \times 19.7989 \times 9.81 \times 20$

$= 30478.03\ W$

7. Diameter (D_1) = 0.3 m, Cd = 0.96, x = 19.62 kN/m²

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

Throat diameter (D_2) = 0.2 m

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

$\rho g = \frac{19.62}{9.81} = 2\ kg/m^3$

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

$h = 29.94\ m$

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) $A_1 = \pi/4\, D_1^2 = \pi/4 (0.153)^2 = 0.018846\ m^2$

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

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

$= \frac{0.97 \times 0.018846 \times 4.5365 \times 10^{-3} \times \sqrt{2 \times 9.81 \times ...}}{(0.018846^2 - (4.5365 \times 10^{-3})^2)}$

$Q = 0.0192\ m^3/s$

ii) $h = \left(\frac{P_1 - P_2}{\rho g}\right) = \frac{15170}{0.87 \times 10^3 \times 9.81} = 1.988\ m$

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

$= \frac{0.97 \times 0.018846 \times 4.5365 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 1.988}}{\sqrt{(0.018846)^2 - (4.5365 \times 10^{-3})^2}}$

$= 0.02798\ m^3/$

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

$A_1 = \pi d_1^2/4 = 0.0707\ m^2$, $A_2 = \pi d_2^2/4 = 0.177\ m^2$

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

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

$Q = VA$

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

$V_1 = 0.5658\ m/s$

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

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

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

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

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

$P_2 = 436.836\ kN/m^2$

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

$= 0.12\left[\frac{13.6}{1.026} ...\right]$

$h = 2.0834$

$v = \sqrt{2gh}$

$= 2 \times 9.81 ...$

$= 6.393$

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

$A_2 = \pi/4\, D_2^2 = \pi/4 (0.076)^2 = 4.5363 \times 10^{-3} m^2$

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

$= \frac{0.97 \times 0.01846 \times 4.5363 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 0.14}}{(0.018146)^2 - (4.5365 \times 10^{-3})^2}$

$Q = 0.0192 m^3/s$

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

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

$= \frac{0.97 \times 0.018146 \times 4.5363 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 1.933}}{\sqrt{(0.018146)^2 - (4.5363 \times 10^{-3})^2}}$

$= 0.02798 m^3/$

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

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

$= 0.177 m^2$

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

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

$Q = VA$

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

$V_1 = 0.5658 m/s$

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

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

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

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

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

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

$h = 2.0834$

$V = \sqrt{2gh}$

$= 2 \times 9.81 \times 2.0834$

$= 6.393 m/sec$