18/ENG05/005
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1 Actual flowrate = 10 dm/min = 0.01 m³/min = 1.67×10^{-4} m³/sec

speed N = 1500 rev/min

$= \frac{1500}{60} = 25$ rev/sec ≃ 25 rps

$\Delta P = 12$ bar ≃ 12×10^5 Nm^{-2}

Nominal displacement = 10 cm³/rev = 10×10^{-6} m³/rev

Ideal flow rate = nominal displacement × speed

$= 25 \times 10 \times 10^{-6} = 2.5 \times 10^{-4}$ m³/sec

(i) Volumetric Efficiency = $\frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100\%$

$= \frac{1.67 \times 10^{-4}}{21.5 \times 10^{-4}} \times 100 = 66.8\%$

(ii) Fluid Power = $Q \cdot \Delta P$

$= 1.67 \times 10^{-4} \times 12 \times 10^5 = 200.4$ watts

(iii) Shaft Power = $T \cdot \omega$

$T = 12.5$ Nm

$\omega = \frac{2\pi N}{60}$

$= 2 \times \frac{22}{7} \times 25 = 157.14$ rad/sec

Shaft Power = 12.5×157.14

$= 1964.25$ watts

(iv) Overall Efficiency = $\frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100\%$

$= \frac{200.4}{1964.25} \times 100$

$= 10.2\%$

2) Change in Pressure $\Delta P = 100bar \simeq 100 \times 10^5 N/m^{-2}$

Flowrate $= 35 dm^3 min^{-1}$

$= \frac{35}{1000 \times 60} = 5.83 \times 10^{-4} m^3 sec^{-1}$

Fluid Power = Flowrate × change in Pressure

$= 5.83 \times 10^{-4} \times 100 \times 10^5$

$= 5830$ watts

recall overall Efficiency $= \frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100$

Shaft Power $= \frac{FP \times 100\%}{\text{Overall Efficiency}}$

$= \frac{5830 \times 100}{87}$

$= 6701.15$ watts

3) Normal displacement $= 50cm^3 rev = 50 \times 10^{-6} m^3/rev$

Actual Flowrate $= 35dm^3/min = 5.83 \times 10^{-4} m^3/sec$

$\Delta P = 100 bar \simeq 100 \times 10^5 Nm^{-2}$

Shaft Power = 15kw = 15000 watts

(i) overall Efficiency $= \frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100$

Fluid Power $= Q \times \Delta P = 5.83 \times 10^{-4} \times 100 \times 10^5 = 5830$ watts

$\therefore$ O.E $= \frac{5830}{15,000} \times 100 = 38.67\%$

Ideal flowrate = nominal displacement × Speed

speed = 850rPm = 14.17rPs $= \frac{850}{60}$

Ideal flowrate $= 50 \times 10^{-6} \times 14.17$

$= 7.085 \times 10^{-4} m^3/sec$

4 $z = 240000m$

$z = 240m$

Volumetric flowrate $Q = 13$ litres/sec

1000 litres $= 1m^3$

$Q = \frac{13}{1000}$ $Q = 13 \times 10^{-3} m^3/sec$

Velocity of Jet $= 66m/sec$

At datum level $P = 0$ and $z = 0$

(i) Power of Jet

Since its at datum level

$P = 0$, $z = 0$ Sub into eq.

$P = PQ + \frac{\rho Q}{2}v^2 + \rho Q\, gz$

$= \frac{\rho Q\, v^2}{2}$

$= \frac{1000 \times 13 \times 10^{-3} \times (66)^2}{2} = 28314$ watts

(ii) Power from reservoir

Here $P = 0$ and $v = 0$

Substitute into equation

$P = PQ + \frac{\rho Q v^2}{2} + \rho g Q z = \rho g Q z$

$= 1000 \times 9.81 \times 13 \times 10^{-3} \times 240$

$=$ ~~306~~ 30607.2 watts

(iii) Head loss in Pipeline (h)

$h = \frac{\text{Power lost in transmission}}{\rho g Q}$

But Power lost in transmission = Power of reservoir − Power of Jet

$= 30607.2 - 28314 = 2293.2$ watts

$h = \frac{2293.2}{1000 \times 9.81 \times 13 \times 10^{-3}} = 17.98m$

(iv) Effiency $= \frac{P \text{ of Jet}}{P \text{ of reservoir}} \times 100\%$ $= \frac{28314}{30607.2} \times 100$

$= 92.5\%$

9 Z 2 30,000 $z = 300m$ 7

volumetric flow rate (Q) = 220 litres/sec = $0.22 m^3/sec$

velocity of jet = 7 m/sec

$S.g = 0.89$

$$S.g = \frac{\text{density of fluid}}{\text{density of pure water}}$$

$$\rho = S.g \times 1000 = 0.89 \times 1000 = 890 Nm^{-2}$$

At datum level

(i) Power of jet $P = 0$ and $z = 0$

$$P = PQ + \frac{\rho Q v^2}{2} + \rho g Q z$$

$$= \frac{\rho Q v^2}{2} = \frac{890 \times 0.22 \times (7)^2}{2}$$

$$= 4797.1 \text{ watts}$$

(ii) Power from reservoir

$P = 0, v = 0$

$$P = PQ + \frac{\rho Q v^2}{2} + \rho g Q z$$

Becomes

$$= \rho g Q z$$

$$= 890 \times 9.81 \times 0.22 \times 300$$

$$= 576239.4 \text{ watts}$$

(iii) Head loss in pipe line

$$h = \frac{\text{Power lost in transmission}}{\rho g Q}$$

Power lost in transmission = Power of reservoir − Power of jet

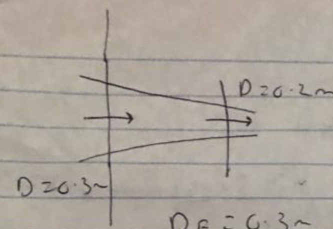
$= 576239.4 - 4797.1 = 571442.3$ watts

$$h = \frac{571442.3}{890 \times 9.81 \times 0.22} = \frac{571442.3}{1920.798} \quad h = 297.5m$$

(iv) Efficiency = $\frac{\text{Power of jet}}{\text{Power of reservoir}} \times 100$

$$= \frac{4797.1}{576239.4} \times 100 = 0.832\%$$

7)



$D_E = 0.3m$

$A_E = \frac{\pi d^2}{4} = \frac{\pi (0.3)^2}{4} = 0.0707m^2$

$D_T = 0.2m$

$A_T = \frac{\pi d^2}{4} = \pi (0.7)^2 = 0.0314m^2$

$\Delta P = 0.06m$

$Cd = 0.96 \quad w = 19.62$

$Q = \frac{C d A_E A_T \sqrt{2gh}}{\sqrt{(A_E - A_T)^2}} \qquad h = \frac{\Delta P}{w} = \frac{0.06}{19.62} = \frac{1}{327}$

$= \frac{0.97 \times 0.0707 \times 0.0314 \sqrt{2 \times 9.81 \times \frac{1}{327}}}{\sqrt{(0.0707^2 - 0.0314^2)}}$

$= \frac{2.13 \times 10^{-3} \times \sqrt{006}}{\sqrt{4.01 \times 10^{-3}}} = 8.24 \times 10^{-3}$

$Q = 8.24 \times 10^{-3} = 0.00824$

6) $h = 20m \quad d = 10cm = 0.1m$

$A = \frac{\pi}{4} d^2 = 0.7854 \quad V_f = 0 \quad w = ?$

$v_f^2 = v_1^2 - 2gh$

$v_1 = \sqrt{v_f^2 + 2gh}$

$v_1 = \sqrt{0^2 + 2(9.8m/s^2)(20m)} = 19.80m/s$

$Q = VA = (19.80)(7.854 \times 10^{-3} m^2) = 0.15 m^3/s$

$w = \rho g Q h$

$= (1000) \times 9.8) \times (0.155) \times (20)$

$= 30478 \ kg\, m^2/s^2$

$= 30 \times 10^3 w$

9 $D_1 = 300mm \approx 0.3m$

$A_1 = \frac{\pi d^2}{4} = \frac{\pi (0.3)^2}{4} = 0.071m^2$

$D_2 = 150mm \approx 0.15$, $A_2 = \frac{\pi d^2}{4} = \frac{\pi (0.15)^2}{4} = 0.0177m^2$

$Q = 40 \, lit/sec \approx 0.04 m^3/sec$

$Z_1 = 10m \quad Z_2 = 6m$

$P_2 = ? \quad P_1 = 400 kN/m^2 \approx 400 \times 10^3 N/m^2$

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

$Q = V_1 A_1 \quad V = \frac{Q}{A}$

$V_1 = \frac{0.04}{0.071} = 0.563 ms^{-1}$, $V_2 = \frac{0.04}{0.0177} = 2.26 ms^{-1}$

$w = \rho g = 1000 \times 9.81$
$= 9810$

$$\frac{400 \times 10^3}{9810} + 10 + \frac{(0.563)^2}{2 \times 9.81} = \frac{x}{9810} + 6 + \frac{(2.26)^2}{2 \times 9.81}$$

$$50.791 = \frac{x}{9810} + 6.26$$

$$P_2 = x = \frac{50.791 - 6.26}{9810}$$

$$P_2 = 4.56 \times 10^{-3} Nm^3$$

10 question 1a $\quad V = \sqrt{2gh} \quad h = y \left[\frac{S.g \text{ of mercury}}{S.g \text{ of liquid}} - 1\right]$

$y = 170 mmHg \approx 0.17 mHg$

S.g of Hg $= 13.6$

Sg of liquid [seawater] $= 1.026$

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

$h = 2.083$

$V = \sqrt{2gh}$
$= \sqrt{2 \times 9.81 \times 2.083}$
$= 6.39 ms^{-1}$