Q.2(b) The velocity of air at throat of venturi is given by,

COP code: 25265

$$V_a = C_{ov}\sqrt{2 C_p T_1 \left[1-\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}\right]}$$

$$92 = 0.8\sqrt{2\times 1000\times 300\left[1-\left(\frac{P_2}{P_1}\right)^{\frac{1.4-1}{1.4}}\right]}$$

$$\therefore \frac{P_2}{P_1} = (1-0.022)^{\frac{1}{0.286}} = 0.925$$

$$P_2 = 0.937 \text{ bar}$$

Considering flow to be isentropic,

$$P_1 v_1^{\gamma} = P_2 v_2^{\gamma}$$

$$\therefore v_2 = v_1\left(\frac{P_1}{P_2}\right)^{\frac{1}{1.4}} = 0.898 \text{ m}^3/\text{kg}$$

The mass flow rate of air is given by,

$$m_a = \frac{A_a V_a}{v_2}$$

$$\therefore A_a = \frac{m_a \cdot v_2}{V_a} = \frac{6\times 0.898}{60\times 92} = \frac{\pi}{4}\left(\frac{d_a}{100}\right)^2$$

$$\therefore \boxed{d_a = 3.52 \text{ cm}}$$

Pressure drop at venturi $= P_1 - P_2 = 1.013 - 0.937 = 0.076$ bar

Pressure drop at fuel nozzle $= 0.75 \times 0.076 = 0.057$ bar

$\therefore$ The mass flow of fuel is given by,

$$m_f = A_f \cdot C_{df} \times \sqrt{2\rho_f (P_1 - P_2)}$$

$$\frac{0.45}{60} = A_f \times 0.6 \times \sqrt{2\times 740\times 0.057\times 10^5}$$

$$\frac{0.45}{60} = A_f \times 0.6 \times 2904.5$$

$$\frac{0.45}{60} = \frac{\pi}{4} d_f^2 \times 0.6 \times 2904.5$$

$$\boxed{d_f = 2.34 \text{ mm}}$$

Q.3(b)

Heat supplied (Q_s) $= \dot{m}_f \times CV$

$= 0.187 \times 42600 = 7966.2$ kJ/min (100%)

Heat carried away by Jacketed water (Q_j) $= \frac{32}{100} \times 7966.2 = 2549.184$ kJ/min (32%)

Heat rejected in calorimeter (Q_c) $= m c_p \Delta T$

$= \frac{580}{60} \times 4.186 \times 36.$

$= 1456.72$ kJ/min (18.28%)

Heat Equivalent to BP (Q_{BP}) $= 42 \times 60 = 2520$ kJ/min (31.63%)

$\frac{\dot{m}_a}{\dot{m}_f} = \frac{18}{1}$ $\therefore$ $\dot{m}_a = 18 \times \dot{m}_f = 18 \times 0.187$

$= 3.366$ kg/min.

$\therefore$ $\dot{m}_g = \dot{m}_a + \dot{m}_f = 3.366 + 0.187$

$= 3.553$ kg/min

$\therefore$ Heat carried away by exhaust gases (Q_g) $= \dot{m}_g \times C_{p_g} \times \Delta T$

$= 3.553 \times 1.05 \times (98-20)$

$= 290.9907$ kJ/min. (3.65%).

$\therefore$ Unaccounted losses = Heat supplied $- [Q_{BP} + Q_j + Q_c + Q_g]$

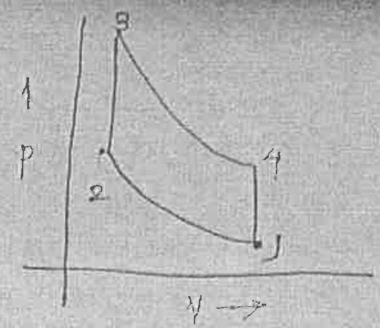
$= 1143.106$ kJ/min. (14.34%)

Q.6(a)

$P_1 V_1 = m R T_1$

$1 \times 10^5 \times V_1 = 1 \times 287 \times 373$

$V_1 = 1.07\ m^3$



For 1-2

$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$

$\therefore P_2 = P_1 \left(\frac{V_1}{V_2}\right)^{\gamma} = 1 \times 8^{1.4} = \underline{18.4\ bar}$

Also, $V_2 = \frac{V_1}{CR} = \frac{1.07}{8} = \underline{0.134\ m^3}$

Similarly, $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \quad \therefore T_2 = \frac{P_2 V_2 T_1}{P_1 V_1} =$

$\therefore T_2 = \frac{18.4 \times 0.134}{1 \times 1.07} \times 373 = \underline{859.5\ K}$

For 2-3

$V_3 = V_2 = 0.134\ m^3$ & $P_3 = 50\ bar$

$\therefore \frac{P_2}{T_2} = \frac{P_3}{T_3} \quad \therefore \underline{T_3 = 2335.5\ K}$

For 3-4

$P_3 V_3^{\gamma} = P_4 V_4^{\gamma} \quad \therefore P_4 = P_3 \left(\frac{V_3}{V_4}\right)^{\gamma} = P_3 \times \left(\frac{V_3}{V_4}\right)^{1.4}$

$\therefore P_4 = 50 / 8^{1.4}$

$\therefore \underline{P_4 = 2.72\ bar}$

Also, $\frac{P_1}{T_1} = \frac{P_4}{T_4}$

$\therefore \underline{T_4} = \frac{P_4}{P_1} \times T_1 = \frac{2.72}{1} \times 373 = \underline{1014.5\ K}$

Heat supplied $(Q_S) = C_V (T_3 - T_2) = 1062.7\ kJ/kg$

& Heat Rejected $(Q_R) = C_V (T_4 - T_1) = 462\ kJ/kg$

$\therefore \frac{Q_R}{Q_S} = \frac{462}{1062.7} = \underline{0.435}$