1. $B = 12.9\ cm,\ S = 18\ cm,\ N = 800\ RPM,\ \tau = 76\ N\text{-}m.$

$$V_d = \frac{\pi}{4} B^2 S = \frac{\pi}{4} \times 12.9^2 \times 18\ cm^3 = 2352.6\ cm^3$$

$$\dot{m}_f = \frac{0.113\ kg}{4\ min} = \frac{0.113\ kg}{4 \times 60\ secs} = 4.7 \times 10^{-4}\ kg/sec$$

$$= \frac{113\ gm}{\frac{4}{60}\ hr} = 1695\ \frac{gm}{hr}.$$

(a) ~~brake~~ brake power $\dot{W}_b = \frac{2\pi N}{60} \times \tau$

$$= \frac{2 \times \pi \times 800}{60} \times \frac{76}{1000}\ kW = 6.37\ kW$$

(b) Average piston speed $= 2SN/60$

$$= 2 \times \frac{18}{100} \times \frac{800}{60}\ m/s = 4.8\ m/s$$

(c) A/F ratio $= 18$.

$\therefore\ \dot{m}_a / \dot{m}_f = 18$

$\therefore\ \dot{m}_a = 18 \times \dot{m}_f = 18 \times 4.7 \times 10^{-4}\ kg/sec = 8.46 \times 10^{-3}\ kg/sec.$

$$\eta_v = \frac{\dot{m}_a}{V_d \times \rho_a \times \frac{N}{120}}\ ; \quad \rho = \frac{101}{0.287 \times 300}\ kg/m^3 \quad \because\ P_a = 101\ kPa$$

$$= 1.17\ kg/m^3$$

$T_a = 27°c$

$= 300\ K$

$R = 0.287\ \frac{kJ}{kg K}$

$$= \frac{8.46 \times 10^{-3}}{2352.6 \times 10^{-6} \times 1.17 \times \frac{800}{120}}$$

$= 0.46 = 46\%$

(d) $bsfc = \frac{\dot{m}_f}{\dot{W}_b} = \frac{1695\ gm/hr}{6.37\ kW} = 266\ \frac{gm}{kW\text{-}hr}$

(e) $bmep = \frac{\dot{W}_b}{V_d \times \frac{N}{120}} = \frac{6.37\ kW}{2352.6 \times 10^{-6} \times \frac{800}{120}} = 406\ kPa.$

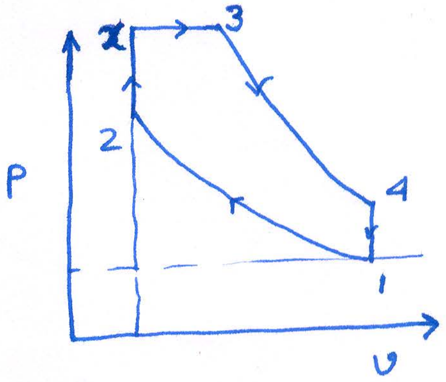
Q.2

Number of cylinders = 6. Total volume = 3.3 liter.

$\therefore V_d$ = Displacement volume of each cylinder

$= \frac{3.3}{6} L = 0.55L$

r_c = compression ratio = 14.



$\therefore 14 = \frac{V_d+V_c}{V_c}$, V_c = clearance volume.

$= \frac{V_d}{V_c} + 1$

$\frac{V_d}{V_c} = 14-1 = 13$

$V_c = \frac{V_d}{13} = \frac{0.55}{13} L = 0.0423L$

$\therefore V_1 = V_d + V_c = 0.55 + 0.0423$

$= 0.5923L$

$P_1 = 101$ kPa

$T_1 = 60^0C = 60+273 = 333K$

$m_m = \frac{P_1V_1}{RT_1} = \frac{101\times10^3 \times 0.5923\times10^{-3}}{287\times333}$

$= 6.26\times10^{-4}$ kg

$P_1v_1^{\gamma} = P_2v_2^{\gamma}$. $\frac{P_2}{P_1} = \left(\frac{v_1}{v_2}\right)^{\gamma} = 14^{1.35} = 35.26$ $P_2 = 3561$ kPa

$T_1v_1^{\gamma-1} = T_2v_2^{\gamma-1} \Rightarrow \frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{\gamma-1} = r_c^{\gamma-1} = 14^{0.35} = 2.52$

$T_2 = 839.2K$

$\frac{A}{F} = 20.$ $m_a + m_f = 6.26\times10^{-4}$

$m_f\left(\frac{m_a}{m_f}+1\right) = 6.26\times10^{-4}$

$m_f(20+1) = 6.26\times10^{-4}$

$m_f = 2.98\times10^{-5}$ kg

$Q_{HV} = 42000$ kJ/kg

$C_v = \frac{R}{\gamma-1} = 0.82$ kJ/kg-K

$C_p = \frac{\gamma R}{\gamma-1} = 1.107$ kJ/kg-K

Half of the heat addition in process 2-x

$\therefore \frac{1}{2}\times m_f \times 42000 = m_m C_v(T_x - T_2)$

$\frac{1}{2}\times 2.98\times10^{-5} \times 42000 = 6.26\times10^{-4} \times 0.82 \times (T_x - 839.2)$

$0.6258 = 5.1332\times10^{-4} \times (T_x - 839.2)$

$T_x - 839.2 = 1233.6$ $T_x = 2058.3K.$

$\frac{P_x}{P_2} = \frac{T_x}{T_2} \Rightarrow P_x = P_2 \times \frac{T_x}{T_2} = 3561 \times \frac{2058.3}{839.2} = 8734$ kPa

Process x-3: $\frac{1}{2}\times m_f \times 42000 = m_m C_p(T_3 - T_x)$

$\frac{1}{2}\times 2.98\times10^{-5} \times 42000 = 6.26\times10^{-4} \times 1.107 \times (T_3 - 2058.3)$

$0.6258 = 6.93\times10^{-4} \times (T_3 - 2058.3)$

$T_3 = 2961.6K$; $\frac{V_3}{V_x} = \frac{T_3}{T_x} = 1.44$; $V_3 = 0.0609$ L

$P_3 V_3^{\gamma} = P_4 V_4^{\gamma}$

$$\left(\frac{P_4}{P_3}\right) = \left(\frac{V_3}{V_4}\right)^{\gamma} = \left(\frac{0.0609}{0.5923}\right)^{1.35} = 0.0464$$

$P_4 = 405$ kPa

$T_3 V_3^{\gamma-1} = T_4 V_4^{\gamma-1}$

$$\frac{T_4}{T_3} = \left(\frac{V_3}{V_4}\right)^{\gamma-1} = \left(\frac{0.0609}{0.5923}\right)^{1.35-1} = 0.451$$

$T_4 = 1336$ K

$P_1 = 101$ kPa, $T_1 = 333$ K

$P_2 = 3561$ kPa, $T_2 = 839.2$ K

$P_x = 8734$ kPa, $T_x = 2058.3$ K

$P_3 = 8734$ kPa, $T_3 = 2961.6$ K

$P_4 = 405$ kPa, $T_4 = 1336$ K

(a) $T_1 = 333$ K; $T_2 = 839.2$ K; $T_x = 2058.3$ K;
$T_3 = 2961.6$ K; $T_4 = 1336$ K.

(b) $P_1 = 101$ kPa; $P_2 = 3561$ kPa; $P_x = 8734$ kPa;
$P_3 = 8734$ kPa; $P_4 = 405$ kPa.

(c) cut-off ratio $= \frac{V_3}{V_x} = 1.44$

(d) Heat added $= m_f \times Q_{cv} = 2.98 \times 10^{-5} \times 42000 = 1.2516$ kJ

Heat rejected $= m_m \times C_v \times (T_4 - T_1)$
$= 6.26 \times 10^{-4} \times 0.82 \times (1336 - 333)$
$= 0.515$ kJ

$\therefore \eta_{ith} = 1 - \frac{0.515}{1.2516} = 0.588 = 58.8\%$

(e) Heat added per kg of mass $= \frac{1.2516}{6.26 \times 10^{-4}}$ kJ/kg $= 1999$ kJ/kg

(f) Net indicated work $= m_m R (T_3 - T_x) + m_m C_v (T_3 - T_4) - m_m C_v (T_2 - T_1)$

$= m_m [0.287 \times (2961.6 - 2058.3) + 0.82 (2961.6 - 1336) - 0.82 (839.2 - 333)]$

$= m_m [259.2 + 1333 - 415]$

$= m_m [1177.2]$

$w_{net} = 1177.2$ kJ/kg of mixture.