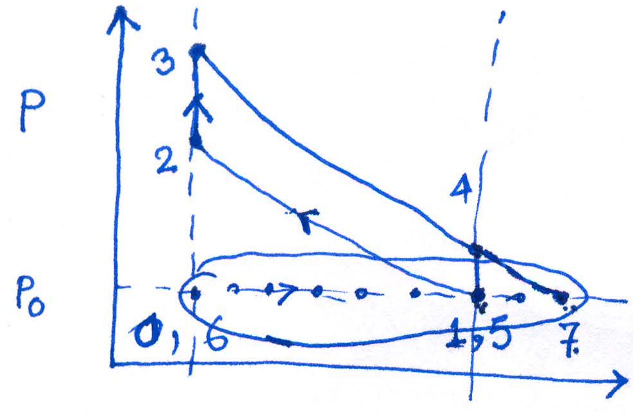


0-1
1-2
2-3
3-4
4-5 →
5-6

v_7 remains same for 7 → 6

V_7 fictitious volume

4-7 isentropic expansion process substituting 4-5

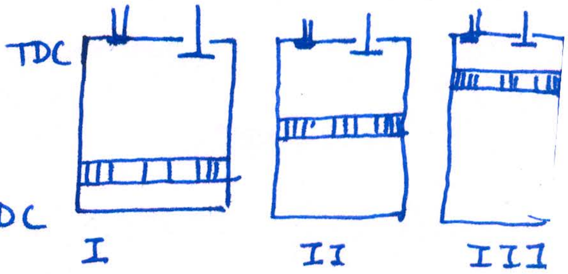
4-7 ~ isentropic process

$$m_m = \underbrace{\frac{V_1}{v_1} = \frac{V_2}{v_2} = \frac{V_3}{v_3} = \frac{V_4}{v_4}}. = \frac{V_7}{v_7}$$

$$P_4 v_4^{\gamma} = P_7 v_7^{\gamma} = P_3 v_3^{\gamma}$$

$$T_4 P_4^{\frac{1-\gamma}{\gamma}} = T_7 P_7^{\frac{1-\gamma}{\gamma}} = T_3 P_3^{\frac{1-\gamma}{\gamma}}$$

$$T_4 v_4^{\gamma-1} = T_7 v_7^{\gamma-1} = T_3 v_3^{\gamma-1}$$



$\frac{V_4}{v_7}$ $\qquad$ $\frac{V_2}{v_7}$ ✓

$m_I > m_{II} > m_{III}$

$V_I > V_{II} > V_{III}$

$$m_{ex} h_{ex} + m_a h_a = \underbrace{(m_{ex} + m_a)}_{= m_m} h_m$$

$v_I = \frac{m_I}{V_I}$

v_{II}

v_{III}

v_7

$$m_{ex} T_7 + m_a T_a = m_m T_1$$

$$x_r = \frac{m_{ex}}{m_m},$$

$$\frac{m_a}{m_m} = \frac{m_m}{m_m} - \frac{m_{ex}}{m_m}$$

$$\boxed{x_r T_7 + (1 - x_r) T_a = T_1}$$

Cylinder conditions at the start of compression in an SI engine operating at WOT on an air-standard Otto cycle are 60°C and 98 kPa. The engine has a compression ratio of 9.5:1 and uses gasoline with AF = 15.5. Combustion efficiency is 96% and it can be assumed that there is no exhaust residual. Calculate:

(a) Temperature at all states in the cycle. [°C]

(b) Pressure at all states in the cycle. [kPa]

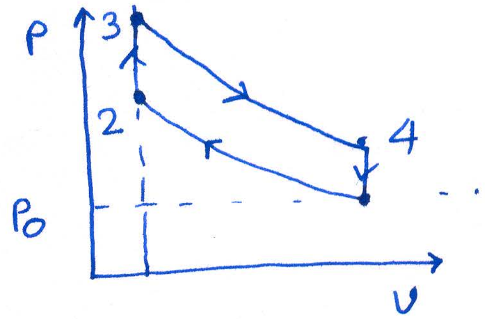
(c) Specific work done during power stroke [kJ/kg]

(d) Heat added during combustion. [kJ/kg]

(e) Net specific work done. [kJ/kg]

(f) Indicated thermal efficiency. [%]

Take $\gamma = 1.35$, $R = 0.287$ kJ/kg-K, $Q_{cv} = 44000$ kJ/kg.



$T_1 = 60°C = 60 + 273 = 333$ K

$P_1 = 98$ kPa

$P_1 v_1^{\gamma} = P_2 v_2^{\gamma} \Rightarrow \frac{P_2}{P_1} = \left(\frac{v_1}{v_2}\right)^{\gamma} = (9.5)^{1.35} = 20.9$

$P_2 = 98 \times 20.9 = 2048$ kPa

$T_1 v_1^{\gamma-1} = T_2 v_2^{\gamma-1} \Rightarrow \frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{\gamma-1} = 9.5^{0.35} = 2.2$

$T_2 = 333 \times 2.2 = 732.6$ K

m_f = mass of fuel

m_a = " " air

$m_m = m_a + m_f$

$m_f Q_{cv} \eta_c = m_m c_v (T_3 - T_2)$

$Q_{cv} \eta_c = \left(\frac{m_f + m_a}{m_f}\right) c_v (T_3 - T_2)$

$= (1 + 15.5) c_v (T_3 - T_2)$

$\underline{R = 0.287 \text{ kJ/kgK}}$

$\frac{R_u}{M_m} = R$

$c_v = \frac{R}{\gamma - 1} = \frac{0.287}{1.35 - 1} = 0.82$

$44000 \times 0.96 = 16.5 \times 0.82 \times (T_3 - T_2)$

$3122 = T_3 - T_2$

$T_3 = 3854.6$ K

$$\frac{P_3}{P_2} = \frac{T_3}{T_2} \Rightarrow P_3 = 2048 \times \frac{3854.6}{732.6}$$

$$= 10775.6 \text{ kPa}$$

$$P_3 v_3^{\gamma} = P_4 v_4^{\gamma}$$

$$\frac{P_4}{P_3} = \left(\frac{v_3}{v_4}\right)^{\gamma} = \left(\frac{1}{r_c}\right)^{\gamma} = \left(\frac{1}{9.5}\right)^{1.35} = 0.048$$

$$P_4 = 517 \text{ kPa}$$

$$T_3 v_3^{\gamma-1} = T_4 v_4^{\gamma-1}$$

$$\frac{T_4}{T_3} = \left(\frac{v_3}{v_4}\right)^{\gamma-1} = \left(\frac{1}{9.5}\right)^{0.35} = 0.455$$

$$T_4 = 1754 \text{ K}$$

$T_2 = 732.6 - 273 = \cancel{44}\,459.6\ ^\circ C$	$P_2 = 2048$ kPa
$T_3 = 3854.6 - 273 = 3581.6\ ^\circ C$	$P_3 = 10775.6$ kPa
$T_4 = 1754. - 273 = 1481\ ^\circ C$	$P_4 = 517$ kPa

$$\cancel{q_{in} - w}\ \ \cancel{\delta q} - \delta w = du$$

$${}_3w_4 = c_v (T_3 - T_4) = 0.82 (3854.6 - 1754) = 1722.5 \text{ kJ/kg}$$

$${}_2q_3 = c_v (T_3 - T_2) = 0.82 (3854.6 - 732.6) = 2560 \text{ kJ/kg}$$

$${}_1w_2 = c_v (T_2 - T_1) = 0.82 (732.6 - 333) = 327.7 \text{ kJ/kg}$$

$$w_{net} = 1722.5 - 327.7 = 1394.8 \text{ kJ/kg}$$

$$\eta_{ith} = \frac{w_{net}}{q_{in}} = \frac{1394.8}{2560} = 54.5\%$$

24/1/17 ④

The engine is a three-liter V6 engine operating at 2400 RPM. At this speed, the mechanical efficiency is 84%.

Calculate:

(a) Brake power. [kW]

(b) Torque [N-m]

(c) Brake mean effective pressure [kPa]

(d) Friction power lost. [kW]

(e) Brake specific fuel consumption [gm/kWh]

(f) Volumetric efficiency [%]

(g) Output displacement [kW/L]