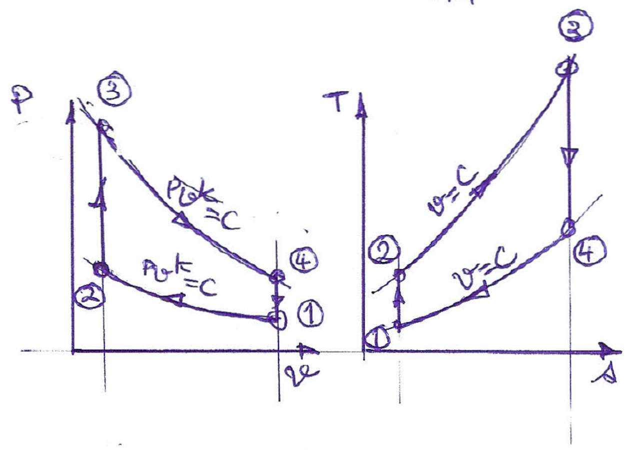
Analysis of an Air Standard Otto Cycle.

Known variables: P_1, T_1, r_v, q_H Find. $T_3, P_3, w_{net}, \eta_{th}$, MEP

Assumptions:

- The working fluid is AIR
- Air is an Ideal Gas
- Constant specific heat.

Analysis state points based on Pv and Ts diagram.



Process ① → ②

Isentropic Compression.

$$P_2 v_2^k = P_1 v_1^k$$

$$\therefore \quad P_2 = P_1\left(\frac{v_1}{v_2}\right)^k = P_1 r_v^k.$$

and
$$T_2 v_2^{k-1} = T_1 v_1^{k-1}$$

$$\therefore \quad T_2 = T_1\left(\frac{v_1}{v_2}\right)^{k-1} = r_v^{k-1}$$

state ①
$$v_1 = \frac{RT_1}{P_1}$$

$r_v = \frac{v_1}{v_2}$;
$$v_2 = \frac{v_1}{r_v}$$

Process ②–③ $+q_H$, $v=C$

1st law:
$${}_2q_3 = \cancel{{}_2w_3}^{\,0} + u_3 - u_2$$

$${}_2q_3 = c_v(T_3 - T_2)$$

$$\therefore \quad T_3 = T_2 + \frac{q_H}{c_v}$$

$(q_H = {}_2q_3)$.

Ideal Gas: $P_3 = \dfrac{RT_3}{v_3}$

where $v_3 = v_2$.

Process ③ – ④ Isentropic exp.

$$P_4 v_4^k = P_3 v_3^k$$

$$\therefore \quad P_4 = P_3\left(\frac{v_3}{v_4}\right)^k = \frac{P_3}{r_v^k}$$

$$T_4 v_4^{k-1} = T_3 v_3^{k-1}$$

$$\therefore \quad T_4 = T_3\left(\frac{v_3}{v_4}\right)^{k-1} = \frac{T_3}{r_v^{k-1}}$$

Process ④ – ① $-q_L$, $v=C$

1st law:
$${}_4q_1 = \cancel{{}_4w_1}^{\,0} + u_4 - u_1$$

$$|q_L| = {}_4q_1 = c_v(T_4 - T_1)$$

Cycle:
$$w_{net} = q_H - q_L.$$

$$\eta_{th} = \frac{w_{net}}{q_H}$$

$$MEP = \frac{w_{net}}{(v_1 - v_2)}$$

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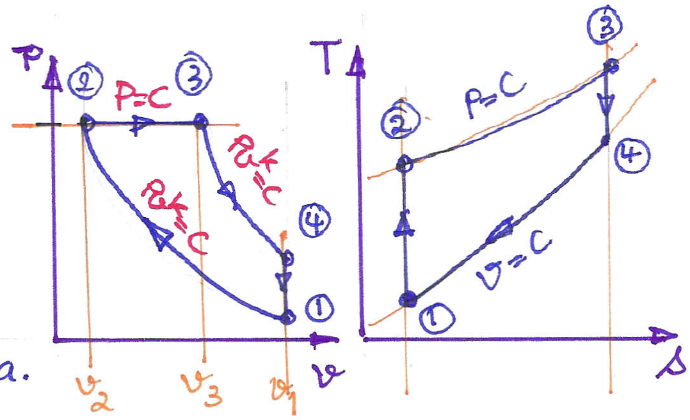
22 Aug 2010

Analysis of an air standard Diesel Cycle.

known variables: P_1, T_1, q_{H}, r_v Find $T_s, P_s, w_{net}, \eta_{th}, MEP$

Assumptions:

- The working fluid is AIR
- Air is an Ideal Gas
- Constant specific heat



Analysis: state points correspond to P–v and T–s dia.

Process ① → ②

Isentropic Compression

$$P_2 v_2^k = P_1 v_1^k$$

$$\therefore \quad P_2 = P_1\left(\frac{v_1}{v_2}\right)^k = P_1 r_v^k \quad \triangleleft$$

and $T_2 v_2^{k-1} = T_1 v_1^{k-1}$

$$\therefore \quad T_2 = T_1\left(\frac{v_1}{v_2}\right)^{k-1} = T_1 r_v^{k} \quad \triangleleft$$

State 1 $\quad v_1 = \dfrac{RT_1}{P_1} \quad \triangleleft$

and $\quad r_v = \dfrac{v_1}{v_2} \Rightarrow v_2 = \dfrac{v_1}{r_v} \quad \triangleleft$

Process ② → ③

Constant pressure heat added

1st Law: $\quad {}_2q_3 = {}_2w_3 + u_3 - u_2$

$$= P(v_3 - v_2) + u_3 - u_2$$

$$= h_3 - h_2$$

$$= c_p(T_3 - T_2)$$

$$\therefore \quad T_3 = T_2 + \frac{q_H}{c_p} \quad \triangleleft$$

$$v_3 = \frac{RT_3}{P_3} \quad \triangleleft$$

$(P_3 = P_2)$

Process ③ – ④

Isentropic expansion.

$$P_4 v_4^k = P_3 v_3^k$$

$$\therefore \quad P_4 = P_3\left(\frac{v_3}{v_4}\right)^k \quad \triangleleft$$

$(v_4 = v_1)$

and $T_4\, {}_4^{k-1} = T_3 v_3^{k-1}$

$$\therefore \quad T_4 = T_3\left(\frac{v_3}{v_4}\right)^{k-1} \quad \triangleleft$$

Process ④ – ① $\quad v = C, \; -q_L$

1st law: $\quad {}_4q_1 = \cancel{{}_4w_1}^{\,0} + u_4 - u_1$

$$|q_L| = {}_4q_1 = c_v(T_4 - T_1) \quad \triangleleft$$

1st Law: for cycle.

$$w_{net} = q_H - q_L \quad \triangleleft$$

$$\eta_{th} = \frac{w_{net}}{q_H} \quad \triangleleft$$

$$MEP = \frac{w_{net}}{(v_1 - v_2)} \quad \triangleleft$$

Sommai
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