iamat3002

"Standard air" I.G. with constant specific heats (reversible)

isothermal: ${}_1q_2 = RT \ln \frac{v_2}{v_1}$ $\quad T_2 = T_1$

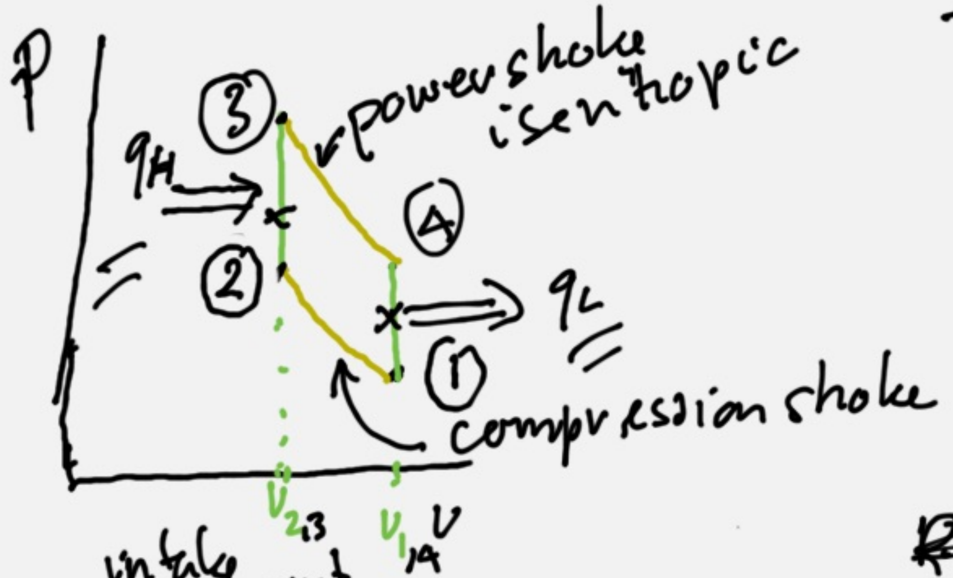
adiabatic: ${}_1q_2 = 0$ $\quad \frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{k-1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$

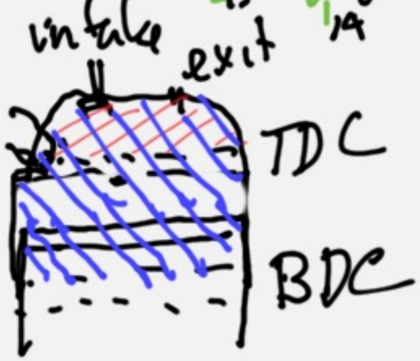
isobaric: ${}_1q_2 = c_p (T_2 - T_1)$ $\quad P_2 = P_1$

isochoric: ${}_1q_2 = c_v (T_2 - T_1)$ $\quad v_2 = v_1$

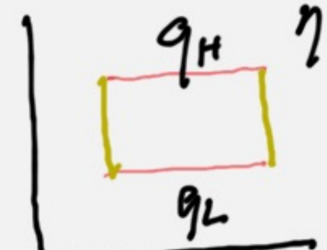
Design Project.

Otto cycle: Idealized car engine





~~Real~~ Recall Carnot



$$\eta = \frac{T_H - T_L}{T_H}$$

$$\eta_{th} = \frac{w}{q_H} = \frac{q_H - q_L}{q_H}$$

$$q_H = c_v(T_3 - T_2)$$

$$q_L = c_v(T_4 - T_1)$$

air $k = 1.4$

$$\eta_{th} = 1 - \frac{q_L}{q_H} = 1 - \frac{c_v(T_4 - T_1)}{c_v(T_3 - T_2)}$$

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{k-1} = \left(\frac{V_4}{V_3}\right)^{k-1} = \frac{T_3}{T_4}$$

$$\frac{T_2}{T_1} = \frac{T_3}{T_4}$$

$$\eta_{th} = 1 - \frac{T_1}{T_2}\,\frac{\frac{T_4}{T_1} - 1}{\frac{T_3}{T_2} - 1}$$

would like T_1/T_3

$$\eta_{th} = 1 - \frac{T_1}{T_2} = 1 - \frac{T_4}{T_3}$$

→ would like (Carnot $\eta_{th} = 1 - \frac{T_L}{T_H}$)

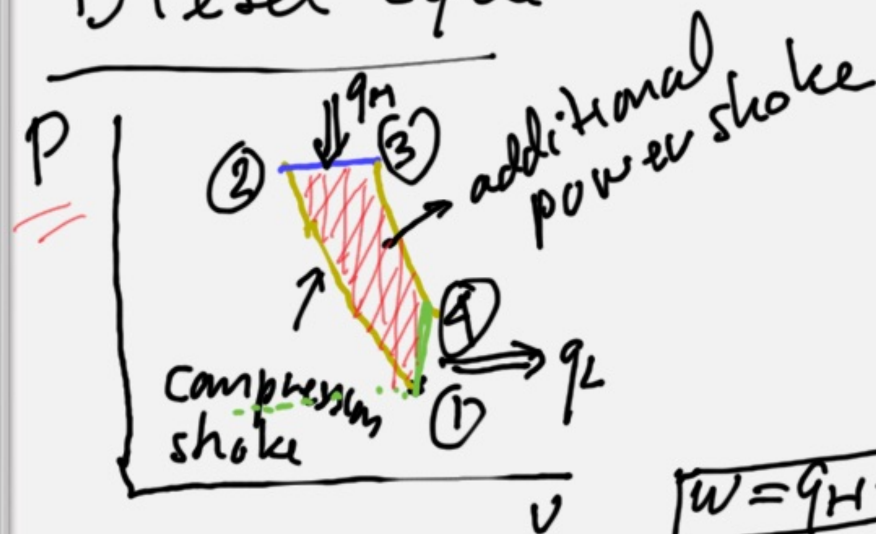
$$= 1 - \frac{\sqrt{T_1 T_4}}{\sqrt{T_2 T_3}}$$

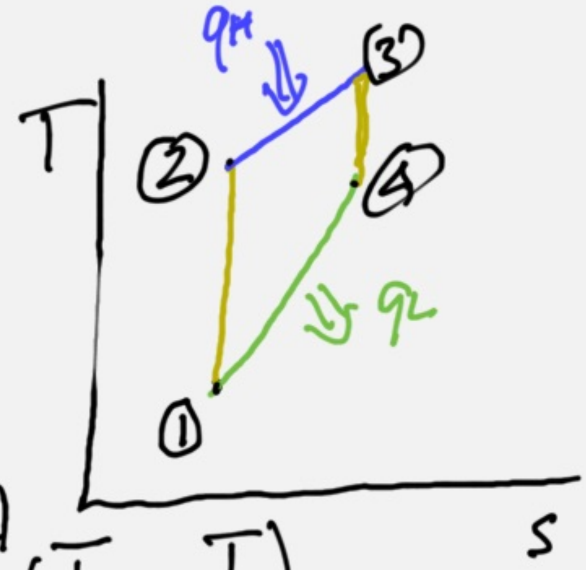
$$\boxed{\eta_{th} = 1 - \frac{1}{(V_1/V_2)^{k-1}}}$$

Definition $r_v = \frac{v_1}{v_2}$ = "compression ratio"

$\eta_{th} = 1 - \frac{1}{r_v^{k-1}}$ want higher compression ratio

Diesel cycle





$$\eta_{th} = \frac{q_H - q_L}{q_H}$$

$$\boxed{W = q_H - q_L}$$

$$q_H = c_p (T_3 - T_2)$$

$$q_L = c_v (T_4 - T_1)$$

$$w = w_{net} = q_H - q_L$$

$$\boxed{\eta_{th} = 1 - \frac{c_v}{c_p} \frac{T_4 - T_1}{T_3 - T_2}}$$

$$\boxed{r_v = \frac{V_1}{V_2}}$$

$$\boxed{W \cong (V_1 - V_2) P_{eff}}$$

P_{eff} = effective pressure

Stirling, Otto, Diesel. (Carnot)

Feb 2010 Sci Am

Ben ~~Knigh~~ Knight V.P. Hondo R&D

60% → heat (50/50 exhaust engine)

15–25% → friction including pumping losses, idling, deceleration.

intake stroke 10–15% power

5–10% drive train.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