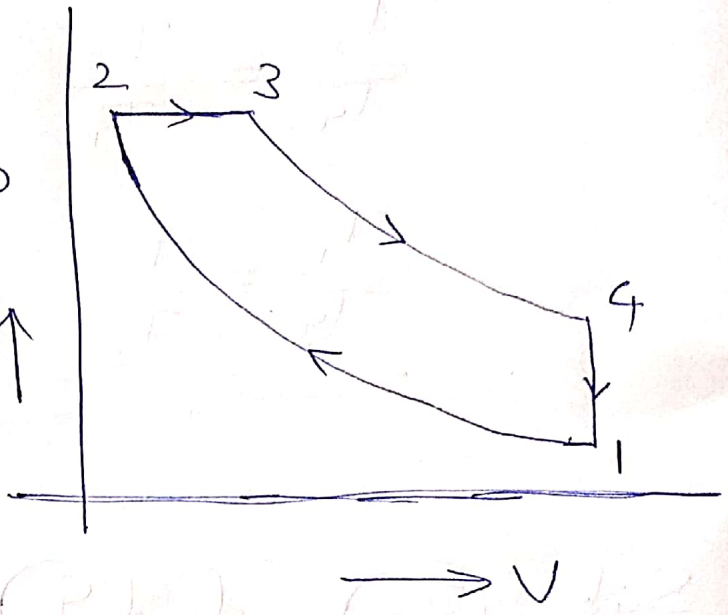
Diesel Cycle

$\frac{V_1}{V_2} = r \Rightarrow$ Compression ratio

$\frac{V_3}{V_2} = r_c \Rightarrow$ Cut-off ratio



$$\eta = \frac{Q_{in} - Q_{rej}}{Q_{in}}$$

$$= \frac{m C_p (T_3 - T_2) - m C_v (T_1 - T_4)}{m C_p (T_3 - T_2)}$$

$$= \frac{C_p (T_3 - T_2) - C_v (T_4 - T_1)}{C_p (T_3 - T_2)}$$

$$= 1 - \frac{C_v}{C_p} \frac{(T_4 - T_1)}{(T_3 - T_2)}$$

$$= 1 - \frac{C_v}{C_p}\frac{T_1}{T_2}\frac{\left(\frac{T_4}{T_1} - 1\right)}{\left(\frac{T_3}{T_2} - 1\right)} \quad \text{---(1)}$$

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$$\frac{C_p}{C_v} = \gamma \Rightarrow \frac{C_v}{C_p} = \frac{1}{\gamma} \quad \text{---(2)}$$

From process 1-2 (adiabatic compression)

$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$$

$$\frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{\gamma-1}$$

$$\frac{T_1}{T_2} = \left(\frac{1}{\gamma}\right)^{\gamma-1} = \frac{1}{\gamma^{\gamma-1}} \quad \text{---(3)}$$

From process 2-3 (Constant pressure)

$$pV \propto T$$

$$V \propto T \quad \{p = \text{Constant}\}$$

$$\frac{T_3}{T_2} = \frac{V_3}{V_2} = r_c \quad \text{---(4)}$$

From process 4-1 {Constant Volume}

$$pV \propto T$$

$$p \propto T$$

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

$$= \frac{P_4}{P_3} \times \frac{P_2}{P_1} \qquad \{P_3 = P_2\}$$

→ 5a

From 3-4 & 1-2

$$P_3 V_3^{\gamma} = P_4 V_4^{\gamma} \qquad P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$$

$$\frac{P_4}{P_3} = \left(\frac{V_3}{V_4}\right)^{\gamma} \qquad \frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma}$$

Sub in 5a

$$\frac{T_4}{T_1} = \left(\frac{V_3}{V_4}\right)^{\gamma} \times \left(\frac{V_1}{V_2}\right)^{\gamma} \qquad \{V_4 = V_1\}$$

$$\frac{T_4}{T_1} = \left(\frac{V_3}{V_2}\right)^{\gamma} = r_c^{\gamma} \quad \text{——— (5)}$$

Sub (2), (3), (4) & (5)

in (1)

$$\eta = 1 - \frac{C_v}{C_p} \frac{T_1}{T_2} \frac{\left(\frac{T_4}{T_1} - 1\right)}{\left(\frac{T_3}{T_2} - 1\right)}$$

$$\eta = 1 - \frac{1}{\gamma} \frac{1}{r^{\gamma-1}} \frac{(r_c^{\gamma} - 1)}{(r_c - 1)}$$

$$\boxed{\eta = 1 - \frac{1}{r^{\gamma-1}} \frac{(r_c^{\gamma} - 1)}{\gamma(r_c - 1)}}$$