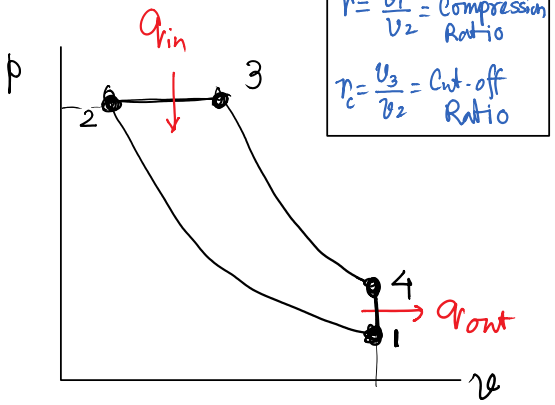
Efficiency of a Diesel Cycle



$r = \frac{v_1}{v_2}$ = Compression Ratio

$r_c = \frac{v_3}{v_2}$ = Cut-off Ratio

1–2: Isentropic compression

$$T_2/T_1 = \left(v_1/v_2\right)^{\gamma-1} = r^{(\gamma-1)}$$

2–3: Constant pressure heat addition (the fuel is being sprayed during this time)

$$T_3/T_2 = v_3/v_2 = r_c$$

3–4: Isentropic expansion (occurs after fuel injection is completed till the remainder of the outward stroke of the piston)

$$\frac{T_4}{T_3} = \left(\frac{v_3}{v_4}\right)^{\gamma-1} = \left(\frac{v_3}{v_2} \times \frac{v_2}{v_1} \times \frac{v_1}{v_4}\right)^{\gamma-1} = \left(r_c \times \frac{1}{r} \times 1\right)^{\gamma-1} = \left(\frac{r_c}{r}\right)^{\gamma-1}$$

Efficiency

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

$C_p/C_v = \gamma$

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

$\frac{T_3}{T_2} = r_c$

$\frac{T_2}{T_1} = r^{\gamma-1}$

$$= 1 - \frac{1}{\gamma} \times \frac{\left(T_4/T_1 - 1\right)}{\left(T_2/T_1\right)\left(r_c - 1\right)} = 1 - \frac{1}{\gamma} \frac{\left(\frac{T_4}{T_3} \times \frac{T_3}{T_2} \times \frac{T_2}{T_1} - 1\right)}{r^{(\gamma-1)} \times \left(r_c - 1\right)}$$

$$= 1 - \frac{1}{\gamma} \frac{\frac{r_c^{\gamma-1}}{r^{\gamma-1}} \times r_c \times r^{\gamma-1} - 1}{r^{\gamma-1}\left(r_c - 1\right)}$$

$$\therefore \boxed{\eta_{diesel} = 1 - \frac{1}{r^{\gamma-1}}\left\{\frac{r_c^{\gamma} - 1}{\gamma\left(r_c - 1\right)}\right\}}$$