Thu 20 Mar

90 01 10

Plan

Computer assign. general Feedback

Otto cycle → Diesel

Einstein solid

Otto cycle

$$\eta = \frac{T_3 - T_4 - T_2 + T_1}{T_3 - T_2} = 1 - \frac{T_4(1 - T_1/T_4)}{T_3(1 - T_2/T_3)} = 1 - \frac{1}{r^{2/3}}$$

Adiabatic stages: $V_1 T_1^{3/2} = V_2 T_2^{3/2}$, $V_1 T_4^{3/2} = V_2 T_3^{3/2}$ } $\frac{T_1}{T_2} = \frac{T_4}{T_3} = \left(\frac{V_2}{V_1}\right)^{2/3} = \frac{1}{r^{2/3}}$

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

$$\eta = 1 - \frac{T_1}{T_2} < 1 - \frac{T_1}{T_3} = \eta_c \checkmark$$

$$T_2 < T_3$$

Maximize η by increasing $r = \frac{V_1}{V_2}$

In practice $\eta \sim 20\% - 30\%$

Obstruction: large r → auto-ignition, "knock"

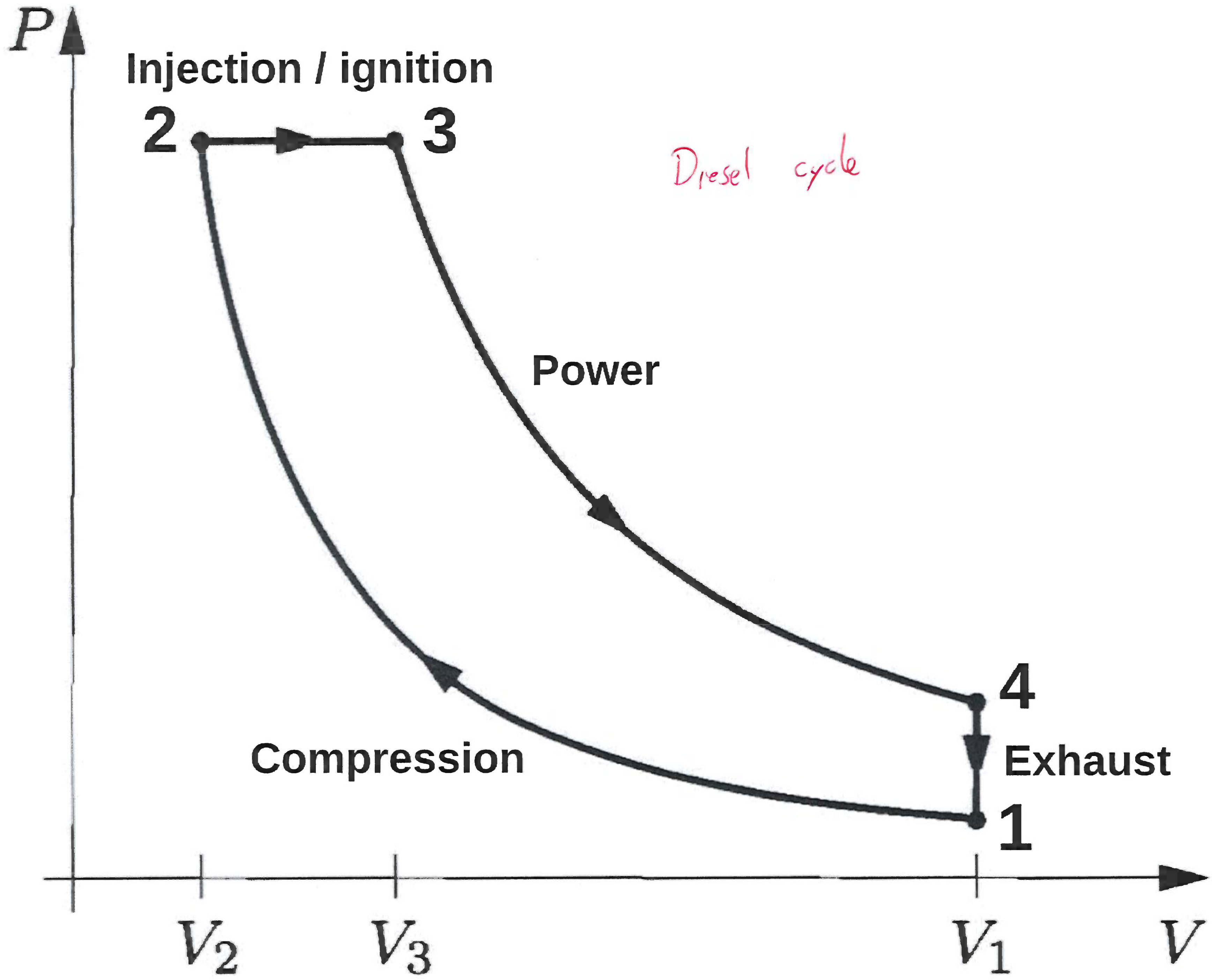
Diesel: Only compress air (non-combustible)

Then inject (diesel) fuel

η depends on both compression ratio $r = \frac{V_1}{V_2}$

and cutoff ratio $c = \frac{V_3}{V_2}$ $1 < c < r$

Can have larger r → higher $\eta \sim 40\%$


P
Injection / ignition
2
3
Diesel cycle
Power
4
Exhaust
1
Compression
V2
V3
V1
V

Heat capacity

$C_V \to 0$ as $T \to 0$ (third law)

C_V increases to constant for high T

Described by ideal gas?

$$C_V = \frac{\partial E}{\partial T} = \frac{\partial}{\partial T}\left(\frac{3}{2} N T\right) = \frac{3}{2} N \quad \times$$

What about dist'able spins?

↳ $C_V \to 0$ for both high and low T

better but not good enough

Einstein solid

Atoms in solid held in place by interacting w/neighbors

↳ oscillators

Suppose oscillators non-interacting

with energies $\varepsilon_i = 0, \hbar\omega, 2\hbar\omega, \ldots$

Start with K units of energy to assign to N osc.

$$E = K\hbar\omega = \sum_i k_i \hbar\omega = \sum_i \varepsilon_i \qquad K = \sum_i k_i$$

Find M → $S = \log M$ → $\frac{1}{T} = \frac{\partial S}{\partial E}$

Invert to find $E(T)$ → $C_V = \frac{\partial E}{\partial T}$

Target: $M = \binom{K+N-1}{K}$ check with $N=3$, $K = 0, 1, 2, 3, \ldots$