Week 7: Lecture 2

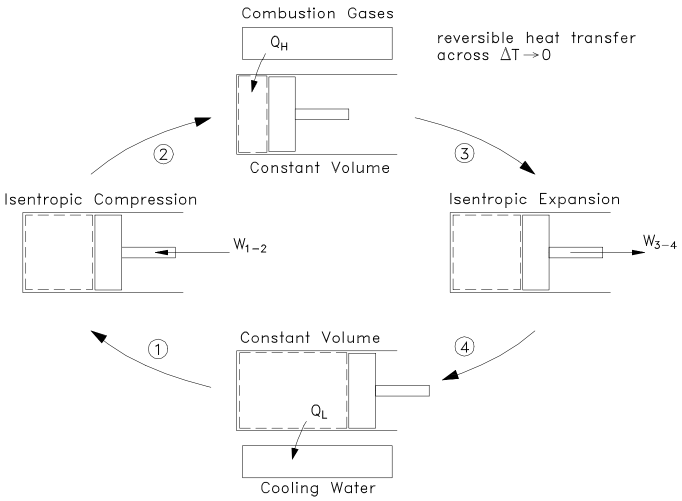
Air Standard Cycle

Assumptions

- air is an ideal gas with constant c_p and c_v
- no intake or exhaust processes
- the cycle is completed by heat transfer to the surroundings
- the internal combustion process is replaced by a heat transfer process from a TER
- all processes are reversible
- heat addition occurs instantaneously while the piston is at TDC

Otto Cycle

- consists of four internally reversible processes
- heat is transferred to the working fluid at constant volume



1 → 2 isentropic compression or air

2 → 3 constant volume heat addition at TDC (represents the ignition process)

3 → 4 isentropic expansion (power stroke)

4 → 1 constant volume heat rejection at BDC

$$\eta_{Otto} = 1 - r^{1-k} \qquad \textbf{where :} \qquad r = \frac{V_1}{V_2} = \frac{V_4}{V_3} \quad \textbf{(compression ratio)}$$

Otto cycle limitations on compression ratio

- increased tendency for the fuel to detonate as the compression ratio increases
- the pressure wave gives rise to engine knock
- can be reduced by adding tetraethyl lead to the fuel
- not good for the environment

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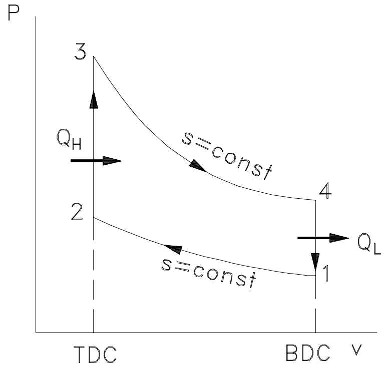
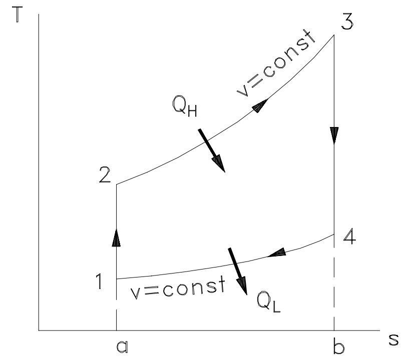
Otto Cycle Process Diagrams





The Diesel Cycle

- heat is transferred to the working fluid at constant pressure

$$\eta_{Diesel} = 1 - \frac{1}{r^{k-1}}\left(\frac{1}{k}\right)\left(\frac{r_v^k - 1}{r_v - 1}\right) \qquad \textbf{where :} \qquad r_v = \frac{V_3}{V_2} = \text{(volume ratio)}$$

Comparison of the Otto and the Diesel Cycle

- $\eta_{Otto} > \eta_{Diesel}$ for the same compression ratio
- but a diesel engine can tolerate a higher ratio since only air is compressed in a diesel cycle and spark knock is not an issue
- direct comparisons are difficult