Sheet 06: Internal combustion engines

Discussion: Thursday 29.06.23

Exercise 1   Ideal Motors

In this task, we consider the cyclic processes of internal combustion engines. We do not want to model the chemical reaction explicitly: The ignition of the fuel is described by a supply of heat and the blowing out of the exhaust gases (with simultaneous injection of air and fuel) by an isochoric release of energy to a reservoir.
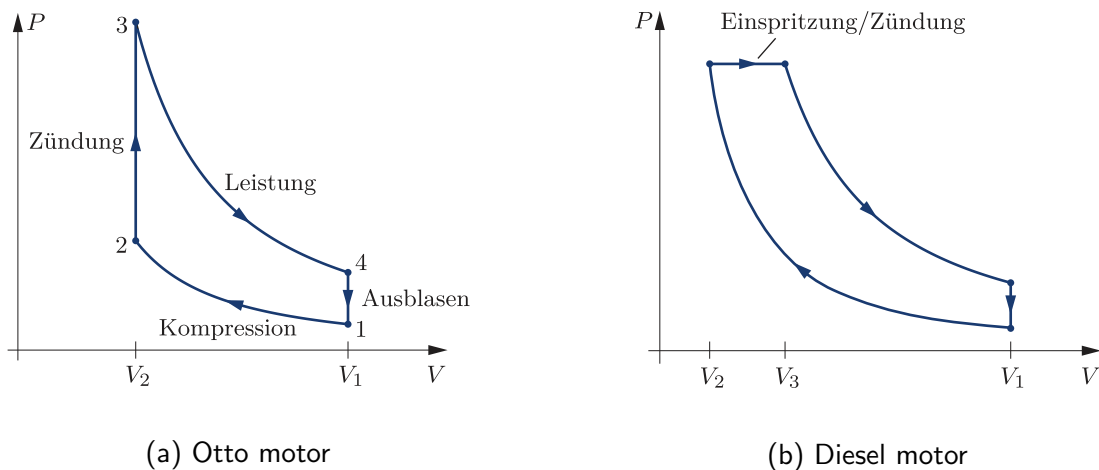

(a) Otto motor   (b) Diesel motor

Figure 1: Circular processes from Schroeder, Thermodynamics and statistical physics.

(a) The cycle of the gasoline engine is sketched in **??**, where power and compression are adiabatic processes.

Show that the efficiency η of a gasoline engine filled with an ideal gas is given by

$$\eta_{\text{Otto}} = 1 - \left(\frac{V_2}{V_1}\right)^{\gamma-1}. \tag{1}$$

(b) The cycle of the diesel engine has two adiabatic processes, as well as one isobaric and one isochoric section each and is sketched in **??**. In addition to the compression ratio $\frac{V_1}{V_2}$, we now have the full pressure ratio $\frac{V_3}{V_2}$ as a second parameter.

Calculate the efficiency of an ideal diesel engine and compare the expression with **??**.

Hint: It is sufficient to make the comparison for an ideal gas with isentropic exponents $\gamma = \frac{7}{5}$.

(c) The advantage of the diesel engine is that larger compression ratios are possible. Compare the two efficiencies if you assume a ratio $\frac{V_1}{V_2} = 8$ for the gasoline engine and $\frac{V_1}{V_2} = 18$ and $\frac{V_3}{V_2} = 2$ for the diesel.

Exercise 2   Real Motors

In an internal combustion engine, the work performed per cycle is is controlled by the amount of fuel: The more fuel, the higher the pressure and temperature after ignition.

In **??** we found, that the efficiency of an ideal engine depends only on the volumes $V_{1,2}$, which are independent of the amount of fuel.

Consider factors that reduce the efficiency of real engines. Is the efficiency still independent of the fuel consumed, if you take friction into account? Do you think a real engine is most efficient when operating at high or low power?