Popular Summary

Growing populations have led to an increasing demand on transportation for people and goods. For decades, internal combustion engines have played an important role in the transportation sector to develop the society, but their widespread utilisation has contributed to massive global energy consumption and pollutant emissions. For instance, an estimated 24% of CO_2 emissions in the world come from the transportation sector. This scenario creates a dual challenge, which is to satisfy the growing transportation needs by keeping the energy demands and risks of climate change at the minimum level.

Historically, the high torque output and fuel efficiency of diesel engines make them a very attractive power source for the transportation sector. However, these engines come with high NOx and soot emissions, which cause a wide variety of environmental and health impacts. For instance, long-term exposure to NOx and soot can potentially decrease the lung function and increase the risk of damaging the respiratory system. Moreover, NOx contributes to acid deposition and nutrient enrichment problems, which can adversely affect both land and aquatic life. As exhaust emissions are harmful to humans and the environment, the European Commission was motivated to implement the emissions legislation Euro I in 1992 regulating NOx, particulate matter, carbon monoxide and hydrocarbons. Since then, the emissions regulations have been increasingly stringent to reduce progressively the negative impact of diesel engines.

To meet stringent emissions legislations, the research community has proposed new combustion strategies based on low-temperature combustion (LTC), which has the potential to achieve a simultaneous reduction in NOx and soot emissions while reducing energy demands through improved efficiency. Typically, gasoline-like fuels with high ignition resistance are utilised in diesel engines to achieve LTC. However, to also meet future legislation on CO_2 emissions, researchers have been working towards renewable fuels, such as methanol. A combination of methanol and LTC strategy can be a future solution to develop clean and sustainable combustion engines.

The goal of this thesis is to explain the relation between fuels with high ignition resistance and the fuel injection process while using LTC. This knowledge was extended by implementing a fully renewable fuel. To reveal the underlying phenomenon, a combination of engine experiments and computer simulations was employed.

The results showed that increasing ignition resistance among the fuels requires increasingly earlier fuel injection. The combustion chamber shape interacts with the spray of the fuel injection, and this study shows how these interactions can be exploited to lower emissions and improve energy use. The use of methanol fuel combined with LTC and triple injection removes soot emissions all together, and a favourable compromise between very low amounts of regulated emissions and low energy consumption can be reached. The results provide engine manufacturers with a preliminary platform for strategies with methanol fuel to meet current and future emissions legislations.