Heavy Duty Fuel Injection

The combustion process of diesel is often associated with the formation of soot particles and various nitrous oxides. Environmental and health related issues related to these substances are well known and are controlled by stringent regulations. They are formed under rather different conditions, resulting in a trade-off situation in which a reduction of both substances are difficult to obtain when designing new combustion systems. Formation of nitrous oxides generally occur early in the combustion process when the temperatures are high in regions with lean fuel mixtures and rapid combustion. Soot particles on the other hand forms when aromatic hydrocarbons fuses together due to rich fuel mixtures and intermediate temperatures.

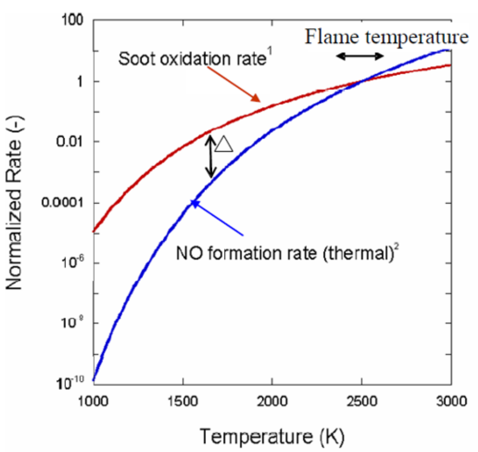

Figure 1: Reaction rates for the oxidisation of soot together with oxygen (O_2) and the formation of nitrous oxides (NO) as function of the local flame temperature[1].

A resent research collaboration between Chalmers University of Technology and Volvo Group Trucks Technology AB has demonstrated the importance of an efficient oxidation of formed soot during the later stages of the combustion process in heavy duty diesel engines[1]. The oxidation of soot can sustain a higher reaction rate than the formation of nitrous oxides at lower temperatures, illustrated in Figure 1. This gives an opportunity to avoid the trade-off situation. The temperature and the reaction rate during the initial stage of the combustion process can be controlled by a number of strategies, like exhaust gas recirculation. These strategies increases the formation of soot but due to the higher oxidation rate at lower temperature can the formed soot be oxidised later during the combustion process when the temperature is lower without the risk of drastic increase in the formation of nitrous oxides. Eismark[1] demonstrated the importance of conservation of fluid momentum until the later stages of the combustion process in order to obtain the required mixing of oxygen and soot for an efficient oxidisation.

Aim

The aim of the project is to increase the knowledge about the parameters and conditions affecting the favourable mixing and late cycle oxidisation of soot. This includes investigation of early fuel jet characteristics, which determines the conditions of the jet and its development later in the cycle, as well as investigation of combustion system geometry, injection strategy, flame interactions and influence from fuel properties.

Method

Investigations of jet and flame development are difficult to perform in real engines and during normal operating conditions. These phenomena are preferably measured in a more controllable and observable environment. The spray chamber facilities at the department of Combustion and propulsion systems at Chalmers enables these kinds of observation to be performed using different types of optical measurement techniques. These observations will be further complemented by numerical modelling and tests in more realistic operation conditions in single cylinder engine cells.

Current project status

(April 2019) The project was initiated at the start of 2019. The first experimental session takes place during the spring of 2019 and will focus on the scales of the turbulence in free and impinging turbulent jets. The experiments will be performed in the HPHT spray chamber (Cell G) at Chalmers University of Technology.

[1] J. Eismark, The Role of Piston Bowl Shape in Controlling Soot Emissions from Heavy-duty Diesel Engines. Division of Combustion and propulsion systems, Department of Mechanics and Maritime Science, Chalmers University of Technology, 2018.