Toluene planar LIF in an optically accessible engine

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Introduction

Engine manufacturers are searching for ways to make diesel engines cleaner to comply with environmental regulations. Premixed Charge Compression Ignition (PCCI) is a concept to achieve this.

PCCI uses an early injection to give more time for fuel mixing. Because the fuel is premixed with the air, start of combustion cannot be controlled with the injection timing. The start of combustion will take place when local equivalence ratio, temperature and pressure initiate it.

For better understanding of the conditions at start of combustion one would like to know the temperature distribution inside the cylinder before ignition. These data will be used to validate and optimize simulation models. To measure the temperature fields, Toluene Laser Induced Fluorescence is used.

Toluene LIF

When toluene is excited with a 248 nm laser, the spectrum of its fluorescence is dependent on temperature. The fluorescence spectrum shifts to longer wavelengths (red shift) with increasing temperature, see Figure 1. This property is used in this investigation to find the temperature field in an engine before ignition. The fluorescence signal is captured with two cameras with different band pass filters. The ratio between the two intensities is a measure for the temperature. This way a 2-D temperature image can be obtained, which is independent of toluene concentration and laser fluctuations.

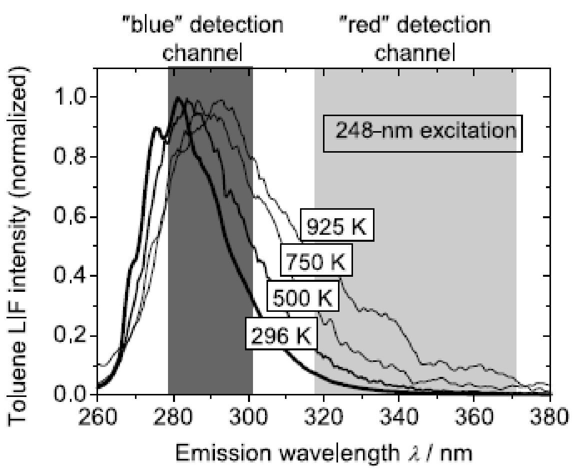

Fig. 1: Toluene spectra and camera detection bands

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COMBURA 2011, the ReeHorst, Ede

Experimental apparatus

For the experiments a single cylinder optically accessible engine is used, see Figure 2. The engine is driven by an electrical motor and kept at a constant speed with an eddy current brake. The optical accessibility is achieved with a sapphire window in the piston and a sapphire ring in the liner. The piston is elongated to house the 45 degree mirror which deflects the light from the combustion chamber towards the cameras.

The toluene is injected with a port fuel injection system and will be vaporized by the heated inlet air. Heptane is injected with the diesel injector, representing the diesel injection event.

The cameras are set up in front of the 45 degree mirror. One camera is pointed directly at the mirror and the second camera is looking via a 300 nm long pass mirror at the engine mirror. This setup splits the signal into a long wavelength part (>300 nm) and a short wavelength band (<300 nm). The Cameras are equipped with band pass filters, 280±10 nm and 320±20 nm respectively.

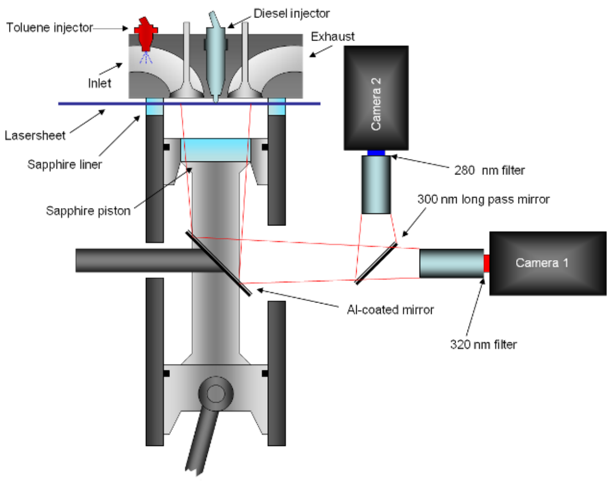

Fig. 2: Optically accessible engine schematic

Calibration

To calibrate this method, toluene is injected in the inlet channel so it is sucked in during the intake stroke. Measurement images are taken at different crank angle degrees. At these different CAD the air in the cylinder is assumed to have a uniform temperature. The measured in-cylinder pressure curve is fitted with a simulation model to determine the temperature calibration graph, see Figure 3. The ratios belonging to these temperatures are found with the measurement images.

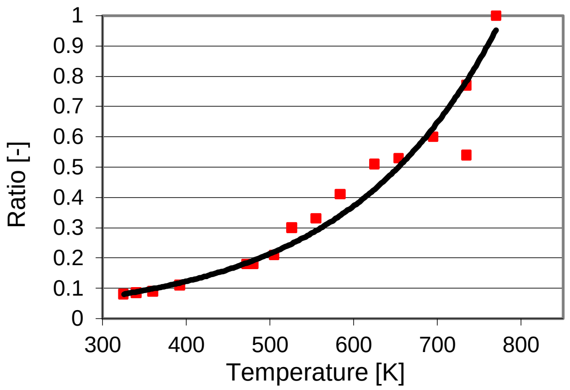

Fig. 3: Calibration graph

Measurements

To visualize the temperature field inside the cylinder during and after injection, toluene is added to the fuel. The directly injected fuel consists of 90% heptane and 10% toluene. Measurement images are made during (Figure 4) and after injection (Figure 5). In this way the development of the temperature field after injection can be analyzed. These measurement series are done for different injection timings to investigate the influence of premixing of the fuel.

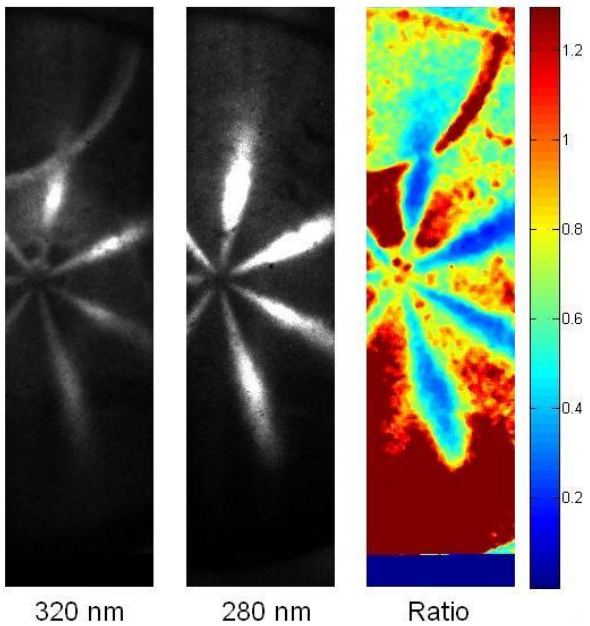

Fig. 4: Measurement images of both cameras and ratio image of a spray, during injection.

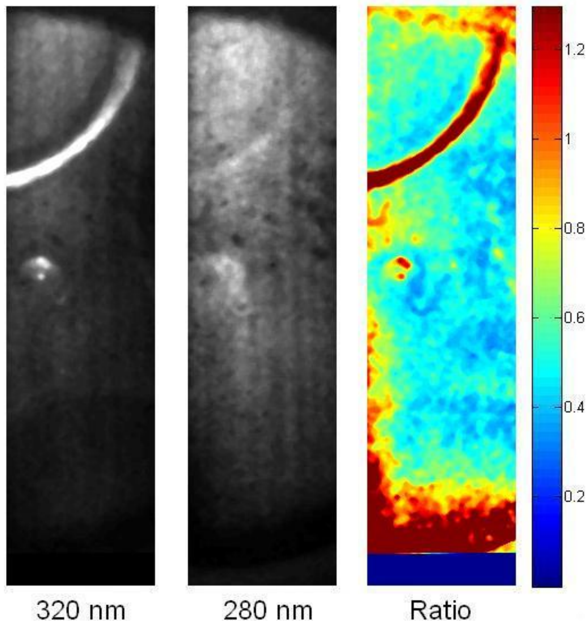

Fig. 5: Measurement images of both cameras and ratio image after the injection.

Results and discussion

The limited signal strength is a serious concern, which makes interpretation of the ratio data not straightforward. This is currently the subject of analysis. Also the use of the ICCD camera is very sensitive to small changes in measurement circumstances. For different recording speeds, the background level is different. It is very important to subtract the right background because signal levels are low and the images are used for a ratio image. A second camera issue is that the chip temperature has to be kept at constant value. Changes in chip temperature cause different background- and noise levels. We hope to present the results of this analysis on the Combura conference.

Acknowledgements

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