Soot particulate size measurements in a heavy duty Diesel engine

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Time-resolved laser-induced incandescence (Tire-LII) was measured in an optically-accessible heavy-duty Diesel engine. The fundamental of a Nd:YAG laser was used to excite the soot particles and the particle size was determined from the temporal decay of the induced incandescence intensity as a function of crank angle. The time response of the measurement system was too slow in order to follow the decay of the LII signals. Therefore, a deconvolution algorithm of the measured Tire-LII curve was applied which compensated for the system response time.

Introduction

The purpose of this paper is to show the feasibility of performing Tire-LII measurements inside the cylinder of a heavy-duty Diesel engine at pressures varying between 1 and 70 bar. A correction for the time response of the system was made by applying a Wiener deconvolution algorithm.

Experimental setup

The experimental setup for the experiment is shown in Fig. 1. The Tire-LII measurements were performed in a heavy duty Diesel engine at two different engine loads. The first cylinder has been modified and has optical access through four quartz windows, one in the cylinder head, one in the piston and two at the side of the cylinder. A slit in the piston crown provides optical access through the side windows during the early stages of the combustion cycle.

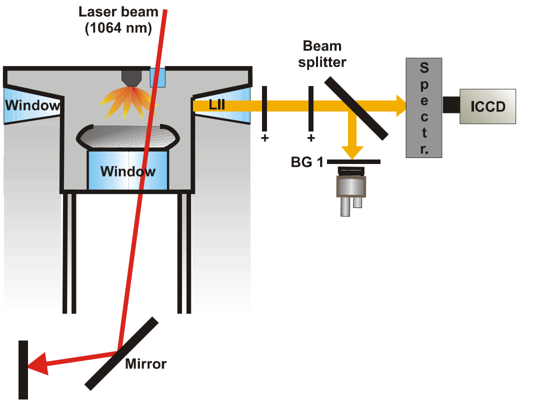

Figure 1: Experimental setup for the LII-experiments.

The soot particles were excited by the laser radiation traversing top-down through the engine and the resulting LII radiation was detected through one of the side windows. After being focused by a lens system the incandescence was simultaneously detected by a grating spectrograph and a fast photomultiplier tube (rise-time < 2 ns) by using a beam splitter. The spectrograph, integrating the soot radiation during the first 5 ns after the laser pulse, was attached to an ICCD-camera and the Tire-LII signal was filtered with a BG 1 filter before detection by the PMT, which was attached to an oscilloscope (300 MHz).

Experimental results

No interference with Swan-band LIF emission appeared from the recorded spectrum. The time-decay behavior is influenced by the ambient pressure [1]. In the analysis of the data it appeared that the response time of the system was not short enough to follow the decay rate of the LII radiation. Therefore, a Wiener deconvolution [2] was applied with the response time of the detection system, which also filtered out the noise of the system.

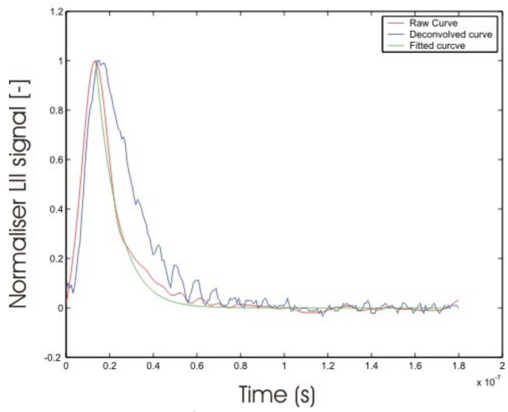

Figure 2: Example of a raw data, a deconvolved curve and a fitted curve according to the model of [3].

A physical model for the cooling behavior of the particles proposed by Kock *et al.* [3] was used to estimate the particle size from the deconvolved data. A fitted curve is shown in Fig. 2 as well. Assuming a mono-disperse particle size distribution, the mean particle size was found to be around 50 nm.

References

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