In-cylinder particulate sizing with combined TR-LII/2C pyrometry

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Time-resolved laser-induced incandescence (TR-LII) measurements have been performed inside the cylinder of a heavy-duty Diesel engine as a function of the crank angle, at two probe locations and for two engine loads. The TR-LII intensities have been recorded in two disjunct wavelength bands. Assuming a log-normal particle size distribution, an increase of the soot particle radius could be measured, followed by a decrease later on during the combustion cycle.

Introduction

This paper focuses on the determination of the soot particulate size distribution with TR-LII at different probe locations for different engine loads. The method is similar to the approach presented by Kock *et al.* [1]. Their model [2] is used to analyze the soot particulate sizes from the TR-LII measurements. The model incorporates cooling phenomena by conduction, sublimation and radiation. The ambient pressure is incorporated in the cooling contributions by conduction and sublimation. The assumption is that the particulates have a spherical shape. In the current study two-color pyrometry is used to measure the initial temperature of the soot particles immediately after the laser pulse.

Experimental setup

Experiments have been performed on the optically accessible cylinder of a heavy duty Diesel engine with a compression ratio of 15. A schematic picture of the setup is shown in Fig. 1. The laser beam (1064 nm, 0.25 J/cm^2) was guided top-down through the cylinder and the TR-LII traces have been recorded through the side-window. A portion of the LII is guided to an ICCD camera which is mounted on a spectrograph. The other part of the LII is filtered with a BG 18 filter, and focused on two photo-multiplier tubes (PMT), via a beam splitter. Each of the PMTs is equipped with its own filter in order to be able to measure the intensity ratio of both signals. A more elaborate description of the experimental setup can be found in [3,4].

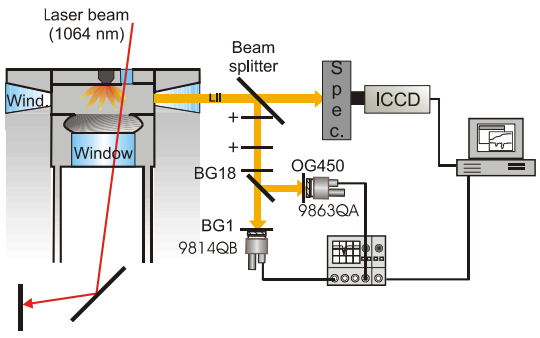

Fig. 1: Experimental setup

Results

TR-LII curves have been recorded for two engine loads (25% and 50%) at two probe locations. The measured curves are only interpreted as TR-LII if both on the camera connected to the spectrograph glowing soot is visible (Fig. 2) and on both PMTs a TR-LII curve is measured. For the analysis of the TR-LII curves, a Wiener deconvolution has been applied with the response function of the detection system of the PMTs, during which the power of the noise spectrum has been conserved [5]. During the complete combustion cycle, TR-LII curves are measured only infrequently. This is probably due to the small probe volume. On the poster the dependence of the particle size as a function of the engine load and probe location will be shown. Results for different engine loads and the dependence of the particle size as a function of the probe location are compared.

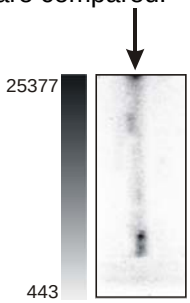

Fig. 2: Glowing soot present in the field of view. The grey scale is a measure for the LII intensity in a.u.

Acknowledgements

This work has been financially supported by the Technology Foundation STW, applied science division of NOW and the technology programme of the Dutch ministry of economic affairs.

[1] B.F. Kock, Th. Eckhardt, P. Roth, *Proc. Combust. Inst. 2002*, **29** (2) (2002), 2775-2781.
[2] B.F. Kock, P. Roth, *Proc. European Combustion Meeting*, (2003).
[3] B. Bougie, L.C. Ganippa, N.J. Dam, J.J. ter Meulen, *Appl. Phys. B: Lasers and Optics*, **83** (3) (2006), 477-485.
[4] B. Bougie, L.C. Ganippa, A.P. van Vliet, W.L. Meerts, N.J. Dam, J.J. ter Meulen, *Proc. Combust. Inst. 2006*, in press.
[5] B. Bougie, L.C. Ganippa, A.P. van Vliet, W.L. Meerts, N.J. Dam, J.J. ter Meulen, *Combustion and Flame*, **145** (3), 635-637.