Pressure effects on LII-signals

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Laser-Induced Incandescence of carbon black particles in relatively high-pressure conditions (1 to 30 bar) was studied. During the second part of the signal, laser-induced emission of carbon black is increasing with pressure, this being rather an unexpected trend. It is believed that the light emitted by laser-heated particles (even those situated outside the measurement volume) might be scattered by the particles inside measurement volume, this signal being recorded together with LII.

Introduction

Due to its advantages over other techniques Laser-Induced Incandescence (LII) was developed lately as a tool for real-time in-situ soot quantification. In many devices e.g. Diesel engines, combustion and soot formation occur in relatively high pressure conditions. Therefore, a particular attention should be paid to pressure effects on LII signals.

Laser-Induced Incandescence of carbon black in high-pressure conditions

An experimental facility was setup, the main feature being a pressure vessel containing carbon black particles. The particles are kept in suspension by means of a fan placed inside the vessel and the pressure is raised by means of an external air bottle. It is proven that temperature inside the vessel, measured with a thermocouple, changes only slightly with pressure (within 20 K for pressures up to 30 bar).

Particles are heated with the fundamental output of a Nd:YAG laser. LII signals are filtered through band pass filters at 441.6 and 650 nm, detected with two photomultipliers and recorded with 1 GHz sample rate, 8 bit acquisition system.

LII signals were recorded for pressures between 1 and 30 bar with an increment of 5 bar. LII evolution versus time for pressures in the investigated range is represented in Figure 1. The curves are normalized and averaged over 100.

As expected, higher pressures involve faster decay of LII signals during the first part of particles cooling. The differences in characteristic decay time as pressure increases are stronger for pressures between 1 and 10 bar, this feature was already observed by Hofmann et al. [1]. For pressures superior to 10 bar we observed that the decay time during the first part of LII signal changes only slightly.

During the second part of LII signals, an unexpected behavior was observed: the recorded signal increases as pressure raises. At this stage of the study, this trend is not completely understood. However, we assume that the incandescence emitted by particles including those outside the measurement volume might be scattered by particles located within the measurement volume (see reference [2]) and in the later part of LII signal scattering is stronger than incandescence. Moreover, enhanced agglomeration of particles is expected when raising pressure and so a stronger scattering signal, certainly in Mie regime, might be recorded together with LII.

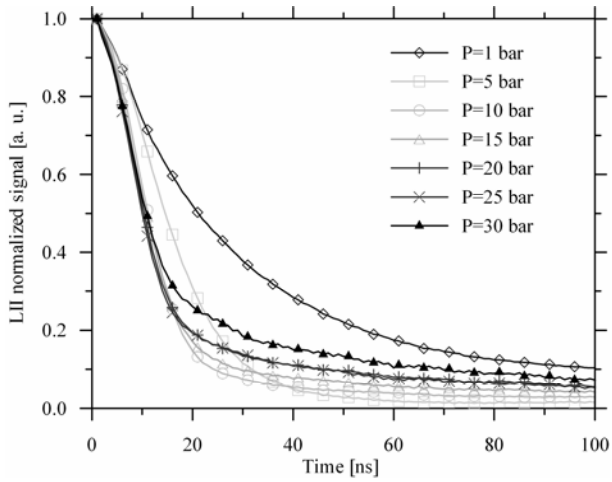

Fig. 1: LII normalized signals (averaged over 100)

Further work will be conducted in order to better explain the behavior of LII signals at relatively high pressures. Sampling of carbon black particles and TEM analysis will be the first step to clarify this behavior.

[1] M. Hofmann, W.G. Bessler, C. Schulz, H. Jander, Appl. Opt. 12, 2052 (2003)

[2] K.A. Thomson, D.R. Snelling, G.J. Smallwood, F. Liu, Appl. Phys. B 83, 469-475 (2006)

[3] B.F. Kock, T. Eckhardt, P. Roth, Proc. Combust. Inst. 29, 2775 (2002)

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