Low Temperature Combustion Concepts: Full Metal and Optical Engine Experiments Compared

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W2P003: LOW TEMPERATURE COMBUSTION CONCEPTS: FULL METAL AND OPTICAL ENGINE EXPERIMENTS COMPARED

Cornelis Leermakers, R.P.C. Zegers, L.M.T. Somers, N.J. Dam, B.H. Johansson, L.P.H. de Goey
Eindhoven University of Technology, The Netherlands

In current diesel combustion engines, legislated emission levels are generally met through aftertreatment. The development of combustion technologies with lower smoke and NO_x emissions can minimize the aftertreatment system required, and thus reduce the related costs. Combustion concepts aiming to do this mostly rely on enhanced mixing and reduced (local) temperatures and can therefore be classified as Low Temperature Combustion (LTC) concepts. Partially Premixed Combustion (PPC) and Reactivity Controlled Compression Ignition (RCCI) are the most well-known applications of this concept, developed at Lund University and the University of Wisconsin-Madison, respectively. Besides their lower smoke and NO_x emissions, these applications have shown a simultaneous efficiency improvement, and as such a CO_2 emission reduction.

Up till now, both applications have almost exclusively been demonstrated in the two university's labs. Secondly, a back-to-back comparison has yet to be performed. In the Eindhoven Engines labs, both concepts are extensively tested on a metal single cylinder engine, and extended to second-generation biofuels. These often have a lower sooting tendency, but more importantly they also offer the possibility to reduce well-to-wheel CO_2 emissions even further.

Further improvements of these LTC concepts are sustained by a detailed understanding of underlying physical and chemical processes. Laser-based diagnostics may contribute significantly to this understanding. However, turbulent combustion exhibits transient phenomena, such as extinction or ignition, which cannot be viewed as statistically stationary. For a better understanding of these phenomena and the effects of the stratification level (i.e. gradients of temperature and mixture strength) present in LTC, laser-based diagnostics of two-dimensional flow and scalar fields at rates much faster ($\geq$ 1 kHz) than typical time-scales of turbulent flames is necessary.

To access combustion dynamics at these short time-scales, spatial distributions of diatomic molecules like OH and CH can be monitored in Eindhoven's optically accessible engine. For their excitation, a Sirah Credo HS dye laser is used, which is pumped by a high-speed EdgeWave IS8II-DE double-cavity Nd:YAG laser with a repetition rate up to 10 kHz and a pulse energy of 7 mJ at 3 kHz repetition rate (per cavity, so 6 kHz net). A 6 kHz repetition rate enables a 1.2°CA resolution at an engine speed of 1200 rpm. R6G and Styryl 8 dyes are used for excitation of OH and CH, respectively. Even when using an intensified camera system, the rather low pulse energies at high repetition rates make imaging of these molecules a challenge.

Cornelis Leermakers: c.a.j.leermakers@tue.nl