High-resolution true color imaging of reacting sprays

High-Resolution True-Color Imaging of Reacting Sprays

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The development of dedicated, scientific cameras has been primarily focused on fast response times, high sensitivity and well-known spectral sensitivity. The downside of these cameras is that they come at a high price tag, producing often gray-scale (intensity) image data and, when compared to modern day consumer cameras, their resolution (~1 megapixel) is rather low.

Consumer cameras offer true-color (RGB) images at high-resolution (~20 megapixel) at a low price (in the order of 1 k€, compared to around 50 k€ for scientific camera systems). Downside of these cameras is the long insertion delay (54 ms for the Nikon D7000 camera used), high jitter (0.5 ms) and limited minimum exposure time (0.125 ms).

Here, the goal is to create high-resolution true-color images of burning fuel sprays in the available optical setups.

A wired remote is adapted to create a trigger box that enables TTL control of a Nikon DSLR camera. With the internal delay of the camera known, the camera can be synchronized with repetitive processes, to take pictures at a pre-selected time. Two combustion events will be imaged: burning Diesel sprays in an optical engine and the pre-burn and subsequent Diesel spray in a constant volume vessel. We present four images for each system.

Optical engine

This single cylinder, heavy-duty engine, with dimensions mimicking DAF production engines, is fitted with a quartz piston crown to allow optical accessibility of the combustion chamber. Fuel is introduced into the cylinder via an 8-hole injector using a double injection scheme, which explains the characteristic pattern in the images (A through D) in Figure 1 below.

- A: *Ignition of the pilot injection*. Short injection pulse just before top-dead-center, fuel ignites after the pilot injection has ended. Combustion remains within the piston bowl region.
- B: Spray-driven phase '*quasi-steady flame thrower*' of the main injection pulse, fuel is burning while injection is still ongoing.
- C: *End-of-injection combustion recession* is captured. Injection has ended, the tail of the fuel spray loses momentum and the flame progresses towards the injector nozzle.
- D: *burn-out phase*. After the end of the main injection, fuel remnants are burned and most of the formed soot will be oxidized.

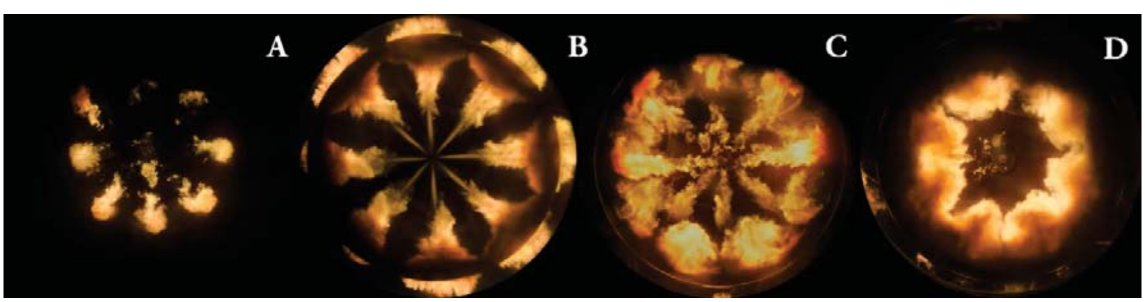

Figure 1. Four example snapshots of a Diesel combustion event.

Eindhoven High-Pressure Cell

A constant-volume high-pressure spray vessel with a single-hole injector mounted to study (non-)reacting fuel sprays under engine-like conditions, without interference of moving parts or neighboring sprays. The desired thermodynamic conditions are created using a pre-burn approach, and after a relatively long cool-down period, a Diesel-like fuel is introduced into the vessel. Figure 2 depicts two snapshots capturing the pre-burn event and two shots visualizing the (igniting) Diesel spray.

- 1: Flame propagation in an acetylene/O_2/N_2 mixture during the early stage of the pre-burn event.
- 2: Soot formation during the final stage of the pre-burn (at high-pressure and high-temperature).
- 3: Ignition of the isolated fuel spray under engine-like pressure and temperature conditions (~60 bar and ~900 K, respectively).
- 4: "quasi-steady" matured Diesel spray.

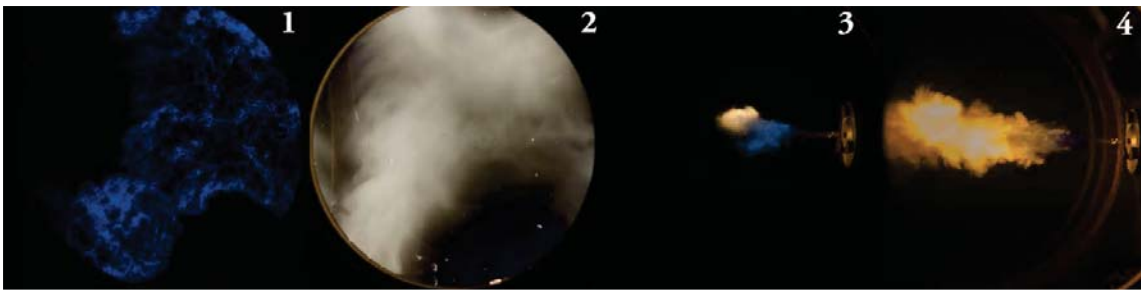

Figure 2. Four photographs of the combustion event(s) in the Eindhoven High-Pressure Cell. Exposure and ISO were adjusted to capture the faint chemiluminescence (no. 1 and 3).