Engine Combustion Network three orifice injector (Spray B) ignition delay, lift-off length and near field visualization measurements

motores térmicos

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1. Introduction

- Although Computational Fluid Dynamic (CFD) simulation results are of great help, experimental data is crucial to validate these models. ECN provides a reliable library of well-documented data.

- A three orifice injector from the ECN dataset, referenced as Spray B, was used. Aditionally, results are compared with an axially drilled single orifice injector, referenced as Spray A.

› Follow up study was needed for ECN standard reacting conditions (highlighted in Orange).

› Near field visualization was performed to observed the behavior of the spray near the nozzle, and measure the spray axis angle fluctuations (Blue).

- Articles published:

R. Payri, F. J. Salvador, J. Manin, A. Viera, Diesel ignition delay and lift-off length through different methodologies using a multi-hole injector, Applied Energy 162 (2016) 541–550.

R. Payri, G. Bracho, P. Martí-Aldavarí, A. Viera, Near field visualization of diesel spray for different nozzle inclination angles in non-vaporizing conditions, Fuel (in review).

2. Objectives

› Measure lift-off length and ignition delay for parametric variations of the boundary conditions.

› Compare combustion results with an analog single orifice inejctor.

› Measure macroscopic parameters in the first milimeters of spray tip penetration and spray axis angle fluctuations.

3. Materials & Methods

Two different vessels and optical setups were used:

› High pressure and temperature vessel, combustion setup.

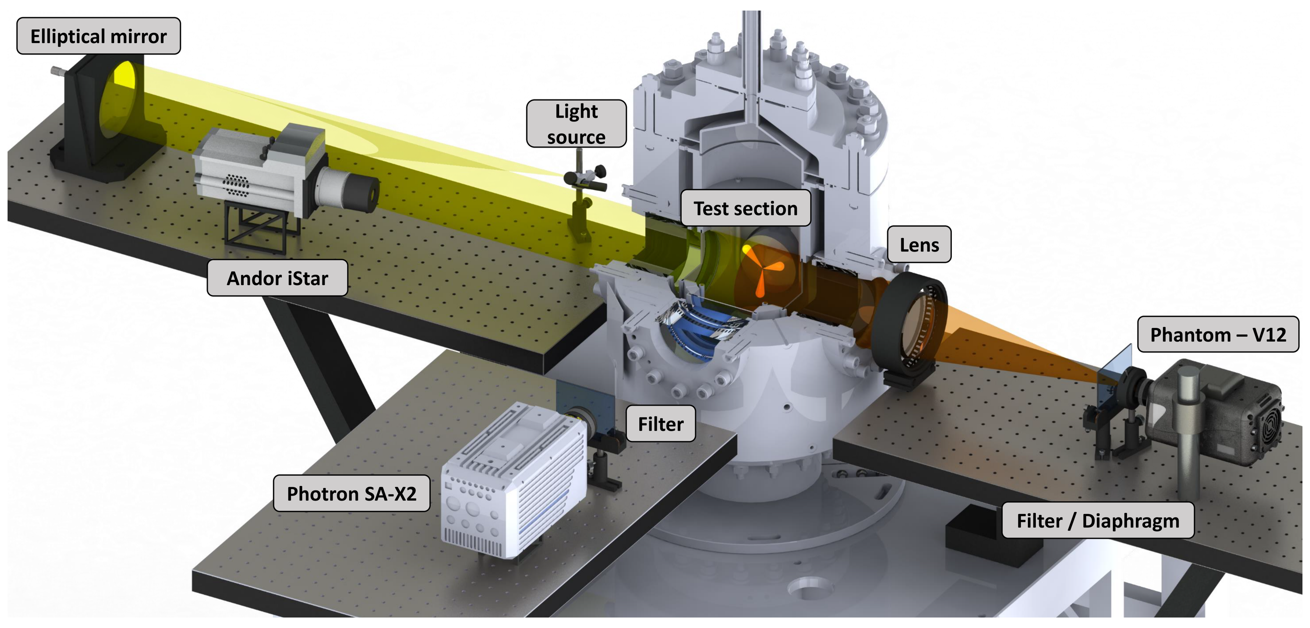

Figure 1. Broadband chemiluminescence, single pass Schlieren and OH chemiluminescence with an intensified ICCD camera.

› Combustion spray visualization.

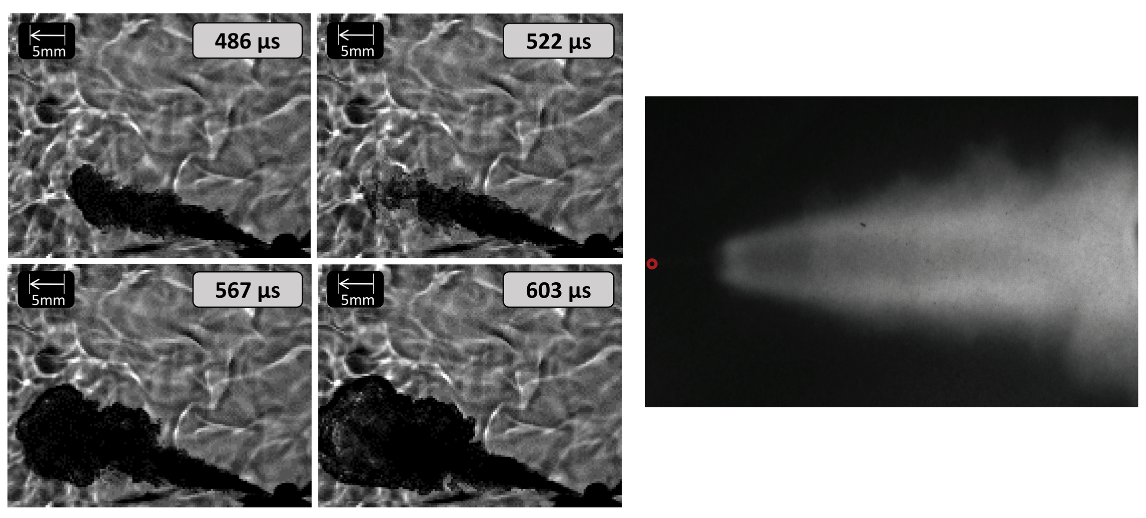

Figure 2. Ignition sequence by the Schlieren images is presented on the left side. A example of the images taken by the ICCD camera with the OH filter is shown on the right, mark is the nozzle position.

› High pressure ambient temperature vessel, near field visualization setup.

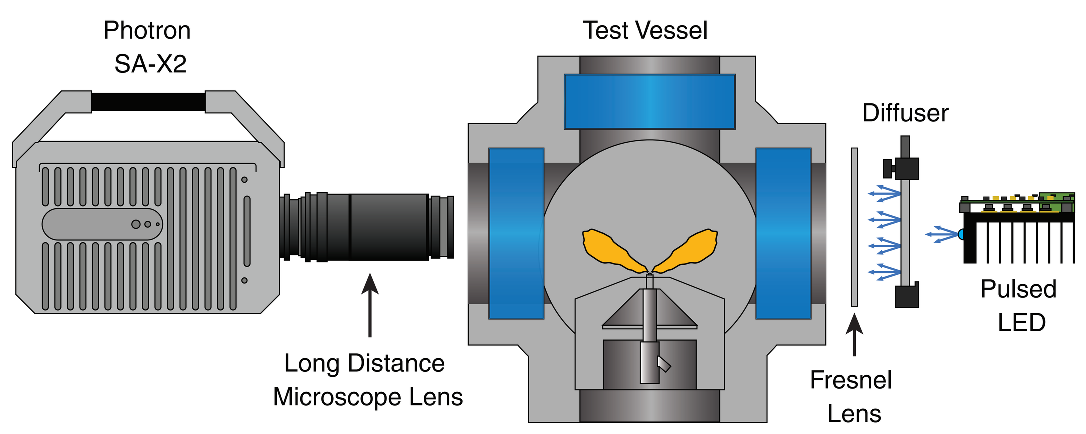

Figure 3. Near field visualization with diffused back-illumination. Fast camera was equiped with long distance miscroscope.

› Near field visualization variables definition and spray processing.

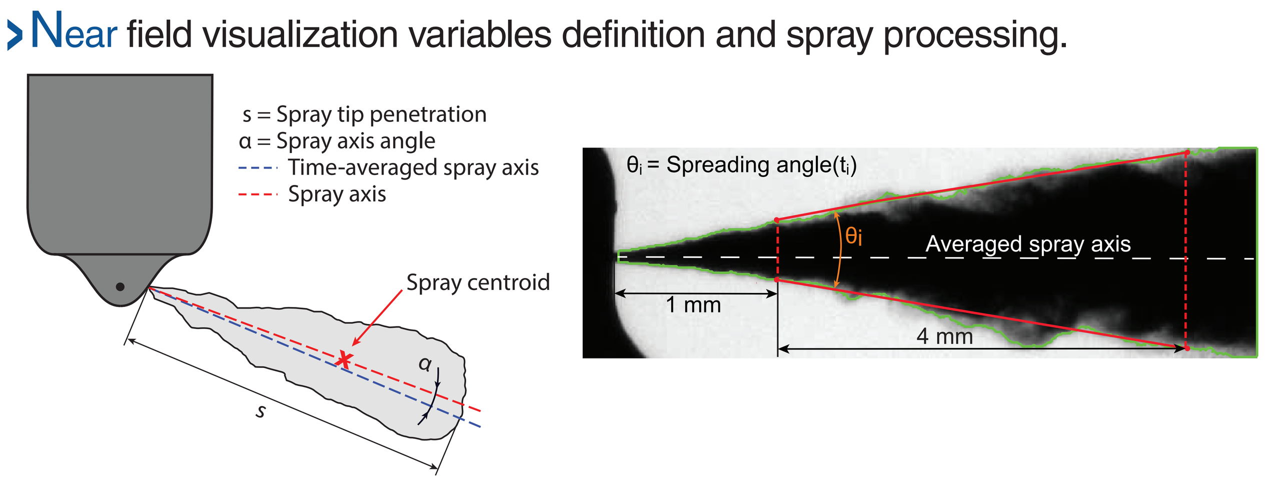

Figure 4. Definition of the macroscopic variables of the spray for near field visualization.

4. Combustion Results

› Combustion results: ignition delay and lift-off length.

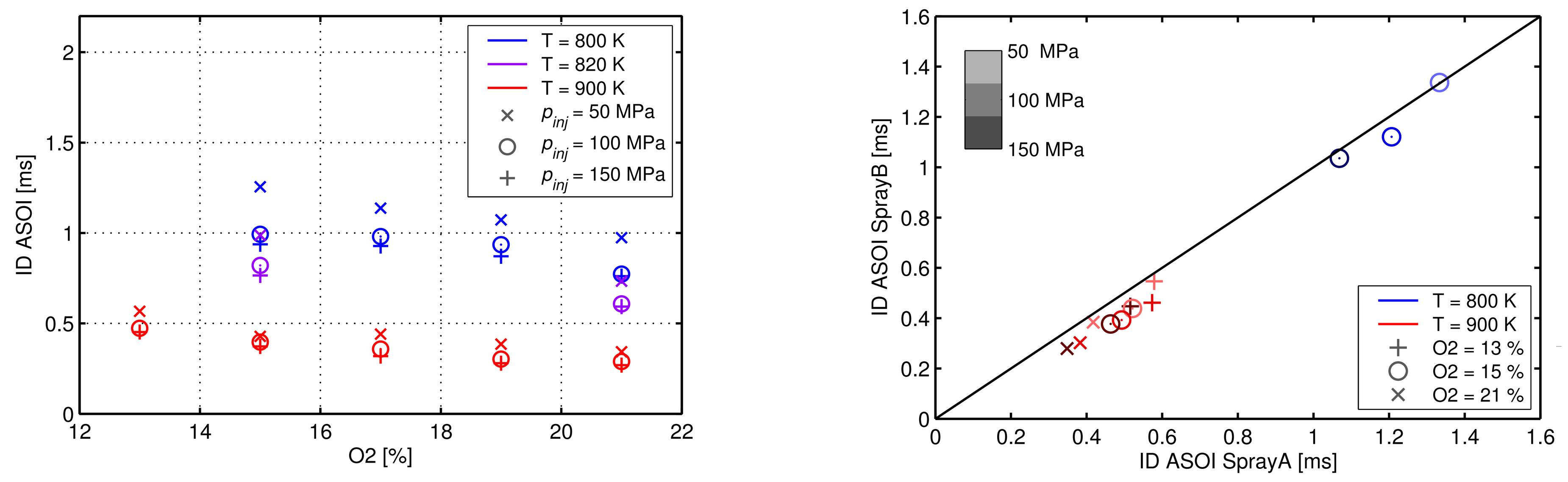

Figure 5. Ignition delay results. Left plot shows the influence of oxygen concentration, injection pressure and temperature. Right plot shows the difference between the Spray B and the analog axially drilled single orifice Spray A.

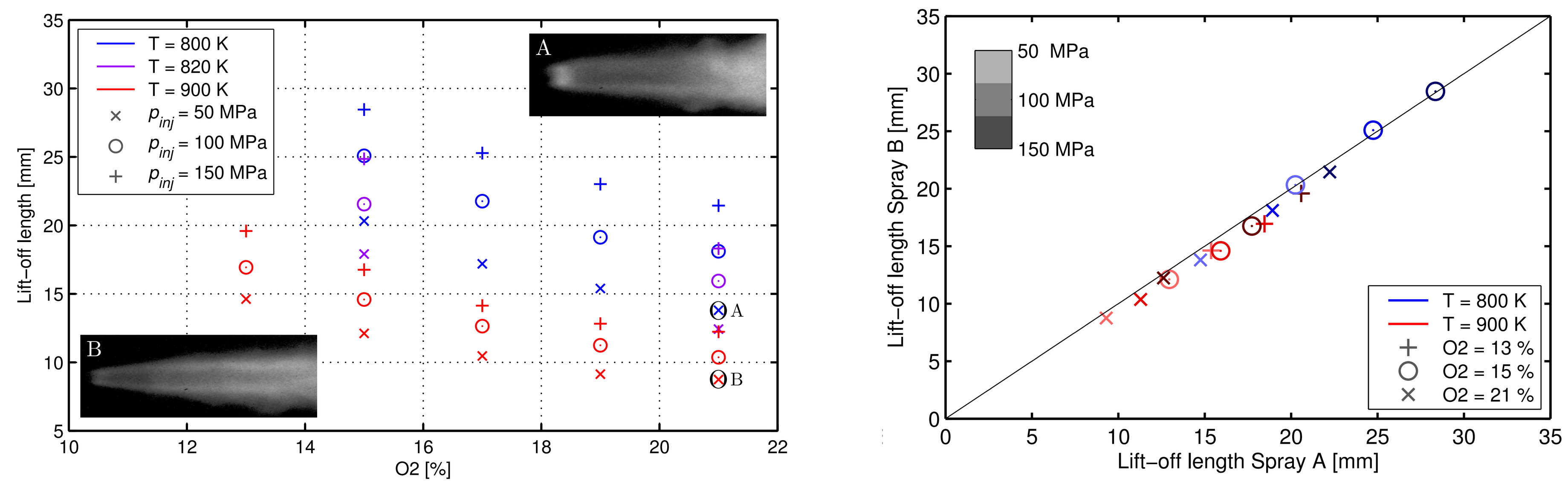

Figure 6. Lift-off length results. Influence of the different boundary conditions are presented in the left plot. Right plot presents the comparison with the single orifice analog injector.

5. Near Field Results

› Near field visualization results: spray axis and spreading angle fluctuations.

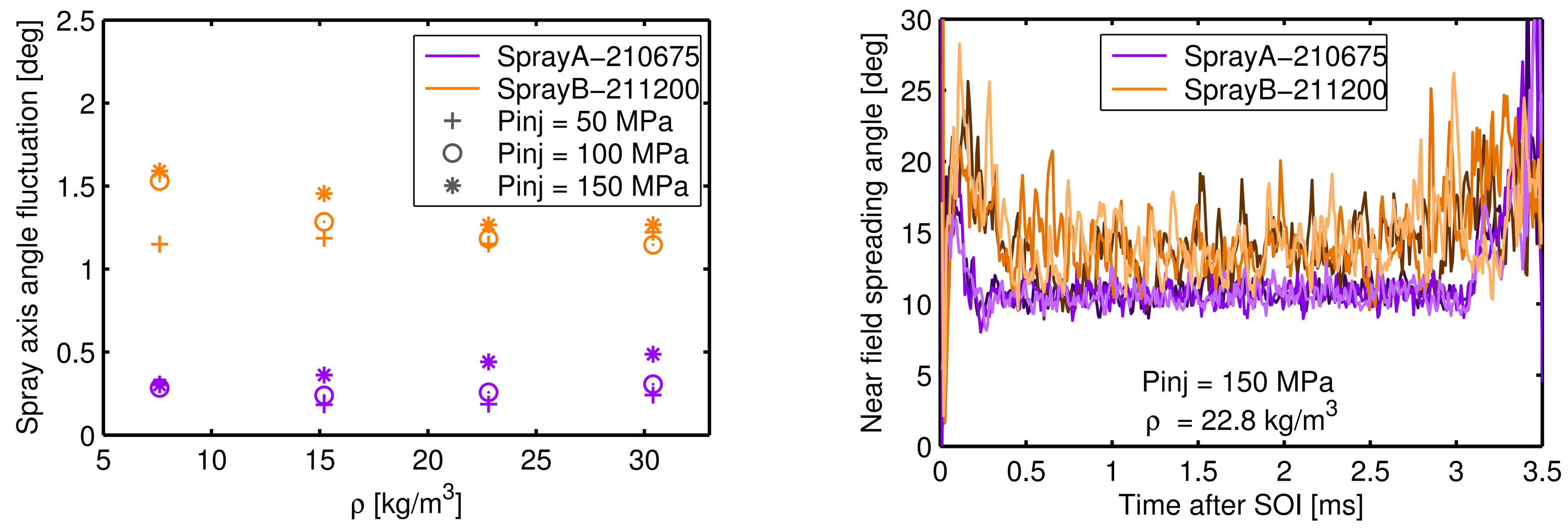

Figure 7. Partial results from the near field visualization for both nozzles. Left plot presents the spray axis angle fluctuation for different densities and injection pressures. Right plot presents spreading angle for three random repetitions, fluctuations for Spray B points to possible cavitation in the nozzle.

- R. Payri, F. J. Salvador, J. Gimeno, J. P. Viera, Experimental analysis on the influence of nozzle geometry over the dispersion of liquid n-dodecane sprays, Frontiers in Mechanical Engineering 1 (October) (2015) 1–10.

- J. M. Desantes, R. Payri, F. J. Salvador, J. De la Morena, Influence of cavitation phenomenon on primary break-up and spray behavior at stationary conditions, Fuel 89 (10) (2010) 3033 – 3041.

6. Conclusions

› Ignition delay drecrease with increasing temperature, injection pressure and oxygen concentration. Oxygen and temperature accelerate oxidation reactions, while injection pressure influence in the mixing process.

› Lift-off length decreased with increasing temperature (evaporation) and oxygen concentration (local combustion conditions). On the contrary, it increased with increasing injection pressures, corresponding to the stabilization of the jet velocity and flame front speed.

› Spray axis angle fluctuations were observed for the multi-orifice injector (Spray B) compared to the analog single orifice injector. They decreased with increasing density, with the opposite effect for increasing injection pressure.

› Spreading angle fluctuations results supports the hypotheses of high turbelence or even incipient cavitation, in the multi orifice injector, as a possible cause for spray axis angle fluctuations.

› In general, Spray B nozzle produced shorter ingnition delay and lift-off length. Aditionally, Spray B showed considerable spray axis fluctuation compared to Spray A, and aditional results indicate the presence of very high turbulence, or even incipient cavitation, in Spray B.

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