Experimental study of laser ignition probability, kernel propagation and air and fuel droplet properties in a confined swirled jet-spray burner

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HIGHLIGHTS

- PDA reveals strong variations of velocity, turbulence and fuel droplet size distribution, which have great impact on laser ignition.
- Slip velocity varies significantly with droplet size and with location within the chamber.
- Ignition probability is zero in the centre of the burner and grows steeply towards the lateral walls, in the ORZ.
- High-speed visualisation shows the flame kernel propagation. Survival and extinction are related to the movement direction.
- Burner ignition follows different stages that are described by simultaneous pressure measurements and high-speed images.

ABSTRACT

Two-phase flow ignition and combustion have to be well understood in order to progress in aeronautical engine conception. This investigation proposes a laser induced ignition study in a real confined swirled jet-spray burner. Phase Doppler anemometry (PDA) is used to characterise airflow velocity and fuel droplet size distribution and velocity in first place. A probabilistic approach to ignition is presented and propitious regions for ignition are identified. High-speed visualisation is used to track the flame kernel movement and development inside the burner in order to analyse the possible paths followed by the kernel towards a stabilised flame or towards extinction. Results show how local properties vary along the chamber. Airflow velocity and turbulent kinetic energy are very intense in the central region of the burner, over the annular co-flow. Fuel droplets of big diameters show high slip velocities, which are greater outside the air jet. These parameters control droplet evaporation and vapour repartition, and have a great impact on ignition probability. The probabilistic ignition study coupled to the kernel high-speed visualisation reveals that a flame kernel is more likely to survive if trapped by the outer recirculation zone (ORZ), showing great correlation with the airflow velocity field. Ignition probabilities grow towards the chamber lateral walls. The different steps of the development of a kernel towards a stabilised flame are compared to the pressure variation in the chamber. This investigation is useful for numerical simulation validations and contributes to scientific knowledge on two-phase ignition.

![Fig. 1 Flame kernel development for laser focusing at point x=20 mm, z=40 mm. Missed ignition.](image_url)