Tomographic PIV Study of lifted flames in turbulent axisymmetric jets of methane.

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In the present work, the capability of the tomo-PIV technique [Elsinga et al. 2006] to measure 3D flow structures in reactive flow is evaluated in a lifted flame configuration. In combustion, two main problems can be encountered: the flame radiation and the imaging of the particle field throughout non-uniform distribution of the refractive index. In order to assess these points, a turbulent lifted flame of methane has been investigated. Indeed, in this simple configuration, some parts of the methane jet is surrounded by the reaction zones and burned gases, both inducing large variations of the refractive index, which are time dependent. (see Figure 1). The main objective of this experiment is to compare the tomo-PIV results performed in reactive conditions to those obtained in the same flow conditions without flame (free jet).

Before the reconstruction step, a specific image processing based on a band-pass filter in spectral space is applied on the images to remove the flame radiation without affecting the particle positions. The reconstructed pairs are then analyzed by means of 3D cross-correlation. One example of 3D velocity field is presented in Figure 2. In the center part, the development of the methane turbulent jet is well resolved with the flame stabilized on its external part (region without vector). Far to the jet, the very low velocities in the co-flow are also correctly predicted. In the upper part of the flame, the velocity in the jet is well measured whereas that the particle fields are imaged through high temperature gradients. The results in that part of the flow show in these experimental conditions, that the refractive index variation has not a too significant impact on the quality of measurement, which is comparable to the case without combustion.

Bibliography:

Figure 1 - Photography of the lifted flame in the light sheet with balanced seeding

The burner consists of a stainless steel tube of 4 mm inner diameter of 300 mm long. The jet of methane is surrounded by a laminar low-velocity co-flow, both flow been independently seeded. For the tomo-PIV measurement, four Imager Pro X cameras of 2k.2k pixels are angularly placed at around 30° in Scheinflug condition, imaging a volume of 50x50x8 mm\textsuperscript{3}, lighted using a dual-cavity Spectra-physics laser Nd:YAG (400nmJervation@632nm).

Two flow conditions of the methane jet have been investigated (Re = 5000 and 10 000), with two seeding strategies; one with balanced seeding in both flows; the jet and the co-flow, the other with seeding only in the turbulent jet of methane.

The computation of the 3D velocity fields has been performed from C++ programs developed in the framework of a French national research program (VIVE3D), involving the CORIA, PPRIME and LML laboratories. The reconstructions are performed using iterative MART algorithm with a correction of the calibration mapping function using a self-calibration procedure [Wieneke 2008].

Figure 2 Raw instantaneous 3D velocity field in a lifted-flame configuration overlapped with the X vorticity.