Gradient-based Filtering Operations for Flame Front Analysis from OH PLIF images in a liquid fuelled combustor

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A burner has been developed to study the flame front topology (positions and curvatures) in presence of both gaseous and liquid fuel. It is based on a modification of a low-swirl burner with a central injection of droplets. This burner is characterized by four quantities, namely the mean bulk velocity $\mathbf{V}$, the swirl number $S$, the mass mixture fraction $\chi$ and the ratio in mass of dodecane injected with respect to the overall injection of fuel $\alpha$. Overall bulk velocity is around 4.2 m/s while the swirl number varies between 1.9 and 2.0. For gaseous cases, lean premixed methane-air cases are investigated while a small amount of dodecane (between 2 to 8% of the total mass of fuel) is injected for the two-phase flames, while keeping the overall mass mixture fraction almost constant ($0.033 \pm 0.002$). Detailed measurements based on OH-PLIF are proposed for those lean mixtures of gas and gas/droplets and statistics are based on the analysis of 1,000 samples for each case. For the two-phase flames, simultaneous Mie scattering images are recorded with the same UV laser sheet to determine regions of high concentrations of droplets even after the main flame front. The main characteristics of the gaseous flames are slightly different as compared to previously published results on a similar geometry [1]. It is found that the probability to have unburned gases along the center axis is never zero in presence of droplets and that the flame is stabilized a bit closer to the exit of the injector. Curvatures are measured for regions in the center of the burner to avoid any spurious effects of entrained air and show that results obtained with droplets show a higher value of fluctuations. This is due to the fact that individual droplets still exist after the flame front and tend to disrupt the initial flame, creating high curvatures. Furthermore, as pockets of unreacted mixtures are more frequent (like the case shown in Figure 2), the mean curvature is biased towards negative values and the bias is seen to grow with the amount of liquid fuel injected. Further statistical moments are presented to describe the main changes induced by droplets on the flame topology.


Fig. 1 Typical OH-PLIF image of the gaseous case. The overall mass mixture fraction is 0.033.

Fig. 2 Typical OH-PLIF image of the mixed gas/liquid case. The amount of dodecane for this case is 2% in mass of the total fuel injected.