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Air assisted atomisation of a liquid film investigated by way of improved phase detection probes

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Abstract

Gas assisted atomization, i.e. the atomization of a slow liquid film, sheet or jet by a rapid gas stream, is commonly exploited in turboreactors as well as in cryotechnic rocket engines. As combustion strongly depends on the characteristics of the spray, to decrease the amount of pollutants emitted.

Previous investigations on droplets stripped off the interface (Figure 1) have shown that three successive instabilities drive the atomization. First, longitudinal waves are formed by a Kelvin-Helmholtz type instability those most amplified wavelength is controlled by the gas vorticity thickness δ_G at the injector exit (Villermaux & Marmottant 2004). The axial frequency prediction was recently improved by accounting for the presence of the splitter plate between gas and liquid (Matas et al. 2011). Second, ligaments arise on the wave crest by a wind induced Rayleigh-Taylor instability (Hong et al. 2002, Varga et al. 2003). These ligaments break then into droplets (Villermaux 2007).

Based on this scenario, a phenomenological model has been proposed for the mean drop size <D> (Hong et al. 2002): <D> evolves as δ_G $We^{-1/2}$ where the Weber number = $\rho_G (U_G- U_C)^2 \delta_G /\sigma$, U_C being the convective velocity of the axial instability. That proposal proved valid both for planar and axisymetric configurations (Ben Rayana et al. 2006). Yet that model was only tested in the limit of large dynamic pressure ratio $M=\rho_G U_G^2/\rho_L U_L^2$, namely for M about 10 and above that correspond to conditions encountered in cryotechnic engines and in turboreactors during take off. M values down to unity or below arise during cruise or relight. Thus, our recent investigations were aimed at testing the model validity at low M and to check if there is any change in the instability mechanisms.

To access drop size and flux, we exploited a new version of the phase detection optical probe (Hong et al. 2004) with a sensitive length as small as 10µm to be compared with 20µm for the previous sensors. The performances of such probes were thoroughly checked. In particular, drops chord distributions from these two sensors proved nearly identical (Figure 2) while the small sensitive length probe detects more droplets below 10-15µm.

The influence of the M parameter on the drop size will be discussed. Measurements indicate a weak sensitivity of the mean drop size and of the chord distributions on the M parameter in the range 4 to 16.

Figure 1

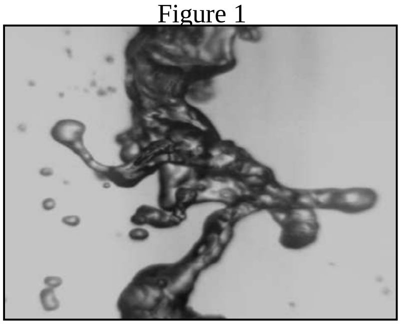


Figure 2

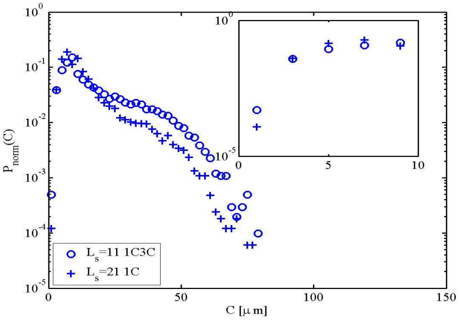
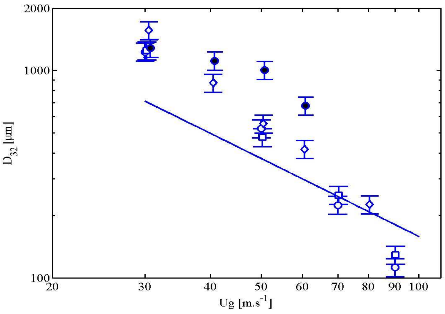


Figure 3



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