Analysis of the transient atomization characteristics of intermittent multijet sprays

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The aim of the work presented here is to analyze the transient characteristics of a multijet atomization strategy operating intermittently and better understand the differences between what is reported in the literature for sprays produced by the impingement of two jets, and the sprays produced with 3 and 4 impinging jets. The multijet sprays considered are aimed at short distance atomization, therefore, the regime of turbulent sheet is chosen in the experiments performed. The information of the atomization characteristics has been acquired with a Phase-Doppler Interferometer which collects simultaneously the size and velocity of droplets. The analysis focus on the relation between the spray intermittency and the fragmentation process; the transient characteristics of multijet sprays exploring the differences induced by the number of impinging jets; and some brief considerations are made relatively to the spray dispersion pattern and the applicability of multijet sprays for spray cooling.

1. Liquid ligament fragmentation

While most research works provide valuable insights into the physics of atomization with 2 impinging jets, little is known about the applicability of such knowledge to the atomization performed by more than 2 jets. Our results suggest that the physics of ligament fragmentation is applicable to multijet sprays produced by the impact of more than 2 jets. Visualization of the sprays produced by 2, 3 and 4 impinging jets allowed identifying two distinct kinds of ligaments: edge and detached. And the main differences observed from the backward formalism used to infer about the relation between ligament fragmentation and mean size of droplets lie in the relative importance of each ligament type in the spray generation. Namely, detached ligaments dominate the process and edge ligaments are gradually less important as the number of impinging jets increases.

Fig. 1 Main atomization structures are identified: edge and detached ligaments; and surface waves. In the image with Nj = 2, two groups of droplets are emphasized to illustrate that edge ligaments produce smaller droplets than detached ligaments.

2. Transient behavior of intermittent multijet spray

The transient analysis of droplets characteristics from the point of view of the periods typically found in intermittent sprays (Leading Front of the Spray, Steady Spray and Spray Tail) has been made in terms of size-velocity correlations. The results suggest that an increase in the number of impinging jets leads droplets formed by detached ligaments to have a more uniform distribution of their axial velocity and, additionally, allow a better distinction from droplets produced by edge ligaments. Also, the present experiments appear to have better atomized the injected liquid, relatively to what correlations proposed in the literature suggest, implying that further research is need at a more fundamental level.

Fig. 2 Joint PDF of the size and velocity of spray droplets normalized by the jet size and velocity, respectively.

3. Spray dispersion pattern

Finally, the dispersion pattern represented by the relation between inertial and surface tension forces, expressed through the Weber number, suggest that multijet sprays are potentially geometric sprays, able to produce small and slow droplets which are likely to deposit on interposed surfaces and, eventually be more adequate for spray cooling than current sprays, thus, becoming a promising, as well as competitive atomization strategy.