Shadowgraphy investigations of high speed water jet atomization into still air

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Abstract

Irrigation sprinkler system is very popular in Europe. To improve its application efficiency, in particular as regards water distribution uniformity, water losses and environmental impact of spraying, a better knowledge of the size and spatial distribution of the generated droplets is necessary. The present study aims at characterizing the atomization of a large-scale pressure-atomized jet of water. The water jet is injected at high velocity into still air thanks to an industrial nozzle particularly used in irrigation. The nozzle diameter is 4.36 mm and exit velocity is about 25 m/s.
The droplet size and velocity are analysed by a double-pulsed shadowgraph imaging technique. A particular attention is paid to the calibration of the imaging system, both to define the measurement volume associated to each droplet size and to improve the estimation of droplet diameters, especially concerning the apparent size of unfocused droplets. For simplicity glass spheres are used instead of droplets in the calibration procedure. The depth of volume measurement is found to be strongly related to the object size. Furthermore, different image processing methods have been tested to estimate the size of non-spherical liquid fragments.
As the spray width is larger than the depth of volume measurement, a number of droplets are not detected by our imaging system. Moreover the spray is very heterogeneous, with more and larger droplets near the jet axis. In order to take into account the whole population of droplets present in the spray at a given distance from the injector, the spray is supposed to be axisymmetric. The validation of the axisymmetric assumption is in progress by getting volume flux distribution using a mechanical patternation technique.
Eventually, drop size distributions are obtained by image processing as a function of the turbulent scales of the upstream flow, as well as Reynolds and Weber number. Particle Tracking Velocimetry (PTV) is used for the investigation of droplet velocities. Preliminary results show that log-normal distributions give the best fit to the experimentally observed drop size distributions. Moreover the ratio of the mass median diameter (MMD) over the Sauter mean diameter (SMD) is found to be constant and equal to 1.2, which is in good agreement with previous studies, and yields to a relation between the mean and the standard deviation of lognormal distributions.
In the near future, an Eulerian model, developed in a previous work and validated up to one hundred diameters from the nozzle, will be extended to the far field and coupled with a Lagrangian approach. Numerical results will be compared with our experimental data of droplet size and velocity measurements and with Particle Image Velocimetry (PIV) measurements in the liquid core.

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