Multijet spray characteristics for spray cooling

M. R. O. Panão, J. L. C. V. Rosa and A. L. N. Moreira*
Department of Mechanical Engineering
IN+, Instituto Superior Técnico, Technical University of Lisbon
Av. Rovisco Pais, 1049-001 Lisbon, PORTUGAL

Abstract

This paper reports an experimental study on the development of a spray pattern, based on the impact of multiple jets on a single point (multijet spray), for the recently proposed concept of intermittent spray cooling (Panão and Moreira, Int. J Heat Fluid Flow, 30:117-130, 2008). Most experimental research in this atomization strategy is focused on the impact of 2 jets, and there is a lack of experimental evidence about the possible advantages of using more than 2 jets. Therefore, we consider the simultaneous impact of 2, 3 and 4 jets (N_{jet}), having developed proto-type atomizers assembled with an electromechanical valve for spraying intermittently. The main objective of this work is to develop low-pressure intermittent sprays useful for spray cooling applications at short impingement distances (10-30mm). The visualization of the flow shows that impinging more than 2 jets leads to tridimensional structures underlying the atomization process. It is observed that a slight increase in mean drop size as the number of jets increases, implying a gain in directionality in spray propagation and, consequently, decrease of the spray dispersion angle. Namely, with 4 impinging jets, the mean size and particle density, within the plane of characterization, are more evenly distributed, resulting in a more uniform spray throughout the impact area. Also, given the spray intermittency, for 90% of the cycle, the correlation between the droplets axial velocity and their size is inversely proportional, which is positive if we require liquid deposition on the surface for cooling purposes. In fact, if we use the criteria established in the literature to estimate the impingement regimes expected to occur (stick, re-bound, spread and splash), when the spray droplets strike an interposed surface at the characterization plane, the impact energy range is mostly within the rebound and spreading regimes, favoring the latter, and generally leading to the deposition of the liquid. Also, the effect of increasing the number of impinging jets in this atomization strategy, maintaining the impact momentum in each jet, is to shift the impact energies of droplets striking a surface to higher values, favoring the occurrence of spreading and, consequently, improving the liquid deposition in spray cooling. The experimental results obtained from the spray characterization indicate that multijet sprays have the potential for enhancing heat transfer when applied to spray cooling systems.

Key words: multijet sprays, design, spray cooling, Phase-Doppler Interferometry

*Corresponding author, moreira@dem.ist.utl.pt