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Evaluation of the cooling performance of individual droplets impinging onto heated targets

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Abstract

The present work reports the experimental evaluation of the cooling performance of individual droplets impinging onto heated targets. The thermal behaviour of the droplets is assessed based on the temporal variation of the surface temperature, within the region of liquid-solid interaction, making use of fast-response thermocouples. A systematic approach considers the variation of several design parameters (e.g. liquid properties, impact velocity and diameter) and boundary conditions to infer on their effect on the thermal and hydrodynamic behaviour of the droplet. The temperature measurements are complemented with the characterization of droplet dynamics and interfacial phenomena, by using high-speed imaging combined with phase Doppler measurements, to provide a better interpretation of the phenomena. Liquid properties are determinant in the cooling performance of the droplet. Particularly, the liquid surface tension and the latent heat of evaporation give rise to relevant morphological modifications of the lamella, which influence the whole heat transfer process. The role of the impact conditions and particularly the impact velocity is secondary, but the use of micro-textured surfaces can be an alternative solution to improve the cooling performance of the impinging droplets. Optimization of the topographical parameters is performed based on the relations between the roughness amplitude and the fundamental wavelength, R_a/λ_R, in a compromising solution of endorsing liquid-solid contact without promoting an excessively intense thermal induced atomization.

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Key words: single droplet impingement, heat transfer regimes, cooling performance, micro-structured surfaces.

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