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Streszczenie rozprawy doktorskiej nt.:

„The influence of flash-boiling effect on droplet size distributions of low-pressure sprays under various ambient pressures and fluid temperatures”

Flash boiling occurs when a heated liquid is suddenly depressurized below its saturation pressure. This scenario can be achieved by overheated fluid injection into the ambient conditions. Due to the nucleation process, bubbles are constantly created inside the flow resulting in two-phase flow through the nozzle. Under certain conditions, this is followed by rapid vapour bubbles expansion inside the droplet and micro explosion of droplets into smaller sizes. As a result, a spray with improved atomization can be achieved.

The flash-boiling phenomenon can be an interesting alternative for improving droplet atomization to the elevation of injection pressure, as this method often leads to a simultaneous increase in spray penetration. This problem can be solved by a proper adjustment of flash-boiling conditions and producing cloud with more uniform droplet and mass distribution, reduced penetration and wider spray angle.

The literature shows a great interest in this topic by researchers from numerous fields of study. A great emphasis was put on understanding of flash boiling-induced phenomena like angle spreading, spray collapse and droplet size reduction. Nevertheless, the review of state-of-the-art revealed that there is a lack of studies regarding the influence of flash-boiling intensity on droplet size distribution shape for low-pressure fluid injection. What is more, there is no studies regarding the individual influence of fluid temperature and ambient pressure conditions on the flash-boiling effect in terms of the overheat level. This is especially important since similar studies for high-pressure injections showed the relevant influence of those factors on the atomization process, regardless of the fact that the flash boiling effect is considered the major. This knowledge gap is addressed within this work.

The goal of this work was to understand the influence of flash-boiling parameters on droplet size distribution and to model this influence in function of overheat parameters. For this purpose, systematic experimental tests which covered a broad spectrum of fluid temperature and ambient pressure conditions were conducted. The experiments were carried out using water injected by a modified commercial low-pressure injector with body temperature control through the cooling jacket. The fluid was injected into a constant-volume vessel with optical access, and the shadowgraph technique with long-distance microscope was used to measure the droplet size.

The conducted tests showed that both fluid temperature and ambient pressure affect the droplet size distributions. It was shown that keeping the same overheat level expressed as saturation to ambient pressure ratio for different fluid temperatures gave substantially different results. Nevertheless, a similar and consistent pattern of droplet size reduction could be observed between data series grouped by fluid temperature. Droplets are reduced in the whole range of size and the level of reduction is decreasing with increasing superheat level.

Based on the observations made for experimental results, a model for simulating droplet size distribution at given overheat conditions was proposed. The model takes into account a global trend of droplet size reduction observed for each fluid temperature. The model was found to simulate the droplet size probability density functions with a satisfactory agreement at all performed experimental conditions.

Słowa kluczowe:

flash boiling, atomization, droplet size distribution, low-pressure injection

Podpis Doktoranta