An experimental study of spray cooling using high-speed visualization and infrared thermometry

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Abstract

Spray cooling as well as micro/mini heat pipes and jet impingement cooling is one of the most effective ways for heat dissipation. Despite all advantages of spray cooling this process is still complicated for physical description. In particular, heat transfer at spray cooling depends on many factors including the flow rate, the sizes and velocities of droplets and it is unequally distributed over a heat exchange surface. At the same time, the most previous studies on heat transfer are based on measuring the local surface temperature. According to these measurements the integral heat transfer coefficient was estimated for the entire heat transfer surface. Therefore, for better understanding and subsequent interpretation of observed phenomena, it is necessary to measure the spatial distribution of the heat transfer coefficient over time at spray cooling.

This report will be devoted to experimental research of the spatial distribution of heat transfer coefficient with the use of high-speed infrared (IR) thermography. Also, for the analysis of the influence of key hydrodynamic parameters of spray on heat transfer, new data on droplets sizes, their velocity, spray angle using the shadow technique and high-speed visualization were obtained in the study.

The water of the room temperature was used as working fluid. Two different types of nozzles: Bosch which generated four droplet jets with droplet diameter about 500 μm and full cone spray nozzle with droplet diameter less than 100 μm were used as a spray source. As a heat transfer surface, 400 μm thick sapphire substrate was used, on the back side of which a thin film heater from indium tin oxide (ITO) with 1 μm thickness was deposited. The main advantage of using ITO as a heater material in experiments at spray cooling is its transparency in the visible spectrum (380–750 nm) and opacity in the mid-IR spectrum (3–5 μm). This property makes it possible to measure non-stationary temperature field on the ITO film surface by infrared camera and visually record the dynamics of irrigation of heat transfer surface by high-speed video camera. Sample was resistively heated (Joule heating) by a DC power supply via silver electrodes deposited onto the ITO film.

Keywords: heat transfer, spray cooling, high, speed IR thermometry, high, speed visualization, transparent heater

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