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Thermohydraulic Characterization of DI Water Flow in Rectangular Microchannels By Means Of Experiments and Simulations

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Extended Abstract

Two-phase flow boiling in microevaporators has promising applications in high performance cooling and chemical process engineering [1-3]. However, this process is still not fully understood due to its high complexity. This is one of the reasons why results of various research studies often differ [4]. High-quality measurements for characterization of microchannel systems are therefore still necessary in order to identify the significant effects for process description and prediction. This is especially true for single microchannels, where the experimental database is rather scarce, since most scientific work examines multichannel systems. Preceding two-phase flow investigations, adiabatic and diabatic single-phase experiments were performed in rectangular stainless-steel microchannels to determine properties like pressure drop, friction factor and heat loss. These properties are crucial for two-phase data reduction and the determination of heat transfer coefficients. Furthermore, such characterization allows for a better choice of boundary conditions in single-phase and two-phase simulations.

The microchannels used in this study were milled into a stainless-steel plate, with a hydraulic diameter of 430 and 750 µm and a length of 65 mm. The mass flux of DI water was between 20 and 1,500 kg/m^{2}s. The microchannels were heated with a heat load of up to 11 watts by 11 cartridge heaters integrated into the steel body along the channel bottom with built-in thermocouples at the respective heater tips. In addition, the local temperature of the DI water inside the channel was measured alongside the channel with up to 17 platinum resistance temperature detectors (RTDs). These RTDs were realized on a glass lid using thin film deposition, photolithography and reactive ion etching of a 200 nm thick platinum layer. This glass lid was located as a top cover onto the semi-open rectangular microchannels. An O-ring sealing surrounding the channel was mounted in-between in such a way that the platinum thin film resistors were in direct contact with the fluid. All temperatures measured by the thermocouples and the platinum RTDs were used to determine the heat taken up by the water while passing through the microchannel. The local fluid temperatures measured with the Pt RTDs are compared with the fluid temperature evaluated by means of a global energy balance of the whole microchannel. The local footprint temperatures and heat fluxes were derived by solving an inverse heat conduction problem utilizing the Newton-Raphson optimization method. In addition to the experimental investigation described, the microchannels are characterized using numerical simulations based on the *chtMultiRegionFoam* solver from the OpenFOAM simulation toolkit. Finally, the results are compared with each other and with existing literature.

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