Experimental techniques for the analysis of Single-Phase Forced Convection in Microchannels

Gian Luca Morini

DIN - Alma Mater Studiorum Università di Bologna, Viale Risorgimento 2, 40136 Bologna (Italy)
gianluca.morini3@unibo.it

In this lecture a critical review of the main experimental techniques proposed in literature for the investigation of single-phase forced convection in microchannels is presented. The problem of the experimental determination of friction factors, critical Reynolds numbers linked to the laminar-to-turbulent transition and convective heat transfer coefficients in channels having dimensions lower than 1 mm is discussed by stressing the positive and negative aspects of each experimental approach both for liquid and gas flows.

Measurement techniques specifically designed for the determination of temperature, pressure, velocity, flow rate in micro-systems will be presented both for liquid and gas flows. It will be demonstrated how the accurate design of the whole test rig is crucial in order to avoid the generation of wrong data. The design of the experimental test rig needs the "*a priori*" knowledge of the main scaling and micro-effects which can play a role during the experimental tests. In addition, in many cases a series of practical issues linked to the real geometry of the microchannel, the real thermal boundary conditions imposed experimentally and the presence of micro-fittings and sensors within the test section can have a strong influence on the convective behavior of the working fluid and these aspects must be considered during the design-phase of the test rig in order to minimize their impact on the experimental results. For this reason, only if the experimental work is coupled to a complete computational thermal fluid-dynamics analysis of the whole tested micro-system it becomes possible to check the physical meaning of the experimental data and improve their interpretation.

Experimental data obtained at the Microfluidics Lab of the University of Bologna together with the main results appeared in the open literature both for liquids and gases will be used in order to highlight the peculiar characteristics of the experimental investigation of convective heat transfer through microchannels and to suggest the guidelines for a physically-based interpretation of the experimental results both in laminar, transitional and turbulent regime.