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Kolloquium für Mechanik

Referee: **Dr. Mirco Magnini**
Department of Chemical Engineering, Imperial College London, London, UK

Date: Thursday, January 24, 2019, 15:45h
Location: Bldg. 10.81, HS 62 (R 153)

Title: **From numerical "experiments" to theoretical modelling of boiling flows in confined geometries**

Abstract

Flow boiling in small channels is recognised as one of the most efficient cooling solutions for high-power density applications [1]. Nevertheless, such two-phase solutions remain rarely utilised for thermal management due to a lack of understanding of the underlying flow and transport characteristics, and limited availability of reliable thermal design tools.
Owing to the limited spatial and temporal accuracy that can be achieved with the current experimental techniques, we have developed a high-fidelity Computational Fluid Dynamics solver based on the open-source package OpenFOAM and its built-in Volume-Of-Fluid (VOF) method. Our self-developed solver implements a 2nd-order level-set based surface tension algorithm for highly-stretched and unstructured grids [2] and a non-equilibrium evaporation model that accounts for the Laplace pressure jump and interfacial resistance to mass transfer [3]. This numerical tool has been widely validated versus in-house experiments and has been extensively utilized to characterize the essential features of the liquid-vapor interface dynamics, fluid mechanics and heat transfer associated with microchannel flow boiling in both circular and non-circular channels [3,4]. The numerical database generated by this research has been utilized to develop and validate theoretical models to predict the liquid-vapor interface profile based on lubrication approximations [5], and mechanistic models to predict boiling heat transfer [6].
During my talk, I will (i) illustrate some of the experimental results obtained using infrared measurements and high-speed flow visualization to characterize flow boiling in multi-microchannel evaporators, (ii) present the numerical model developed in OpenFOAM, (iii) the results of the analysis of microchannel flow boiling, and the (iv) prediction models built based on this database. Finally, (v) I will introduce some preliminary results on the multiscale simulation of nucleate boiling performed in the framework of a post-doc collaborative research grant with colleagues at Imperial College.

References:

[1] S. Szczukiewicz, M. Magnini, J. R. Thome, Proposed models, ongoing experiments, and latest numerical simulations of microchannel two-phase flow boiling, Int. J. Multiphase Flow 59 (2014) 84-101.
[2] A. Ferrari, M. Magnini, J. R. Thome, A Flexible Coupled Level Set and Volume of Fluid (flexCLV) method to simulate microscale two-phase flow in non-uniform and unstructured meshes, Int. J. Multiphase Flow 91 (2017) 276-295.
[3] A. Ferrari, M. Magnini, J. R. Thome, Numerical analysis of slug flow boiling within square microchannels, Int. J. Heat Mass Transfer 123 (2018) 928-944.
[4] M. Magnini, J. R. Thome, A CFD study of the parameters influencing heat transfer in microchannel slug flow boiling, Int. J. Thermal Sciences 110 (2016) 119-136.
[5] M. Magnini, A. Ferrari, J. R. Thome, H. A. Stone, Undulations on the surface of elongated bubbles in confined gas-liquid flows, Physical Review Fluids 2 (2017) 084001.
[6] M. Magnini, J. R. Thome, An updated three-zone heat transfer model for slug flow boiling in microchannels, Int. J. Multiphase Flow 91 (2017) 296-314.

Alle Interessenten sind herzlich eingeladen.
Prof. Dr.-Ing. Bettina Frohnapfel