DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

Lecture

From numerical simulations to theoretical modelling of boiling flows in confined geometries

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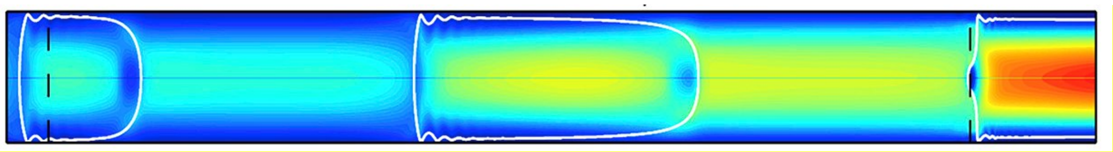

giovedì 16 gennaio, ore 11.00

Aula grande 3° piano
Via Venezia 1, Padova

Abstract

Flow boiling in small channels is recognised as one of the most efficient cooling solutions for high-power density applications. 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 and a non-equilibrium evaporation model that accounts for the Laplace pressure jump and interfacial resistance to mass transfer. 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. 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, and mechanistic models to predict boiling heat transfer.

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 micro-pin fins 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 present the results of a joint experimental/numerical study of the dynamics of Taylor bubbles in small, vertical channels, in a regime characterised by a Bond number of the flow $Bo \approx 1$, where some interesting phenomena occur.

Curriculum Vitae

Dr. Mirco Magnini is Assistant Professor in the Department of Mechanical, Materials and Manufacturing Engineering at the University of Nottingham.

He received a Master Degree in Mechanical Engineering from the University of Bologna, Italy, and a PhD in Energy Engineering from the same institution in 2012. From 2013 to 2017 he was a post-doc research assistant at the Laboratory of Heat and Mass Transfer, EPFL, Switzerland, where his research into numerical and theoretical modelling of microchannel flow boiling was funded by the Swiss National Science Foundation. Prior to joining Nottingham, he was a post-doc research associate in the Chemical Engineering Dept of Imperial College London where he worked on the numerical modelling of wax deposition in crude oil flows.