MICROGRAVITY SCIENCES AND PROCESSES (A2)
Fluid and Materials Sciences (2)

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ANNULAR /STRATIFIED LOW-GRAVITY INTERNAL CONDENSING FLOWS IN MILLIMETER TO MICROMETER SCALE DUCTS

Abstract

This talk presents computational simulations and experimental results for internal condensing shear driven flows. The experiments deal with flow condensation in a 2-mm gap horizontal channel. Simulations show that horizontal channel and zero-gravity results are expected to agree up to a certain distance from the inlet. Once sufficient vapor has condensed, the simulations show that downstream behaviors are significantly different for zero/low gravity – where there is no transverse gravity. Over the mm-scale, three sets of condensing flow results are presented that are obtained from: (i) full computational fluid dynamics (CFD) based steady simulations, (ii) quasi-1D steady simulations that employ solutions of singular non-linear ordinary differential equations, and (iii) experiments involving partially/fully shear driven condensing flows of FC-72 vapor.

Theory and experiments show that zero-gravity condensing (perhaps also boiling) flows have to deal with two kinds of sensitivities that will arise from presence of compressors/pumps at the inlet or the outlet. One is the well known effects of fluctuations in a parabolic problem which leads to interfacial waves. We show that, for this sensitivity, if the cooling approach allows the condensing surface temperature to change, there are significant thermal transients (within the condenser as well as the system outside the condenser) that precede significant heat-transfer enhancements. Furthermore we show a unique newly identified feature of these flows and call it “elliptic-sensitivity.” This sensitivity says that the unspecified pressure boundary condition for the parabolic problem can also be additionally specified or forced by an energy source in the presence of suitable time-periodic fluctuations. This feature induces its own hydrodynamic and/or thermal transients that depends on the cooling approach.

It is concluded that suitable system miniaturization as well as proper consideration of these noise-sensitivity issues must precede suitable low/zero-gravity experiments.

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