Effects of exit-condition, gravity, and surface-tension on stability and noise-sensitivity issues for steady condensing flows inside tubes and channels

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Abstract

The paper presents accurate numerical solutions of the full 2D governing equations for steady and unsteady laminar/laminar internal condensing flows of pure vapor (FC-72 and R-113) inside a vertical tube and a channel. The film condensation is on the inside wall of a tube or one of the walls of a channel (the lower wall in case of a downward sloping channel). Computations find that exit condition specifications are important and are able to characterize the flows’ sensitivity or insensitivity to the exit condition (which, in turn, depends upon the flow downstream of the condenser). If well-defined natural steady/quasi-steady flows exist—as is shown to be the case for gravity dominated or strong shear dominated condensate flows that remain parabolic up to the exit location—the computations are able to predict both the natural exit condition and any point of transition (from stable to unstable or smooth to wavy behavior) that may exist within this zone. Results on the role of surface tension and sensitivity to ever-present minuscule noise of the condensing surface are also reported.