Dimensionless Transition Criteria for Condensation in Microchannels

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In convective condensation, the fluid flows in a variety of flow regimes as it changes from vapor to liquid. The flow patterns formed in microchannels differ in type and extent from those seen in conventional tubes. Wavy and stratified flows decrease in extent at the small dimensions, while intermittent and annular flows predominate. Transition criteria based on physical considerations are developed in this paper based on flow-regime observations at $1 < Dh < 4.91$ mm during condensation of refrigerant R-134a over a wide range of mass fluxes and qualities. Transition to intermittent flow from wavy or annular flow was modeled based on the vapor-phase Weber number and the Martinelli parameter. A critical Bond number determined whether this transition occurs from the wavy or the annular regime. The discrete-disperse wave flow transition was modeled using a modified Froude number. The transition to the annular film regime from intermittent flow was based on the vapor-phase Weber number and the Martinelli parameter. To model the wavy-annular film transition, it was suggested that the Bond number should be included along with the vapor-phase Weber number to account for the effect of gravity. Transition to mist flow was also modeled by the vapor-phase Weber number and the Martinelli parameter. The transition criteria developed here were compared with several adiabatic and condensing flow regime investigations on tube diameters ranging from 1-25.4 mm and several fluids with reasonable agreement. Thus, the map may be viewed as having a wide range of applicability beyond the conditions for the data used to develop the criteria.