Numerical Analysis of Laminar Reflux Condensation from Gas-Vapour Mixtures in Vertical Parallel Plate Channels

Authors : Foad Hassaninejadafarahani, Scott Ormiston

Abstract : Reflux condensation occurs in a vertical channels and tubes when there is an upward core flow of vapor (or gas-vapor mixture) and a downward flow of the liquid film. The understanding of this condensation configuration is crucial in the design of reflux condensers, distillation columns, and in loss-of-coolant safety analyses in nuclear power plant steam generators. The unique feature of this flow is the upward flow of the vapor-gas mixture (or pure vapor) that retards the liquid flow via shear at the liquid-mixture interface. The present model solves the full, elliptic governing equations in both the film and the gas-vapor core flow. The computational mesh is non-orthogonal and adapts dynamically the phase interface, thus produces sharp and accurate interface. Shear forces and heat and mass transfer at the interface are accounted for fundamentally. This modeling is a big step ahead of current capabilities by removing the limitations of previous reflux condensation models which inherently cannot account for the detailed local balances of shear, mass, and heat transfer at the interface. Discretisation has been done based on a finite volume method and a co-located variable storage scheme. An in-house computer code was developed to implement the numerical solution scheme. Detailed results are presented for laminar reflux condensation from steam-air mixtures flowing in vertical parallel plate channels. The results include velocity and pressure profiles, as well as axial variations of film thickness, Nusselt number and interface gas mass fraction.

Keywords : Reflux, Condensation, CFD-Two Phase, Nusselt number
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