Mechanistic Multidimensional Analysis of Adiabatic Gas/liquid Two-Phase Flows

by

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ABSTRACT

The development of modeling and simulation capabilities of two-phase flows is very important for the design, operation and safety of a variety of industrial devices and systems.

For the past years many researchers have studied multiphase flows in pipes of small and large diameters, but majority of these studies are based on the flows in vertical channels. The research of horizontal flows so far has been concentrated on the flows in straight channels mostly. At the same time limited work has been done to study the flow development in both vertical and horizontal channels. Thus the goal of the present research is to enhance the understanding of gas/liquid two-phase flows in conduits of different geometries and orientations, and for medium and large gas-to-liquid volumetric flow ratios. The main intention was to develop and validate improved mechanistic modeling closure laws for Computational Multiphase Fluid Dynamics (CMFD) simulations of such flows. Two cases have been investigated:

- air-water flow in a horizontal pipe with 90-degree elbow,
- developing air-water flow in a vertical adiabatic bubble column

The main emphasis of the work has been on the modeling of various interfacial forces between the dispersed bubbles and the continuous liquid, as well as of bubble/bubble interactions (coalescence and breakup).

The proposed modeling concept uses a complete set of transport equations for each field, such as the continuous liquid and dispersed bubble fields. The overall model has been implemented in a state-of-the-art Computational Multiphase Fluid Dynamics Code, NPHASE–CMFD. The NPHASE-CMFD simulations demonstrated the capability of the proposed modeling concepts to predict the evolution of bubble concentration from channel inlet to near-equilibrium (fully-developed) conditions downstream.

The proper closure laws for horizontal and vertical flow have been proposed and implemented in NPHASE-CMFD code. The results of NPHASE-CMFD-based computer simulations confirm both the modeling and computational consistencies.

The results of calculations have been compared with the several experimental data sets and a good agreement has been observed for both horizontal and vertical flow distribution.