NUMERICAL SIMULATION OF TWO-PHASE ANNULAR FLOW

by

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ABSTRACT

A numerical simulation of a two-phase annular flow was performed using a three-dimensional (3-D) stabilized finite element code, PHASTA-IC, with an implemented level set method to capture the interface between the liquid and gas phases. The problem simulated was run #602 of the experimental tests of Wurtz (1978), which was a 70 bar, adiabatic, steam/water annular flow in a 20mm I.D. tube having a total inlet mass flux of 500 kg/s-m^2 and an exit quality of 0.30. The mean experimental film thickness at the exit of the tube was measured to be 0.94mm. The simulation modeled a 30 degree segment of the tube of length 0.025m using a uniform tetrahedron mesh of edge length size 0.00005m. The simulation, although not yet reaching equilibrium annular flow, was able to capture the major mechanisms associated with annular flow. This includes generation of instabilities on the interface between the steam core and liquid film, formation of liquid ligaments that stretch into the steam core and shear off to form liquid droplets, deposition of droplets back into the liquid film, the carry-under of steam bubbles into the liquid film, and the development of large roll waves responsible for most of these mechanisms. A classification tool was developed that interrogates the 3-D solution and classified all entities in the domain into one of four fields: continuous liquid (i.e., the liquid film), continuous vapor (i.e., the steam core), dispersed liquid (i.e., liquid droplets in the steam core), and dispersed vapor (i.e., steam bubbles in the liquid film). Various quantities, such as the mass flow rate, volume fraction, velocity, and interfacial area density, were calculated for each field. In addition, methods were developed to compute the total shear stress distribution, the interfacial shear stress, and the wall shear stress. Comparisons were made to the experimental flow rates, shear stresses, and film thickness.