FLOW CHARACTERISTICS OF SWEEPOUT AND ENTRAINMENT IN THE ANNULAR DOWNCOMER

Sang H. Yoon, Kune Y. Suh
Seoul National University

Abstract

Sweepout from the water surface by gas (vapor or air) flow plays an important role in analyzing the mass and momentum transfer in the reactor downcomer of multidimensional geometry during a loss-of-coolant accident (LOCA) by decreasing the water level in the downcomer. The core water level will tend to decrease rapidly if a considerable amount of the entrained water stream and droplets bypasses through the break. The amount of entrained water is mostly determined by the interacting gas flow rate, the geometric condition, and the interfacial area between the gas and the water. The sweepout is observed to take place in three regions: the beginning of oscillation, the full wave and the wave peak (droplet separation). The beginning of oscillation normally occurs by the Helmholtz instability, which is defined in terms of the difference between the gas and the liquid velocities. The horizontal water surface is waved greatly before the gas flow reaches the critical point of droplet detachment. In the full-wave region, the droplets from the rough wave are swept into the gas flow and driven to the break. The water stream and droplets near the wave-peak region bypass through the break at extremely high velocities. In view of these observations we investigated the relation between the gas flow rate and the amount of bypass as a function of time. The test facility was constructed in a 1/10 linear scale-down model from the APR1400 (Advanced Power Reactor 1400MWe), which has four DVI (Direct Vessel Injection) lines, four cold legs, and two hot legs. The air was injected through the three intact cold legs and bypassed through the broken cold leg. The sweepout was visualized by using the acrylic test vessel. When the water level was located at the bottom of the break nozzle, the amount of bypass increased at the high Reynolds number of the gas. In the test the downcomer water level rapidly decreased for the initial one minute. Then, given the Reynolds number of the gas, the sweepout hardly occurred as the water level approached the critical point after ten minutes. So far, the experiment and the analysis for the sweepout have been limited to small annuli, flat plates and T-junctions, which yielded the two-dimensional flow field. The experimental results shed light on the flow mechanism and the semi-empirical relations for the sweepout phenomena, which has three-dimensional flow patterns in the large annulus as in the reactor case. The sweepout and entrainment are physically understood by visual inspection of flow in the downcomer. A physico-numerical model is being developed to predict the multidimensional bypass flow rate resulting from the sweepout and entrainment in the downcomer.