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Experimental Investigation of Bubble Dynamics During Loss of Coolant Accident Conditions in a Pressurized Water Small Modular Reactor (PWSMR)

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The purpose of this investigation was to study bubble dynamics in an adiabatic air-water two-phase flow, mimicking the Loss of Coolant Accident (LOCA) scenario in a Pressurized Water Small Modular Reactor (PWSMR). A 5x5 rod bundle, with each rod 9.5 mm in diameter and a pitch-to-Diameter ratio (P/D) of 1.33, was used to represent the fuel rods. A 4-point fiber optical probe was used to obtain detailed data on bubble dynamics, including local void fraction, bubble velocity, bubble chord length, interfacial area concentration, and bubble passage frequency at a wide range of water and air superficial velocities. The experiment was conducted at various axial and radial locations before and right after the spacer grids to assess the impact of spacer grid mixing vanes. Higher void fraction, bubble passage, and specific interfacial area were observed in the subchannels compared to those obtained in the gap between the rods at all conditions. However, no significant differences were observed for the bubble chord length and bubble velocity. Moreover, Computational Fluid Dynamics (CFD) simulations were utilized to validate the data collected, which revealed a significant agreement between the experimental and numerical results. This study offers valuable insights into the behavior of air-water two-phase flow in rod bundles, which is critical to improving the safety and effectiveness of nuclear reactor design and operation.

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