Two-phase bubbly flows are encountered in boiling water reactors and high performance heat exchangers. These flows have been extensively studied in pipes with air as the dispersed phase in water. However, data on thin rectangular ducts are sparse. Measurements in thin geometries are particularly challenging since large bubbles bridge the gap, and it is difficult to compare point measurements with photographic techniques. The objectives of this work are to demonstrate the feasibility of gas velocity measurements in a narrow vertical duct for different flowing void fractions using hot film anemometry and high speed photography and to explain the effect of bubble size on flowing void fraction and relative mean velocity.

Hot-film anemometry is a measurement technique originally developed for the measurement of fluid velocities, but has since been found to have applications for broader measurements in multiphase flow. With the sensor operating on the principle of heat loss, the method takes advantage of the differing abilities of the phases to transport heat, with each phase leaving its own signature in the signal response. The linchpin of this method lies in the ability to accurately distinguish between the two phases within the signal, and to execute this operation, various algorithms and techniques have been developed and used with some success for a wide range of flow conditions. This thesis is a study of the various methods of analysis such as amplitude threshold for triggering, and small slope threshold for finely tuning the edges of the bubble interactions, and demonstrates the capabilities of the hot-film sensor in a narrow rectangular vertical duct with a high aspect ratio.

A vertical acrylic test section was fabricated for the purposes of this study, inset with a rectangular channel 38.1mm in width and 3.125mm in depth. Experiments were conducted for volume fractions ranging from 2% to 35%, which remained within the limits of the bubbly flow regime, but ranged from small uniform bubbles to larger bubbles coalescing into a transition regime.

The hot-film signal was analyzed for void fraction, bubble speed, and bubble size. An in-depth study of the various methods of phase discrimination was performed and the effect of threshold selection was examined. High-speed video footage was taken in conjunction with the anemometer data for a detailed comparison between methods. The velocity was found to be in close agreement between the HFA and high-speed video, staying within 10% for volume fractions above 10%, but still remaining under a 30% difference for even as low as the 2% volume fraction, where measurements have been found to be historically difficult. The trends with volume fraction between the HFA and high-speed results were very similar. A correlation for narrow rectangular channels employing a simple drift flux model was found to compare with the void fraction data where appropriate. Good agreement was found between the methods using a hybrid phase discrimination technique for the HFA data for the void fraction and velocity results, with the high-speed video results showing a slight over-estimation in regards to the bubble size.
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The public is welcome to attend.