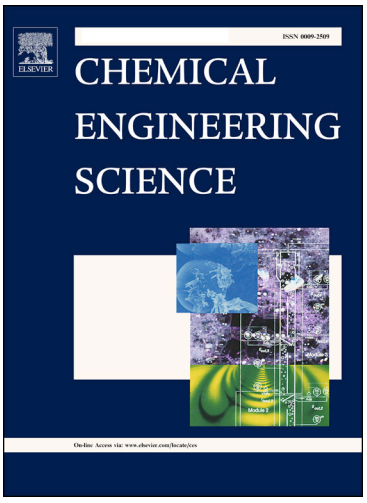

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Interrogating flow development and phase distribution in vertical and horizontal pipes using advanced instrumentation

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Abstract

The characterization of two-phase flow in both vertical and horizontal pipes is important in oil/gas transportation. As the pipe orientation may change from well to well, it is also important to understand the characteristic responses expected of a two-phase mixture to a change in pipe inclination. This study concerns the changes in the void fraction, structure frequency and structure velocity that occur within an air–silicone oil mixture as a function of the pipe orientation. Experimental data were obtained from the combined use of electrical capacitance tomography (ECT) and wire mesh sensors (WMS), which allow the 3D visualization of the flow patterns. The reported experiments were performed on a 67 mm diameter pipe, in a flow loop, in which a pipe section may be inclined at angles of between -5 or 90^o to the horizontal. For this study, the inclined pipe was either set at an angle of 0 or 90 to the horizontal, which correspond to a horizontal or vertical pipe setting, respectively. The results of flow development using the PDF of void fraction obtained at 3 measurement locations; ECT 1, ECT 2 and WMS at 4.4, 4.489 and 4.92 m, respectively, showed that the flow is fully developed and statistically stable for the vertical two-phase flow. While on the other hand, the flow is in rapid development for the horizontal two-phase flow scenario at same liquid and gas superficial velocities. The processed data reveal the differences in flow distribution produced by the pipe inclination. Within the vertical pipe configuration spherical cap bubbles, slug and churn two phase flow patterns were observed, whilst plug, slug and stratified wavy two-phase flows were identified in the horizontal configuration of the pipe. It is concluded that a plot of mixture superficial velocity against average void fraction may be used to provide a qualitative assessment of the flow patterns observed, regardless of pipe inclination. The two-phase flow variables that are concluded to significantly influence the distribution coefficient, C_0, and drift velocity, V_D, are the pipe orientation and flow patterns.

Keywords: void fraction, drift-flux model, ECT, WMS, C_0, V_D, flow patterns.