



Similarities and differences in the flow patterns and void fraction in vertical upward and downward two phase flow

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ABSTRACT

Most of the research in vertical two phase flow is dedicated to the vertical upward flow whereas the vertical downward two phase flow has received considerably little attention. In this study we have presented the experimental results of the flow patterns and the void fraction measurements for vertical upward and downward two phase flow. As a consequence of the interaction of the liquid inertia and the buoyancy force a definite difference in the appearance of the upward and downward two phase flow was observed. The analysis of the 1208 and 909 experimental data points for up and down flow showed a definite tendency of the variation of the void fraction with varying phase flow rates. The investigation is principally concerned with the differences in the flow patterns and void fraction for both orientations. Another important aspect of this investigation was the performance analysis of the available void fraction correlations. The results of the top five performing correlations among the pool of 52 correlations for vertical upward and 26 correlations for vertical downward orientation are presented.

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1. Introduction

The gas–liquid two phase flow finds its practical application in the field of chemical engineering for mass transfer, in the energy sector for heat transfer and in the petroleum industry for the simultaneous transportation of the oil and natural gas. The flow patterns and the void fraction are one of the key parameters in two phase flow. The two phase flow in vertical pipes is symmetrical about the pipe axis and is governed by the interaction between the liquid inertia, buoyancy, gravity and surface tension forces. Significant amount of research has been done in the field of flow patterns and void fraction of vertical upward two phase flow while comparatively less literature is available for downward orientation. Both vertical upward and downward two phase flow were studied by Golan [1], Beggs [2], Mukherjee [3], Nguyen [4] and Oshinowo and Charles [5]. Oshinowo and Charles [5] presented a description of the differences observed in the vertical upward and downward two phase flow. It was observed in the present study that the structure of the bubbly and slug flow regimes, to be more precise the size, shape and motion of the gas phase in these two phase flow patterns is different than that observed in the vertical upward flow. The relationship between the void fraction and the gas volumetric flow fraction, the void fraction and slip ratio was studied and observed to be different for up and down flow, respectively. There are numerous void fraction correlations

reported in the literature, however their accuracy against a comprehensive data set is not verified yet. The endeavor of this study is to verify the performance of the different void fraction correlations against a comprehensive data set of 1208 data points for vertical upward flow and 909 data points for downward flow. It is observed that the correlations developed for vertical upward flow and based on the concept of the drift flux model can be used to predict the void fraction for vertical downward orientation merely by flipping the sign of the drift velocity from positive to negative assuming the phase velocities to be positive in the flow direction. This study eventually leads to a discussion on the requirements for an idealized void fraction correlation.

2. Experimental setup

The experimental setup used in this study consists of a clear 0.0127 m ID polycarbonate pipe and is capable of flow visualization and measurement of void fraction, two phase pressure drop and two phase convective heat transfer coefficient. The experimental setup is mounted on a platform which can be oriented to any inclination from +90° to –90° including horizontal. The fluid combination used for experimentation is air and distilled water. The flow patterns are identified based on the visual observation and the still photographs captured by high speed camera. The void fraction is measured using the quick closing valve technique. The void fraction measured using this technique was comparable and within ±10% of those measured by other investigators. Yijun and Rezkallah [6] experimentally measured the void fraction for

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