Abstract

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Numerical Study of an Individual Taylor Bubble Rising through Stagnant Liquids under Laminar Flow Regime

Slug flow is one of the main flow regimes encountered in multiphase flow systems especially in oil and gas production systems. In the present study, the rise of single Taylor bubble through vertical stagnant Newtonian liquid is investigated by performing complete dimensionless treatment followed by an order of magnitude analysis of the terms of equations of motion. Based on this analysis, it is concluded that Froude, E€otv€os and Reynolds numbers are the sole physical parameters influencing the dimensionless slug flow equations. Using the guidelines of the order of magnitude analysis, computational fluid dynamics simulation is carried out to investigate the dynamics of Taylor bubbles in vertical pipe using the volume-of-fluid (VOF) method. Good agreement with previous experimental data and models available in the literature is established confirming that the density ratio, viscosity ratio and the initial ratio of bubble size to pipe diameter ðLTB=DÞ have minimal effect on the main hydrodynamic features of slug flow. Based on the developed results, correlations for the terminal velocity of the Taylor bubble and the dimensionless wall shear stress are proposed showing the significance of these main dimensionless parameters and support other important theoretical and experimental work available in the literature. 1. Introduction Multiphase flows occur in a wide range of applications including natural processes, chemical processes, nuclear systems and petroleum industries. The petroleum industry is considered one of the most important applications of multiphase flow, as it could be encountered in different processes/stages such as: oil processing, oil and gas transport in pipelines, and sloshing in offshore separator devices. For two-phase gas-liquid flow in pipes, different flow patterns can occur known as “flow pattern/flow regime”. These patterns depend on the flow rates, the geometry of the system, and inclination of the pipe (Morgado et al., 2016). Multiphase flow is classified according to the distribution of different phases building up the flow field, known as “flow regime/pattern”. Multiphase flow can be encountered in various flow patterns such as bubbly, slug, plug, annular and dispersed flow. Fluid flow investigation includes an important aspect which is the identification of the encountered flow pattern. For gas-liquid flow in pipes, one of the common