SPE Flow Assurance Technology Congress
Rio de Janeiro, Brazil, November 15 – 18 2022

Detailed Analysis of The Diameter Influence on Air-Water Slug Flow Characteristics in Upward Vertical Flow

Paul Adrian Delgado Maldonado[1*], Carolina Cimarelli Rodrigues[1], Eduardo Nunes dos Santos[1], Roberto da Fonseca Junior.[2], Moises Alves Marcelino Neto[1], Marco José da Silva[1], Rigoberto E. M. Morales[1]
[1]Multiphase Flow Research Center – NUEM, Federal Technological University of Parana, Brazil
[2]CENPES/PDIEP/EE Petrobrás,
*paul@alunos.utfpr.edu.br

Abstract
Vertical slug flow commonly occurs in pipes in the oil & gas industry in the form of intermittent flow whose alternate passage of bubbles and liquid slugs shows different lengths and velocities. The gas expansion in vertical multiphase flow is highly relevant, affecting all the characteristic parameters. Therefore, knowing the flow evolution and not only its average behavior is essential to the design of processing equipment and pipelines. This work evaluates the influence of the internal pipe diameter on the evolution of the characteristic parameters of slug flow, such as the bubble nose velocity, Taylor bubble and slug lengths, void fractions in the bubble and the slug regions, and the unit cell frequency. An experimental study with three internal diameters (26, 40.8 and 50 mm) with air-water mixture was carried out. Five measuring stations were used: four two-wire resistive sensors and one wire-mesh capacitive sensor; in all the five stations, pressure data were acquired. A high speed image acquisition camera was used to analyze the characteristics in three different elevations. The results provided information for the development of models/simulators and engineering correlations that allow an accurate prediction of the evolution of vertical slug flows and information concerning the influence of the diameter.

Keywords
Vertical slug flow; flow assurance, flow visualization

Introduction
Vertical slug flow occurs in a wide range of engineering applications; see [1] for various examples and an extensive review. In Oil & Gas industry, it occurs during the production and transportation of oil-gas mixtures through hydrocarbon production pipelines. In vertical production pipelines, there is a significant pressure difference along the liquid column; hence, the prediction of pressure drop and gas–liquid spatial distribution in the pipeline is pivotal in the design of separators or even in predicting the flow behavior along the pipeline. Those variables require proper knowledge of the characteristic hydrodynamic parameters.
Slug flows are characterized by the intermittent passage of two structures: an elongated bubble (known as the Taylor bubble) whose length exceeds a pipe diameter, followed by the passage of a liquid body known as the liquid slug [2]. The movement of the Taylor bubble is affected by the velocity field of the liquid phase ahead of it. Hence, information on the mean and instantaneous velocity fields around elongated bubbles, as well as the local instantaneous void fraction distribution within the liquid slug, are therefore indispensable for understanding the relative movement of elongated and dispersed gas bubbles.
Numerous models for fully developed flow have been published [3], [4], but vertical slug flow has the characteristic of a stochastic phenomenon, varying randomly in both time and space. With that in mind, new experimental data for the slug flow development and evolution have been carried out. The need for knowledge on flow evolution and distribution data for the principal hydrodynamic parameters has been a concern in the academy. Some authors worked with slug flow data and evolution [5], [6], [7].
In this work, the study of the flow evolution and the statistical distribution of the characteristic parameters have been evaluated, and the results obtained can be used to predict the flow behavior along a vertical pipeline.

Experimental Methodology
The experimental study was developed in the Multilab experimental loop of the Multiphase Flow Center at UTFPR/NUEM with three internal diameters (26, 40.8 and 50 mm). The inlet section is a horizontal tube with a length (LE) of 10.6 m for flow development, which is connected to a 90°-