CFD SIMULATIONS OF BUBBLE COALESCENCE AND BREAKUP IN A BUBBLE COLUMN WITH AN EXTERNAL LOOP

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ABSTRACT

CFD simulations of a cylindrical bubble column with an external loop were carried out. The effects of average bubble size, bubble size distribution, axial liquid velocity and the two-inlets configuration were evaluated and compared with experimental and simulation data. The drag force was modeled with the Ishii-Zuber model and the turbulence of the continuous phase with the k-ε model. For breakup the Luo and Svendsen model was chosen and for the coalescence effects the Prince and Blanch model was used. Results show that the external loop influences gas holdup near the entrance and at high gas superficial velocities a radial symmetry is obtained in the fully developed region.

Introduction

One of the main characteristics that determine the proper performance of a bubble column is the fluid dynamics inside of it, which is very complex since the flow is highly turbulent, multiphase and its dynamics are chaotic. The complexities of gas-liquid flows due to bubble shape and bubble wake are dependent on bubble size and its prediction is very important for understanding the hydrodynamics of bubble columns. Bubble size and holdup in the column strongly depend on the properties of the gas-liquid system and on the type and design of the gas distributor. When bubble coalescence and breakup are significant, the evolution of the bubble size distribution is also governed by the relative magnitudes of bubble coalescence and breakup rates. This is typically the case for operation of bubble columns in the transition or heterogeneous regime. In recent years, more and more attention has been focused on coupling the PBM (population balance model) and the CFD framework to improve the accuracy of estimation of the interfacial area in multiphase flow systems. The aim of this study is to present the effects of important parameters in CFD simulations of the heterogeneous regime, such as bubble size, bubble size distribution and axial liquid velocity.

Simulation

In the present work, a three-dimensional gas-liquid simulation is carried out using the Eulerian-Eulerian approach. The commercial CFD package ANSYS CFX 11 was used and the simulated geometry basically consists of a cylindrical bubble column with a recirculation pipe, as shown in Figure 1, where two phases come in contact: a gas phase (air) at 25°C and water as a continuous phase. Two different types of spargers are used in the simulations, a sintered plate and a perforated plate. In this study air is assumed to be a polydispersed phase, with different bubble size groups, six for the uniform entrance and seven for the perforated plate, varying according to a probability density function (Lin et al., 2004). In the bubble column, air is sparged at the bottom and the continuous phase is inside the column up to a height of 5m. The measurements were taken at three axial levels of the equipment (z = 0.8m, 2.4m and 4.6m) and at its respective radial position in accordance with the experimental data of Lin et al. (2004). In this work, the population balance was applied according to Silva et al. (2010), the simulated data was then compared with the work of Dionisio et al. (2009) in which the CFD model was validated for both inlet types at the same superficial gas velocity of 3.2cm/s, considering a mean bubble size of 4 mm for the uniform inlet and 5mm for the perforated plate. Simulations in the heterogeneous regime, at superficial gas velocities of 5.0, 6.4 and 8.0cm/s were developed in order to better evaluate the breakup and coalescence process.
For the sintered plate, as shown in Figure 2, the results with the population balance show better agreement with the experimental data near the wall, than those obtained by Dionísio et al. (2009). For the perforated plate, the population balance application underestimates the experimental and the simulated data for mean bubble size, as shown in Figure 3. In Figure 4 the maps of gas holdup in the fully developed region (z = 4.6 m) are shown for the three gas superficial velocities tested. It can be observed that as long as the gas superficial velocity is increasing, the radial symmetry in the fully developed region is also increasing.

**Conclusions**

The predicted gas holdup profile shows better agreement in the fully developed region near the wall, when the population balance model is applied than with the mean bubble diameter consideration at the uniform inlet; however with the gas distributor the gas holdup is underpredicted with the implementation of the population balance. The external loop influences the gas holdup behavior in the sparger region, where gas is concentrated at the wall. A parabolic gas holdup profile characterizing the heterogeneous regime was obtained and at high gas superficial velocities a radial symmetry is observed in the fully developed region. The mean bubble diameter increases as it nears the wall in the sparger zone; in the transition and the fully developed region it does not show significant variation.

**References**

