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# Tuning a multi-fluid model for gas lift simulations in wells

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ABSTRACT

A multi-fluid formulation based on the $k$–$\varepsilon$ turbulence closure is used for modeling bubbly flow in vertical pipes. Each bubble-size group is considered as a separate dispersed phase. The current $k$–$\varepsilon$ based multi-fluid models suffer from the problem of large overprediction of void fraction peak and lead to satisfactory results in limited ranges. In this study, first, we establish a model for gas lift simulations in wells. For this purpose, we propose new modified lift and wall force coefficients by tuning the model with many experimental databases. As shown here, the tuned multi-fluid model is able to predict flows in all the three bubbly flow subregimes, namely the wall-peak, core-peak, and transition subregimes, with reasonable accuracy. The predictions by the tuned model are compared with other numerical simulations, as well. Finally, the tuned model is used to simulate gas-lift problems in oil wells and the performance of eight empirical and semi-empirical correlations for predicting pressure drop is investigated, carefully. It is observed that, there is a correlation (i.e. Guet, S., Ooms, G., Oliemans, R.V.A., Mudde, R.F., 2004. Bubble size effect on low liquid input drift-flux parameters. Chem. Eng. Sci. 59, 3315–3329) which predicts gravitational pressure drop in very good agreement with the tuned multi-fluid model in all ranges of bubble diameters, including the wall-peak and core-peak regimes.



*Keywords:* Multi-fluid; Eulerian–Eulerian; Bubbly flow; Gas-lift; Numerical; Pressure drop

## 1. Introduction

Turbulent upward bubbly flow in a vertical pipe is encountered in many industrial applications, e.g. bubble stirred chemical reactor, air lift reactor for enhancing mixing or providing oxygen to micro organisms, deep sea air lifting of solid particles, $CO_2$ sequestration at deep sea and gas-lift technique.

Injection of compressed gas into the upward flow of oil in a well to increase oil production rate is called gas lift. Gas is guided through the casing and injected by gas-lift valves into the lower section of the tubing (see Fig. 1).

The gas-lift efficiency has long been known to be influenced by a large number of flow parameters, e.g. gas superfacial velocity, bubble size distribution, tubing diameter, the injector geometry and location, etc. The knowledge of fluid mechanical aspects of gas lift is crucial for selecting the appropriate flow conditions for applying the gas-lift technique at optimum efficiency (Guet and Ooms, 2006). This knowledge is extracted from experimental and numerical investigations.

One of the objectives of experimental studies is to provide database for CFD-code development and validation. There are several well-known experimental databases for bubbly air–water flow in vertical pipes, (e.g. Prasser et al., 2003; Lucas et al., 2005; Liu and Bankoff, 1993; Liu, 1998; Serizawa et al., 1975; Wang et al., 1987), and many of them are used for the validation in this study. Also recently, new databases for bubbly air–water flow in vertical large diameter pipes were provided (Lucas et al., 2010a,b) that are useful especially for coalescence and break-up model validations.

Several multi-fluid CFD simulations of turbulent bubbly flows in vertical pipes have been reported in the literature. Most of them use a two-equation model for turbulence modeling. Other approaches, e.g. algebraic stress model (Bertodano, 1992), have also been reported. Selecting appropriate and

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