NTech Lehrstuhl für Nukleartechnik

THE LINDE GROUP Linde

Numerical Simulation of Bubble Column Hydrodynamics using OpenFOAM®

INTRODUCTION

Bubble columns are intensively used as multiphase contactors and reactors in chemical, biochemical and petrochemical industries. Due to their simple construction, bubble column reactors are considered as reliable devices for applications such as oxidations, hydrogenations, oligomerisations or waste water treatment. During the operation, a gaseous phase is dispersed as bubbles in a continuous liquid phase.

The characteristics of the complex two-phase flow in a bubble column determine the functionality and efficiency of the apparatus. To investigate the significant properties of the flow, an analysis by means of computational fluid dynamics (CFD) is carried out. The prior goal is to determine the practicability of the applied CFD method by comparing its results to corresponding experimental and theoretical data. The conclusions can be assigned to other two-phase flow applications.

METHOD

The Volume-of-Fluid (VOF) method which is employed in this work enables a study of detailed flow structures as well as the evaluation of global parameters. The shape and motion of the interface is simulated explicitly with this method resulting in the depiction of the interface as a continuous transition of the phases (see Fig. 1). The local flow properties are derived by using the gas volume fraction α as a scalar weight for the corresponding gas and liquid values. With application of the VOF method the influence of surface tension and contact angle on the flow pattern are directly taken into account.

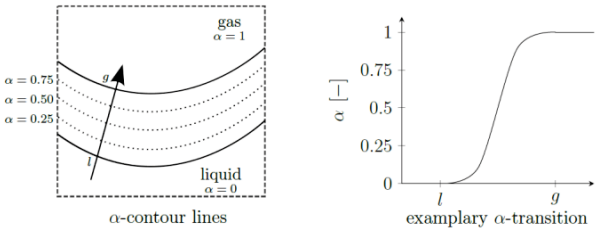

Figure 1: Description of the interface with the VOF method

SIMULATION RESULTS AND VALIDATION

The simulations are carried out for two bubble column configurations. A single-holed and a three-holed gas sparger have been examined. In both cases the diameter of the column as well as the initial height of liquid is 172*mm*.

The simulation results are evaluated on the basis of several flow characteristics:

➢ Bubble Formation

The validation of the bubble formation process is conducted by comparing pictures and footage of the experiments with simulation results edited by postprocessing tools (see Fig. 2). Depending on the flow pattern, the comparison shows accurate to good agreement.

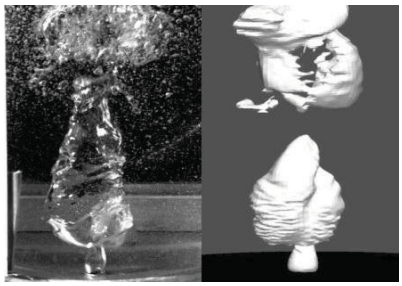

Figure 2: Bubble formation in the experiment (left) and the simulation (right)

➢ Gas Hold-up

For the gas hold-up, the experimental results as well as several theoretical models are taken as a reference for the quality of the simulation data (see Fig. 3).

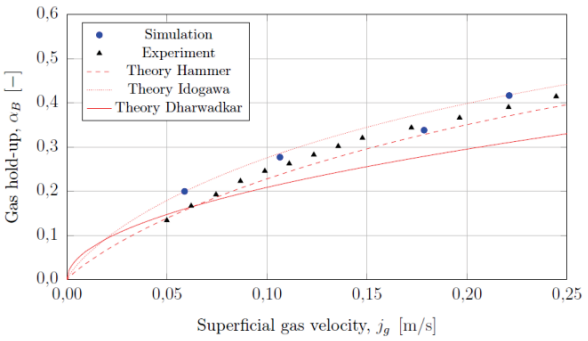

Figure 3: Gas hold-up for the three holed gas sparger

➢ Bubble Size

Three numerical meshes are created to analyze the influence of the spatial resolution on the simulation results.

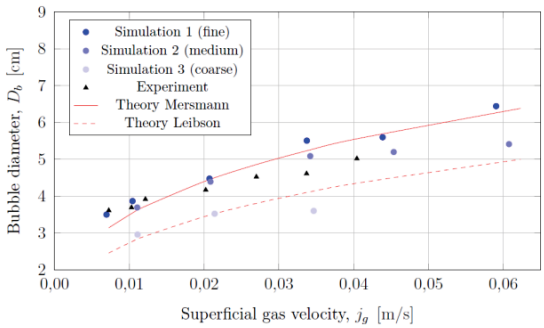

Figure 4: Bubble diameter for the single-holed gas sparger

CONCLUSION

The simulation findings indicate that the VOF method is capable of giving accurate results for a detailed analysis of two-phase flows. Whereas the computational costs for this approach may be considerably high in comparison to two-fluid methods, no substance-specific models such as lift and drag correlations need to be taken into account.

For further queries, please contact:
thomas.acher@linde-le.com; Tel. : +49 (0) 89 7445 - 3457