Three Dimensional CFD Model of a Single Rising Bubble in Stagnant Liquids.

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Two-phase (gas-liquid) flows are fundamental to wide range of chemical industrial processes such as absorption or distillation. Gaseous phase is mostly represented by rising bubble swarms through the liquid bulk. Physicochemical properties of the liquid and gaseous phases together with the bubble diameter and shape largely affect the bubble rise velocity, which defines the residence time of the bubble in the liquid bulk.[1]. Bubble behaviour can be studied experimentally, theoretically or most recently - using CFD solvers. These solvers are designed to numerically solve Navier-Stokes equations.[2]

In this work, the motion of the bubble's interface is tracked using the Level set method, which is implemented in COMSOL Multiphysics. During the testing of the solver's capabilities a 2D-axisymmetric model was constructed. Terminal velocities and shape deformations were obtained for bubbles of various diameters rising in water and n-propanol. Resulting velocities and shape deformations for sub-milli-meter bubbles agreed with experimental data and theoretical predictions. However, terminal velocities and shape deformations for above-milli-meter bubbles did not agree with experimental observations and theory. Thus, a fully 3D simulation of a single rising bubble was calculated. Parametric study for bubbles of different sizes, rising in three different liquids (water, n-propanol, glycerol) was conducted. The liquids were chosen because of their difference in surface tension, viscosity and density to test the solver's convergence abilities. The obtained values of terminal velocities for different bubble diameters from COMSOL agree with experimental data and theoretical velocities of a deformed bubble. Steady-state shape deformations of the bubble also correspond to experimental data and theoretically calculated values. Simulation has shown that a 3D model is needed for above-millimeter bubbles, as their rising path can slightly differ from rectilinear motion and the use of 2D-axisymmetrical model is not appropriate for these cases.

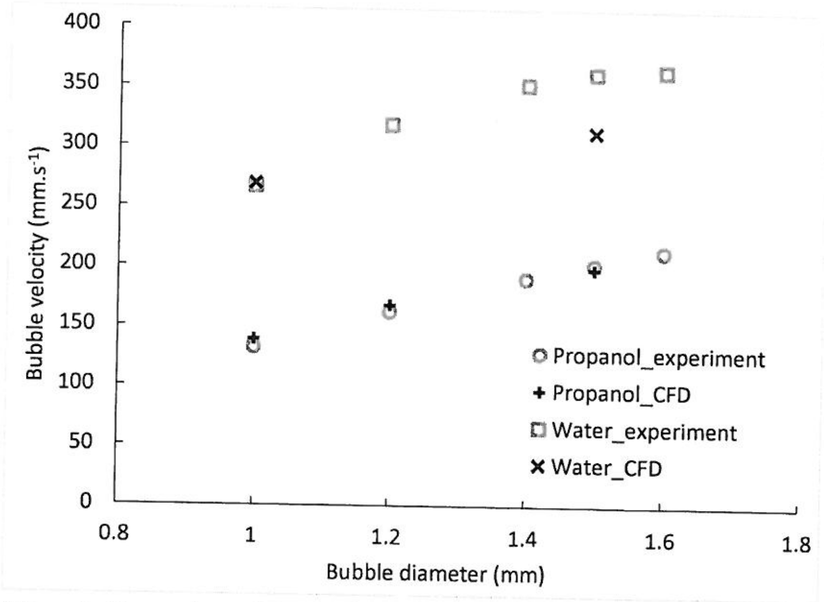

Figure 1: Comparison of obtained terminal velocities from COMSOL with experimental values for different bubble diameters rising in water and n-propanol.

Acknowledgements

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References

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