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Computational Fluid Dynamics Simulations and Analysis of Air Bubble Rising in a Column of Liquid

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Abstract : Multiphase flows occur widely in many engineering and industrial processes as well as in the environment we live in. In particular, bubbly flows are considered to be crucial phenomena in fluid flow applications and can be studied and analyzed experimentally, analytically, and computationally. In the present paper, the dynamic motion of an air bubble rising within a column of liquid is numerically simulated using an open-source CFD modeling tool 'OpenFOAM'. An interface tracking numerical algorithm called MULES algorithm, which is built-in OpenFOAM, is chosen to solve an appropriate mathematical model based on the volume of fluid (VOF) numerical method. The bubbles initially have a spherical shape and starting from rest in the stagnant column of liquid. The algorithm is initially verified against numerical results and is also validated against available experimental data. The comparison revealed that this algorithm provides results that are in a very good agreement with the 2D numerical data of other CFD codes. Also, the results of the bubble shape and terminal velocity obtained from the 3D numerical simulation showed a very good qualitative and quantitative agreement with the experimental data. The simulated rising bubbles yield a very small percentage of error in the bubble terminal velocity compared with the experimental data. The obtained results prove the capability of OpenFOAM as a powerful tool to predict the behavior of rising characteristics of the spherical bubbles in the stagnant column of liquid. This will pave the way for a deeper understanding of the phenomenon of the rise of bubbles in liquids.

Keywords : CFD simulations, multiphase flows, OpenFOAM, rise of bubble, volume of fluid method, VOF
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