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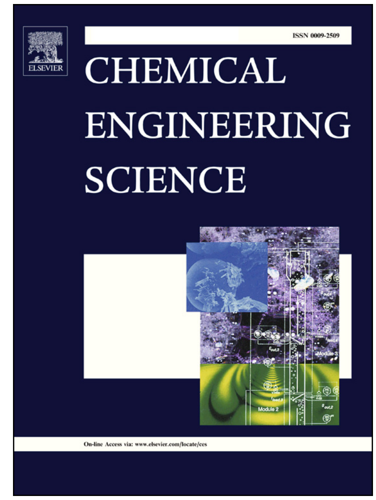

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Numerical study of Taylor bubbles rising in a stagnant liquid using a Level-Set / Moving-Mesh method

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Abstract

An Arbitrary Lagrangian-Eulerian formulation has been posed to solve the challenging problem of the three-dimensional Taylor bubble, within a Conservative Level Set (CLS) framework. By employing a domain optimization method (i.e. the moving mesh method), smaller domains can be used to simulate rising bubbles, thus saving computational resources. As the method requires the use of open boundaries, a careful treatment of both inflow and outflow boundary conditions has been carried out. The coupled CLS - Moving Mesh method has been verified by means of extensive numerical tests. The challenging problem of the full three-dimensional Taylor bubble has then been thoroughly addressed, providing a detailed description of its features. The study also includes a sensitivity analyses with respect to the initial shape of the bubble, the initial volume of the bubble, the flow regime and the inclination of the channel.

Keywords: **Taylor bubble, Arbitrary Lagrangian-Eulerian formulation, Level set method, Open boundary condition, Multiphase flow, Unstructured meshes**

1. Introduction

The slug flow is of fundamental importance in a vast variety of engineering applications and natural phenomena. This flow pattern consists of bullet-shaped bubbles separated by liquid slugs. The bubbles almost completely fill the channel cross section, where at most a thin liquid film separates them from the wall. In reference to its applications, the growing interest in miniaturization of chemical unit operations makes slug flow an important area of study [1]. In addition, due to the fact that biomedical studies are becoming increasingly important for the scientific community, slug flows seems to be the key to understand complex blood flow cases, i.e. embolisms. Other relevant scientific fields are also directly related to this flow pattern: microfluidics, volcanology [2], geothermal power plants, gas and oil extraction, cryogenic fluids, etc.

To understand these flows the elemental problem of a single Taylor bubble should be thoroughly comprehended, laying a solid foundation for the analysis of more complex cases. Buoyant bubble problems need the use of large domains to achieve proper capture of the phenomena. That is due to the need of leaving enough vertical space for the bubble to reach its steady state. This introduces a problem: the loss of computational efficiency due to the resolution of areas with no influence in the calculation of the dynamic properties of the bubble. In effect, on a specific point of the simulation, the region of interest includes the bubble and its

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