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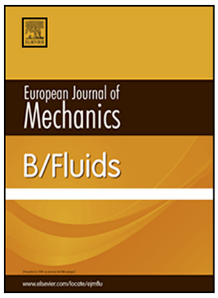

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Abstract

The paper presents results of numerical simulations of freely rising solid spheres in a viscous fluid. The diameter of spheres was 5 mm, 7 mm, 10 mm, and 20 mm, and the corresponding Reynolds numbers varies in the interval 1400 < Re < 10100. It has been found that the free rise path varies, as the Galileo number increases. The paper describes the principal zigzag path generating mechanism, which is determined by regularly generated and freed, oppositely oriented vortex structures, which carry away the momentum and mass of fluid from a rising sphere. Quantitative characteristics are given with respect to oscillation periods of a sphere path, transverse velocity components, and accumulation of fluid mass involved in the attached vorticity. It has been found that the vortex detachment period is coincident with the half-period of oscillations. A critical mass of a fluid in the attached vorticity has been calculated, and a mechanism of changeover from zigzagging to spiraling has been suggested.

Introduction

Throughout last decades much attention has been given to the study of the motion of bubbles and hard spheres in a fluid in a gravitational field [1 – 6]. The yielded area represents a huge field for researches due to variety of modes of motion and the broadest range of change in possible characteristic parameters.

It is also important to note that by now no agreement has been reached among researchers on many issues relating to the regularity of the motion of bubble flow in general and, even, the freely rising of a single bubble [4, 7, 8]. In order to obtain a complete picture of the bubble rise, it is necessary to take into account the nonlinear interaction of many factors, such as the physical properties of the liquid and gas filling the bubble, surface tension, inertia of the surrounding fluid, medium resistance and buoyancy. All this, as well as the three-dimensional nature of the rise, make this problem practically inaccessible for both detailed experimental study and construction of theoretical models accounting all these aspects [4, 7, 8].

As for rising/falling solid spheres of a fixed shape, the picture is clearer as compared to the case of moving bubbles, because the shape of a sphere has no effect on the dynamics of its motion. Nevertheless, in spite of the simplifications there are also some disagreements among the authors of works on this subject concerning the conditions and the occurrence time of vibrations as well as the existing types of motion [5, 9 – 12].