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Author: Mr. Dmytro Yevdokymov
Oles Honchar Dnipropetrovsk National University, Ukraine, devd@ukr.net

MATHEMATICAL MODELING AND NUMERICAL SIMULATION OF MULTIPHASE MEDIA MOTIONS IN MICROGRAVITY CONDITIONS

Abstract

Multiphase media in microgravity conditions can sufficiently differ from the similar media in usual terrestrial conditions, because a gravitational separation (floatation or sedimentation) of disperse phase objects is absent (negligibly small) in microgravity. It means that any small object of any density, which can be more or less than the density of main liquid phase, including solid particles in liquids and gases or bubbles in liquids, can remain in the multiphase media during extremely long time. In contrast, the same particle or bubble in terrestrial conditions must leave the media due to gravitational force or buoyancy force, correspondingly. From the point of view of practical applications of multiphase media in microgravity conditions, for example, in space technologies and investigations during long-time space flight, the described circumstances can lead to accumulation of disperse phase objects of completely different nature in multiphase media. As it is well-known, there are some enough small body forces in microgravity conditions. Such forces can be regular and non-regular; they can have different amplitudes and change in time according periodic, non-periodic or occasional modes. The mentioned disperse phase objects under the acting small body forces can move in different directions (it depends on density of the object) and with various velocities and accelerations, however their velocities remain small during all time of the motion. As a result, motions of the objects stimulate specific fluid flow in Stokes mode. Beside of that, there may thermal or diffusive processes inside the system, which cause thermal and concentration weak free convection, thermophoresis and diffusiophoresis, Marangoni effects for drop and bubbles. The listed phenomena are connected with surface forces, acting on the disperse phase objects, in other words, they stimulate additional motions of the objects and additional fluid flows in Stokes mode too. The aim of the present work is to formulate mathematical models for the described above fluid flow and motions of the objects and to develop an effective numerical algorithm for calculations on the base of the proposed mathematical models. Boundary element algorithm is developed in the present work for numerical calculations. It differs from usual boundary element algorithms for Stokes flow by presence of small size moving objects. It is proposed to model the moving objects by discrete singularities. The obtained algorithm shows enough high effectiveness. The proposed computational approach is illustrated by numerical solutions of several model problems in two-dimensional and three-dimensional cases.