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MATHEMATICAL MODELING OF MULTIPHASE MEDIA IN LOW GRAVITY CONDITIONS

Abstract

Systematic investigations of great variety of phenomena concerning physics, mechanics, fluid dynamics, heat and mass transfer processes under microgravity conditions are considered at the moment as high important part of space investigations and explorations. They create a theoretical background for future development of human scientific and industrial space activity. Unfortunately, experimental investigations of the processes listed above are extremely expensive, especially in case of orbital experiments. This circumstance makes investigators and engineers, working in relevant fields, to prefer mathematical modeling and numerical simulation in their professional activity. Hydrodynamic and heat and mass transfer processes in multiphase media belong to difficult for analysis even in usual terrestrial conditions, however, disperse phase objects in normal gravity conditions meet with gravitational separation, in particular, flotation or sedimentation. In contrast to last case, a multiphase media remains with minimal changes in microgravity conditions, where gravitational separation is extremely weak and inertial separation is used very seldom. Thus, objects of disperse phase are accumulated inside the main phase, because there is not any effective way to move them away. There a lot of approaches to formulation of mathematical models of hydrodynamic, heat and mass transfer phenomena in multiphase media in normal gravity conditions. Most of them are based on some principles of averaging, included mutually penetrating continuum or "particle in cell" principle. However, opportunity to construct physical and mathematical models for microgravity conditions, where sufficiently different fractions are simultaneously presence, is strongly restricted. Therefore, the mathematical model in the present work is formulated on the base of computational potential theory and Lagrangian approach. Several simplifying assumptions are made: (i) the forced convection is absent in the system and the natural convection is sufficiently weak; (ii) the main phase flow corresponds to Stokes flow; (iii) the temperature and concentrations' fields is described by initial-boundary-value problems for Onsager's equation system, taking into account thermal diffusions, coupled diffusions and so on; (iv) distances between discrete phase objects are enough to present them mutual influences as local point interactions; (v) thermophoresis and diffusiophoresis effects are taken into account. Boundary element method is used for calculation of main Stokes flow and Runge-Kutta algorithm is applied to the system of second order ordinary differential equations, describing motions of objects. The proposed approach is illustrated by several examples of numerical calculations.