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ONE MATHEMATICAL MODEL OF HEAT AND MASS TRANSFER IN MICROGRAVITY CONDITION

Abstract

Constantly growing interest to space exploration and fast development of space technologies during last two decades require a development of mathematical models and calculation methods for quantitative analysis of physical and chemical processes in space, in particular, heat and mass transfer in microgaviry conditions. There are a lot of specific features of heat and mass transfer in microgravity condition, for example, an absence (or, at least smallness) of the natural convection and forced convection is assumed in the present work. By these reasons the heat and mass transfer process is mainly determined by heat conduction phenomena, but influence of several other effects can be sufficient too, including of diffusion, thermodiffusion and coupled diffusion (for multicomponent systems) must be taken into account too. From the mathematical point of view the problem is described by Onsager's equation system for temperature and concentrations in domain with possibly moving boundary (phase transition with Stefan condition and segregation condition on the moving boundary). Generally speaking, Onsager's equation system can be obtained as a first approximation in asymptotic expansion of usual heat and mass transfer equation system for slow fluid flow, that is with respect to small Reynolds number (fluid flow in such case is described by Stokes equation system). Beside of that, possible heat and mass sources, as a result of chemical reactions and phase transitions, together with small convective terms can be added to Onsager's equation system, created a generalized Onsager's equation system. Methods of analytical and numerical solution of Onsager's equation system and generalized Onsager's equation system are developed in the present work. Because of smallness of non-diagonal elements of Onsager's matrix, it is proposed to use preliminary transformation of Onsager's equation system to heat conduction equation system. The last system can be solved by any relevant numerical method usually using for solution of heat conduction equation. The similar algorithm is developed for generalized Onsager's equation system. Computational potential theory is better for numerical calculation of the considered class of boundary-value problems, than finite difference or finite element method, because the problem is linear, it is formulated in domain of complex shape and there are possible moving boundaries. Then boundary integral equation method with following numerical solution by boundary element method is applied to the transformed system.