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MATHEMATICAL MODELLING OF THERMOGRAVITATIONAL CIRCULATION IN CONDITIONS TENDING TO ZERO-GRAVITY

Abstract

Functioning of various space systems frequently results in occurrence of heterogeneity of distribution of temperature or concentration of liquid or gaseous working substances in conditions of microgravitation. It demands of the creation of techniques of numerical calculation of the heat and mass transfer processes at interaction of thermal, concentration and hydrodynamical fields in the sphere of the complex form frequently with mobile borders. In the paper we focus on problems about thermogravitational convection between two isothermal concentric and eccentric horizontal cylinders, and in the cubical enclosure with two opposite isothermal differentially-heated lateral faces which are most approached to configurations of space devices. The three-dimensional flow occurs not only due to the temperature gradients in fluid, but also as a result of the interaction between vortices and fixed leading and trailing edges of the enclosure. The theoretical model includes system of the equations of the natural convection in fluids and gases originates from inhomogeneity of temperature or concentration distributions of chemical components. The advance in space technology led to the necessity of studying physical basics of complex heat-mass exchanging processes with the interaction between thermal, concentration and hydrodynamic fields in complex domains, often with moving boundaries. In order to solve combined equations of spatial convection and heat transfer of incompressible flow with the Boissinesq approximation the numerical technique, algorithmically realized in the form of application program complex, was designed. The governing equations representing the conservation laws are used in the integrated form. We aim at obtaining higher accuracy of computations by application of the second-order accurate TVD scheme for the convective terms approximation, and subiterations for time integration. Testing of the designed numerical technique and program complex was performed for the problem about the lid-driven cavity flow, problem about the flow over a circular cylinder with vortex shedding, and problem about thermogravitational convection in a differentially-heated square cavity. Compared the results with the known computations and experimental data. The special attention is given the analysis of influence of microgravitation on obtained heat flux distribution, isotherms, velocity vectors, streamlines. Influence of numbers Rayleigh, Prandtl, Grasgoh on circulating structure of current, heat exchange and thermal streams in the closed cavities is analyzed. The technique and the received results can find application by development and improvement of various space systems and research of features of development thermogravitational convection at low values of a gravity.