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Fluid and Materials Sciences (2)

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KEYNOTE: INVESTIGATION OF THE FLUIDS BEHAVIOR UNDER MICROGRAVITY CONDITIONS: CONDUCTING EXPERIMENTS, MATHEMATICAL MODELING AND NUMERICAL SIMULATIONS

Abstract

The behavior of liquids in microgravity is significantly different from the behavior in terrestrial conditions. In the absence of terrestrial gravity, capillary pressure becomes the main driving force. The study of capillary effects under terrestrial conditions is difficult, since they are masked by the gravitational force. Capillary imbibition under ordinary gravity is possible in small capillaries, in which it is difficult to observe it. To observe capillary flow in larger capillaries, where the flow is well visualized, it is necessary to resort to experiments in conditions of reduced gravity. This work is devoted to the study of fluid flow in microgravity. Studies of the flow of liquids due to capillary forces are very relevant for space technologies. For example, on board the space station, the supply of liquid from a reservoir (for example, fuel) is possible only due to capillary forces. Also, the results of studying seepage processes in microgravity can be useful in the development of a plant growing system for bioregenerative life support systems in space for long-term manned flights. It should be noted that the results of studying seepage processes under microgravity conditions can also find applications for Earth technologies and processes, for example, for oil production. Capillary effects strongly influence the seepage processes under terrestrial conditions, but the study of capillary effects under standard gravity is difficult: it is problematic to visualize the liquid flow in small pores, and capillary imbibition is impossible in large pores due to the prevailing gravity. Therefore, it is so important to conduct experiments on the flow of liquid due to capillary effects in microgravity. This paper describes experiments on capillary imbibition at a spacecraft in Earth orbit, as well as during parabolic flights. The features of the experiments, experimental equipment, post-processing of experimental data are described. Experiments in microgravity are very time-consuming and expensive. Therefore, it is important to develop mathematical models and numerical schemes for predictive simulations of fluid flow in microgravity. Description of the behavior of fluids in microgravity requires special mathematical models, which are described in this paper. Comparison of the results of numerical simulations with experimental data makes it possible to develop verified software packages. The paper also discusses the issues of numerical modeling of the processes of flow through a porous medium, taking into account chemical interactions between fluids. The authors wish to acknowledge the support by Russian Science Foundation (Grant initiative 22-21-00236).