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Microgravity Sciences Onboard the International Space Station and Beyond - Part 1 (6)

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EXPERIMENTAL AND NUMERICAL STUDY OF THERMAL DIFFUSION IN THE PRESENCE OF CONTROLLED VIBRATIONS USING TWO EQUATION OF STATES

Abstract

Microgravity environments provide perspective platforms for studying the phenomenon of thermal diffusion. Nevertheless, the residual micro accelerations in the space laboratories induce convection and may affect the accuracy of experiments. Therefore, an appropriate interpretation of experimental results from the space relies on a thorough understanding of the influence of vibration on the thermal diffusion process. In this paper, we have modeled the thermal diffusion process under different vibration level onboard the International Space Station (ISS) i.e. zero gravity environment. The binary mixture of water-isopropanol that was investigated earlier by Pan et al in the absence of microgravity effects have been considered again. In this investigation a rectangular cavity laterally heated, filled with two different concentrations of this binary mixture and subjected to the applied controlled vibrations. The complete Navier-Stokes equations along with the energy equation and the mass transfer equation were solved using the finite volume method. The physical properties, including density, have been calculated using two different models, Boussinesq Approximation and PC-SAFT equation of state. Using the calculated thermodynamic properties from the equation of state and by utilizing the Firoozabadi model, mass and thermal diffusion coefficients have been computed as a function of temperature and concentration in the PC-SAFT model. The analysis repeated for the referred models and comparisons have been made between them for various runs with different applied vibrational levels i.e. frequency and amplitude. Subsequently, the related experimental results for the same applied vibrational levels in the form of laser images have been processed and compared with the numerical. Comparisons have been made both between the two numerical models and with the experimental results. Recommendations are made according to the findings from this study for improvement in the design of future diffusion experiments in Space as well as adopting the best numerical model.