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ON THE VARIOUS NUMERICAL METHODS FOR THE SIMULATION AND VALIDATION OF THERMOVIBRATIONALLY-DRIVEN SOLID PARTICLE ACCUMULATION PHENOMENA IN MICROGRAVITY CONDITIONS

Abstract

With the ever increasing relevance of space-based construction, manufacturing and production methods, the recent theoretical discovery and experimental confirmation on board the International Space Station of solid particle self-organization phenomena driven by the joint application of vibrations and a temperature difference to a liquid, this study is devoted to a critical assessment of the numerical strategies to be used to reproduce with a good level of success and fidelity such experimental findings and improve our understanding of the related cause-and-effect relationships. Accordingly, a diversity of model types, ranging from simple to complex, in which various effects are selectively included or excluded, are used, and the results carefully diagnosed against the experimental evidence. The considered liquid is ethanol, while the dispersed particles are made of glass and display different size and density according to the considered experimental run. Gravity is absent and vibrations with different amplitudes and frequency are imposed. Previous research only accounted for conventional CFD methods that failed to capture certain features that were a defining characteristic of the particle accumulation structures observed for certain outlier experimental runs. The core aim of this study was to explore different strategies that could account for these anomalies, thereby revealing more information about this novel phenomenon. For this study in addition to the classical OpenFOAM and Fluent Lagrangian-Eulerian solvers, a CFD-DEM approach was also envisioned to be incorporated for simulations via Ansys ROCKY. The model was first compiled on ROCKY by coupling with Fluent. Since different resolutions of coupling can be achieved using this method, a methodology was devised to incorporate the vibrational and thermal effects in microgravity conditions. Preliminary findings suggest that Rocky is a robust DEM solver which enables multitudes of coupling options with Fluent and other solvers hinting its versatility in future computations which could take into account particles with varying size distributions and cross-sectional profiles. This coupling strategy also builds on the advantage of the Dense Discrete Particle Modelling approach in Fluent in which inter-particle stresses are also taken into account. We show that the agreement between the numerical and experimental findings depends significantly on the level of coupling and (especially) the ability of the solver to capture properly particle mutual-interference effects.