Book of abstracts: ISBN: 978-81-965909-4-9, pp. 234-235

First Joint International Conference on

Advances in Mechanical & Aerospace Engineering

(ATCON 2: ICAMAE 2023), November 28 - 30, 2023, Glasgow, UK

Session II - Track 5: Aerospace Engineering - Article ID: ICAMAE-2023-5-24

Comparative assessment of numerical models for the simulation of thermovibrational-driven solid particle accumulation phenomena in microgravity conditions

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Abstract:

Considering the recent theoretical discovery and confirmation by means of space experiments 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. Two different computational platforms are considered for the ensuing numerical analysis, i.e. ANSYS Fluent and OpenFoam. Both are equipped with Eulerian-Lagrangian solvers where different levels of coupling between the involved fluid and solid phases can be selected. For ANSYS Fluent these are the Discrete Particle Modelling (DPM), i.e. a standard two-way coupled approach and the Dense Discrete Particle Modelling (DDPM) where in addition to the localized exchange of momentum between the two phases, the inter-particles stresses are also somehow taken into account. Similar options are also available in OpenFOAM. 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.

This is an accepted author manuscript of the following abstract: Manayil Santhosh, B & Lappa, M 2023, Comparative assessment of numerical models for the simulation of thermovibrational-driven solid particle accumulation phenomena in microgravity conditions. in MH Kumar, S Bal & G B.M. (eds), Proceedings of First Joint International Conference on Advances in Mechanical & Aerospace Engineering (ATCON 2: ICAMAE 2023): Book of Abstracts., ICAMAE-2023-5-24, Alliance University, Bangalore, pp. 234-235.