DEM and Micro–Macro Methods for Industrial Particulate Processes

Key words: Particulate system, DEM, micro-macro, rheology

Particulate and granular materials are encountered in natural phenomena and industrial processes, including pharmaceutical powder processing/handling, granulation, tableting, additive manufacturing, food processing, energy systems, civil-engineering, and geomechanics. Due to their intrinsically disordered nature and diverse particle properties, these systems exhibit complex multi-scale behavior involving solid-like, fluid-like, and transitional states. Understanding and predicting these phenomena remains a major challenge for science and engineering.

Particle-resolved computational methods, in particular the Discrete Element Method (DEM), have greatly improved our understanding of such systems at the microscopic scale. DEM and coupled multi-physics approaches enable detailed investigation of particle interactions, rheology, segregation, compaction, agglomeration, powder spreading, and state transitions.

However, since many industrial applications involve very large particle numbers, complex geometries, and multi-physics interactions, the direct particle-scale simulation is computationally challenging. Micro–macro transition techniques, coarse-graining approaches, continuum descriptions, and hybrid multi-scale frameworks are therefore essential to bridge from the particle-scale mechanics and physics to the engineering application scale.

This invited mini-symposium aims to bring together researchers from academia and industry working on DEM, micro–macro methods, continuum modeling, and industrial applications of particulate systems. It will provide a platform for exchange between the granular physics, computational mechanics, powder technology, pharmaceutical engineering, and process engineering communities.

Particular emphasis will be placed on connecting fundamental developments in particle mechanics with practical industrial applications. Topics include, but are not limited to:

- **Discrete Element Method (DEM)** and other particle-resolved simulations
- **Micro–macro transition methods**, coarse-graining, and homogenisation
- **Continuum modelling** and constitutive descriptions
- **Granular rheology** and solid–fluid state transitions
- **Coupled multi-physics** and multi-scale modelling
- **Calibration and validation** of particle-based models
- **Reduced-order, hybrid, and data-driven models** for particulate processes
- **Particle technology** (e.g. granulation, tableting, powder handling, …)
- **Pharmaceutical, food, energy, geotechnical, and additive-manufacturing**

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