Investigating the fragility of packed structures with a combined finite-discrete element method

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ABSTRACT

The tendency of particles in a pack to break under mechanical loads follows from both the quality of the contact force network, i.e. the way in which forces are transmitted between particles, and the stress field that these contact forces generate in each individual particle. On the one hand, particle shape plays a crucial role in determining the properties of the pack structure, such as packing density, particle orientations, number of contacts and, in turn, the quality of the contact force network in the pack. On the other, the geometry of bodies, such as the presence of holes or geometrical features concentrating the stresses locally, can effectively determine a weakness of the particle for particular loading conditions. This opens an opportunity for the application of a combined finite-discrete element method (FEMDEM) to simulate the multi-body interactions between particles (DEM) and the stresses and deformations within each individual body (FEM). In the context of packed structures of manufactured particles with well defined sizes and geometries, e.g. catalyst pellets in fixed bed reactors, the correct representation of the geometrical features, such as cavities and sharp edges, is key to simulate with an adequate level of accuracy both the packing structure and the stresses and deformations of particles. By discretising the particles in a tetrahedral mesh and by employing sophisticated and parallelised contact algorithms, the Solidity FEDEM code developed by the AMCG at Imperial College London is capable of simulating the behaviour of systems of thousands of complex-shaped bodies to a high degree of accuracy.

In this work different packing structures originated from the deposition of particles of different geometries will be compared. Mechanical loads will be applied to the packed columns to investigate the relation between shape, contact force networks and stresses. Lastly, the data obtained for the number of particles experiencing stresses that might cause breakage will be used to investigate the fragility of the different packing structures under consideration.

REFERENCES

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