Powder compaction with polygonal particles built from radially extending one-dimensional frictional devices

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ABSTRACT

Powder compaction is a major ingredient in a wide range of production techniques for objects of every day importance. Diverse applications ranging from pharmaceutical tablets to metallic and ceramic parts, where compaction is usually a part in the sintering process, are covered by current technology. The aim of the cold compaction is to increase the relative density of the parts.

Due to the granular nature of the powder material compaction is a random process. This requires a careful mastering and comprehensive understanding of the compaction. The experimental access to compaction processes, even for simple ones as uniaxial compaction, are limited. Therefore the simulation of compaction processes offers the opportunity to tighten the hold of mastering and understanding of compaction.

The Discrete Element Method (DEM) simulates the powder as individual particles. These particles are distinct from each other and the forces on the entire powder are equilibrated by the contacting forces between the particles. Usually, an explicit time integration, with or without considering dynamic effects, allows the particles to move and the powder to be compacted.

Especially for metallic powders the plastic deformation of individual particles plays an important role and has a perceptible influence up to the macroscopic scale of the whole part. This lead to efforts to use a Meshed DEM, where individual particles are simulated as distinct FE models (e.g. [1]). Yet, such approaches are deemed too costly for the simulation of whole powders.

Therefore a new approach for plastic particle deformation has been devised. The particles are simulated as 'hedgehogs' of one-dimensional frictional devices [2]. The frictional devices form spikes that extend in a radial way from the centre of the particle. The tips of the spikes are connected and the connections form the edges of the polygonal particles. The contacts between the particles are found by geometric means as intersections of the spikes of one particle with the edges of the particle's contact partner. The indentation of a spike and its frictional device generates forces that act on the two particles. This allows multiple contacts between two particles and intrinsically treats concave particles.

Preliminary results indicate that this new approach to plastic particles might bridge the gap between sufficiently realistic behaviour of the plastic particles and a feasible computational effort. For now, the results are obtained for a two-dimensional model and, for the sake of simplicity, the springs in the spikes are linear and the friction is rate-independent and perfectly plastic. However this alone offers considerable liberties to tune the plastic behaviour of the particles to experimental results.

REFERENCES

[1] B. Harthong et. al., “Modeling of high-density compaction of granular materials by the DEM”, *Int. J. Solids and Structures*, **46**, 3357-3364 (2009).

[2] J.C. Simo and T.J.R. Hughes, *Computational Inelasticity*, Springer, (2000).