Discrete Element Modeling of Highly Deformable Particles

Zhang R[1], Metzger JP[1], Müller CR[1]*
*lead presenter: muelchri@ethz.ch
1 Department of Mechanical and Process Engineering, ETH Zurich, Switzerland

Granular media are encountered in many natural phenomena and industrial processes. When limiting granular systems to rigid (i.e. non-deformable) particles, discrete element model simulations have aided the elucidation of the underlying physics of such systems [1-3]. However, despite their industrial relevance (highly) deformable particles such as rubber, microgels, and molten ash have received far less attention and their peculiar rheological and mechanical behavior is less understood than that of their rigid counterparts [4,5]. To date, soft-particle systems still lack efficient and accurate simulation tools capable of handling large numbers of highly deformable particles.

In this work, we propose a bonded-sphere model based on the discrete element method that allows for the simulation of linear-elastic, highly deformable particles. Voronoi-tessellation is employed to segment an arbitrarily shaped particle into a network of sub-spheres that accurately mimics the mechanical properties of the original particle; the model does not require any pre-calibration. Inter-particle collisions are resolved by considering contacts between the respective sub-spheres.

The proposed model is validated using well-established single and multi-particle benchmark systems. Furthermore, it is demonstrated that the new model can handle a large number of particles as demonstrated by the simulation of particle packings and granular flows down an inclined plane or in a vertical channel. These simulations give access to key quantities in granular systems such as the solid volume fraction, particle deformation, and particle stresses that are required to rationalize the rheology of such systems.

References

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