Modelling and simulation of dry powder compaction for ceramic materials by means of discrete element method and weighted Voronoi tessellation

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ABSTRACT

Powder compaction of granular material plays a substantial role in the manufacturing processes of ceramics industry and powder metallurgy industry. In the ceramic forming process of spray-dried powders pourable granular powder is filled into a die or mould and compacted through the application of high pressures. The mechanical properties of the compacted green part is ruled by its granular microstructure, which is a result of polydisperse granular material behaviour and applied boundary conditions.

Discrete element method (DEM) allows one to investigate the die filling and powder compaction process numerically on the microscale. Three-dimensional data about particle size distribution and spatial structure of the particle packing can be extracted from micro-computed tomography (µCT). Mechanical properties have to be calibrated from different experiments.

The connection of the discrete micro-description and the macro-description using continuum theories is a challenging task. An average stress tensor can be computed from DEM results, evaluating the contact forces and the distances from the particle center to the contact point with respect to an average cell volume [1, 2]. Instead of using a grid of cells for homogenization, we apply a weighted-voronoi tesselation technique for defining the cell volume with respect to each individual particle. Local bulk density as well as local void fraction can be computed by the way. With this approach all structural information (size, position and neighbors of individual particles, particle interaction forces) can be transferred to a continuum description of heterogeneous microstructure, suited for finite element modeling. Computed discrete stress fields at different stages of powder compaction process will be presented together with data about corresponding particle size distribution and spatial structure of particle packings.

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