Micromechanical investigation of fracture of powder compacts

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ABSTRACT

Compaction of powders followed by sintering is a popular production route of components of hard materials, like cutting tools, and components of complex shape. First, a die, shaped as the final product, is filled with powder material. The powder is pressed and the resulting compact, the green body, is ejected. The green body has very weak mechanical properties but from sintering the component gets its full strength but it also gets changes in its dimensions dependent on the density distribution before sintering. It is also of importance that the green body is crack-free before sintering due to the fact that green body cracks introduces weak zones and crack initiation points in the final products. In this context, it is obvious that modeling of the compaction process is of great importance for the product development.

In this work, an experimental and numerical investigation of the fracture of powder compacts is presented with the aim of predicting cracks in the green body. The materials studied are two types of spry dried cemented carbide granules used in the industry. In the experimental part, powder compacts are pressed to different compact densities and later crushed in two different modes, axial and radial crushing. A microscopy study of the fracture surfaces is performed which shows that both fracture of the individual powder granules and fracture of inter-particle contacts is important in order to describe the fracture process.

The whole experimental process, including compaction, unloading and compact crushing, is simulated using an in-house developed Discrete Element Method (DEM) code. The material behavior of the granules was determined in Olsson and Larsson [1] and it will be used together with the bonding models described in [2] to derive the relations between contact force and indentation depth needed in DEM. Crushing of the individual particles is introduced by formulating a particle fracture criterion using the forces acting on a particle. If the fracture criterion is fulfilled a fracture plane is introduced in the particle using all the forces acting on that particle. The post-fracture behavior is determined by assigning different stiffness reductions to each contact force depending on the angle between the contact force and the introduced fracture plane.

The proposed numerical model shows a very good agreement with the outcome of the experimental investigation for both crushing modes if fracture of the particles is included in the model.

REFERENCES

[1] E. Olsson, P.-L. Larsson, A Numerical Analysis of Cold Powder Compaction Based on Micromechanical Experiments, Powder Technol. 243 (2013) 71–78.

[2] E. Olsson, P.-L. Larsson, On Force-Displacement Relations at Contact Between Elastic-Plastic Adhesive Bodies, J. Mech. Phys. Solids 61 (5) (2013) 1185–1201.