SIMULATING THE MECHANICAL BEHAVIOR OF THREE-DIMENSIONAL HONEYCOMBS

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This paper presents microstructural models for three-dimensional honeycombs along with corresponding simulation results which describe the mechanical behavior of such structures. Three-dimensional honeycombs are the result of a production process which involves the expansion of organic spheres that are coated with a metal powder slurry [1]. The expansion process merges the coatings of adjacent spheres to form the cell walls of a closed cell structure which is isolated by removing the precursor spheres and stabilized by sintering.

Depending on the effort that is put into the arrangement of the precursor spheres more or less regular cellular structures can be obtained. For obtaining suitable generic models for the cellular structure a regular face-centered cubic arrangement of the spheres is assumed corresponding to a close-packing of spheres in an infinite cellular medium. Expanding the spheres results in a thin-walled structure that can be seen as a Voronoi tessellation of the face-centered cubic lattice. The building block of such a tessellation is the rhombic dodecahedron, which is a polyhedron with 12 rhombic faces. The chosen designation 'three-dimensional honeycomb' stems from the fact that this structure can be cut by specific planes for obtaining regular hexagonal cross-sections.

Exploiting the symmetries of the rhombic dodecahedron, finite-element unit-cell models are set up in order to predict the mechanical behavior of an infinite, periodic arrangement of cells. The unit-cell method allows for the prediction of the effective behavior of a periodic structure by observing the behavior of a representative building block in combination with appropriate periodic boundary conditions.

The mechanical behavior of the three-dimensional honeycomb is influenced not only by their geometry, but also by the production process which is governed by non-uniform stretching of the coating during expansion of the precursor spheres. An attempt is made to simulate the changes in coating thickness and porosity during the expansion and to map the results on the final unit-cell models, which are subsequently analyzed.

The obtained results comprise the full tensor of elasticity and its dependence on the effective density. By studying the nonlinear behavior up to the effective, macromechanical limit load including the effects of multi-axial loading conditions valuable information for the homogenized representation of the cellular material under consideration is obtained.

References

[1] O. Friedl, C. Motz, J. Färber, M. Stoibner, and R. Pippan, "Experimental characterisation of the deformation in hollow sphere structures," *to be published in: Proc. MetFoam 2005*, September 2005, Kyoto, Japan.

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