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Multiscale numerical modeling of regular open-cell cellular structures with elastic filler material

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ABSTRACT

Open-cell cellular materials with their high energy absorption performances are of particular importance in automotive, railway, ship and aerospace industry as crash absorbers where the impact energy is absorbed and dissipated. In our recent research [1, 2] the benefit of using second phase filler material, resulting in energy absorption increase, is addressed. The research in [1, 2] was focused on the regular open-cell structures to avoid randomness and irregularities in cellular structures (e.g. metal foams) and to assure a certain degree of reproduction in order to investigate the influence of the second phase filler material.

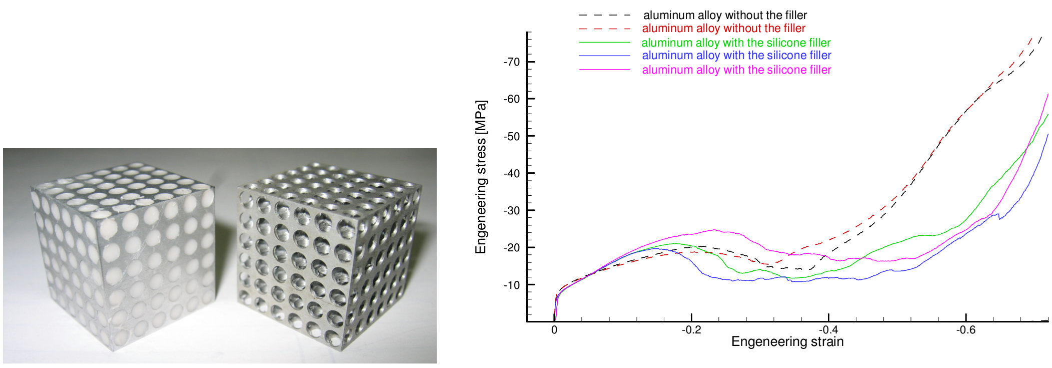

Figure 1. The open-cell aluminum alloy structure with and without silicone filler material [2]

Modeling of such open-cell structures on the macroscale (the scale of product) is hardly achievable with current computational power, due to complex material behavior of the two phase material. However, the global mechanical and thermal properties of these structures can be evaluated accurately and efficiently by means of a computational homogenization procedure. In the presented research a nonlinear homogenization method is applied [3] for modeling the open-cell structure including the filler material on the mesoscale (1/8 of a unit cell) and applying the homogenized model on the macroscale, i.e. the 24×24×24 mm aluminum alloy Al3003-H12 with 6×6×6 holes of 3 mm in diameter.

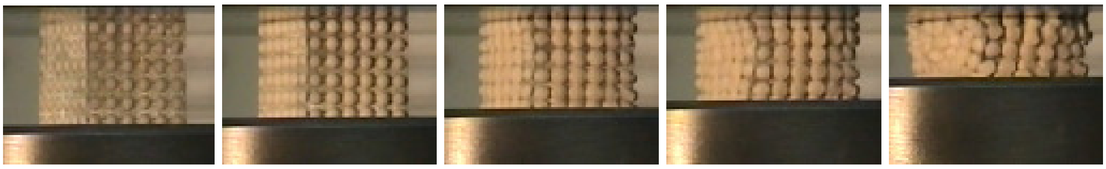

Figure 2. The deformation of a 6x6x6 aluminum alloy specimen with filler under compressive loading [2]

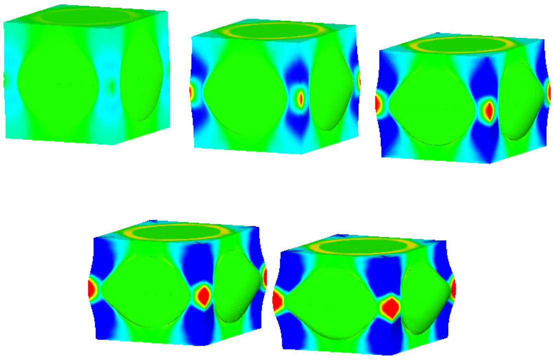

Figure 3. Computational simulation of a mesoscale unit cell with the silicone filler material

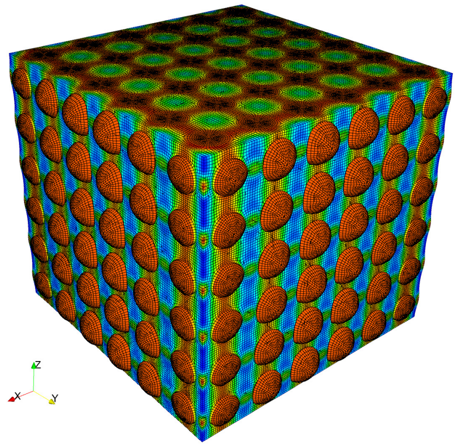

Figure 4. Computational simulation of 6x6x6 cell macroscale model

The presented validation of multiscale computational method using experimentally obtained data (Fig. 1) allows for extensive investigation of open-cell cellular structures with second phase filler, as well as development of computational models for irregular open-cell cellular structures.

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