A NOVEL UNIT-CELL MODEL FOR CLOSED-CELL FOAMS SUBJECT TO COMPLEX LOADINGS

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Cellular materials possess a favorable combination of good mechanical and physical properties, while maintaining very low weight (6%-20% of the parent material). They constitute an excellent candidate for innovative future designs, in which low weight and high strength are strict design parameters. The current investigation is devoted to the advanced modeling techniques of this type of materials with a special attention dedicated to development of a new representative three-dimensional unit-cell-based foam model.

Aluminum foam is a structure composed of non-uniform closed-packed closed-cells. Several models have been proposed to replicate these structures. Most of these models rely on the assumption that the load is generally applied perpendicular to cell top and bottom surfaces. Based on our observations and careful study of the morphology of this particular foam, we developed a new representative unit-cell model, which can be subject to complex loading conditions. It is approximated as an assembly of two closed-packed cells of large and small sizes. Small spheres are interconnected though a truncated tetrahedron which represents larger cell size. This model, which can be subjected to a range of large deformations, enables accurate characterization of the behavior of cellular materials under multi-axial loadings.

Three aspects of the problem are accordingly examined. The first is concerned with the development of the representative unit-cell model able to account for complex loading conditions. Three-dimensional FE analyses were conducted using the commercial code LS-DYNA. The meshing routine was parameterized to accommodate the highly irregular geometries in the proposed model. The second is devoted to the validation of the numerical predictions with experimental findings based on quasistatic uniaxial compression, shear and oblique loading tests. The third is concerned with sensitivity analyses so as to examine key geometric characteristics of the individual cell such as the foam cell size, foam density, anisotropy, on the collapse load, nominal stress-strain curves as well as the corresponding energy absorption. The results show that geometrical futures of generalized model have significant impact on the overall behavior of the aluminum foam.