Society of Engineering Science 51st Annual Technical Meeting

1–3 October 2014

Purdue University, West Lafayette, Indiana, USA

A finite deformation coupled plastic-damage model for simulating fracture of metal foams

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ABSTRACT

Metal foams are a novel class of lightweight materials with unique mechanical, thermal, and acoustical properties. The low ductility of metal foams hinders the possibilities of applying secondary forming techniques to shape metal foam sandwich panels into desired industrial components. An important factor is the limited studies on their macroscopic damage and fracture behavior under complex loading conditions. There exist numerous mechanistic micromechanics models describing the fracture behavior of metal foams at the strut level, but very few work have been done on modeling their macroscopically coupled plasticity-damage constitutive behavior. The objective of this study is to develop a continuum finite deformation elasto-plastic-damage mechanics-based constitutive model for metal foams. The constitutive model is implemented in a user-defined material subroutine (UMAT) in the finite element software ABAQUS/Standard. The elasto-plastic part is implemented using backward-Euler return algorithm within Deshpande–Fleck constitutive framework. Continuum damage mechanics framework is formulated for the development of damage evolution equations. These damage evolution equations take into consideration the various key degradation mechanisms that lead to the macroscopic fracture of metal foams under various loading conditions. The model is calibrated and validated based on experimental data on aluminum foams under different loading paths, strain rates, and temperatures.