Society of Engineering Science 51st Annual Technical Meeting

1–3 October 2014

Purdue University, West Lafayette, Indiana, USA

Numerical analysis of yield properties of closed-cell aluminum foam under multiaxial loads by 3D voronoi model

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ABSTRACT

Metallic foam is a typical porous material whose yield surface is related to not only von Mises equivalent stress but also the hydrostatic pressure. It is essential to study the yield properties of closed-cell aluminum foam under complex loading conditions. However, because the current experimental technique may support only a few proportions of multiaxial loading, it is hard to learn the yield surface well especially for the tensile hydrostatic pressure. In this article, we explored a numerical method to learn the yield properties of aluminum foam, in which the meso structures of aluminum foam were simulated by 3D Voronoi method. In addition, the yield surface of aluminum foam was drawn successfully with the numerical method. The main works included: (1) In our numerical simulation, we tested the calculating parameters such as mass scaling, elements number, and loading velocity on simulation results and verified the homogeneity of the 3D Voronoi model firstly. Furthermore, the optimized calculating parameters were determined by considering both reliability and feasibility of the calculation. Homogeneity of 3D Voronoi model was checked by the compression behaviors of aluminum in different directions. (2) In order to overcome the difficulty to determine critical yield state of metallic foams under complex loads, we recommended criterion by setting a dimensionless plastic dissipation value to determine the onset yield state of the foam under multiaxial loads. The critical value of dimensionless plastic dissipation was deduced from the common criterion—0.2% plastic strain in uniaxial loading, and the effect of relative densities on critical values was analyzed. (3) Three normal stresses were applied on cubic aluminum foam proportionally to implement the proportional loading. The different loading proportional factors of the three normal stresses were set widely to insure the yield surface including enough data, such as the hydrostatic loads cover from minimum negative to maximum positive values; each proportion has three loading proportional factors. Further, effects of the relative density on yield surface were investigated.