CHARACTERIZATION AND MODELING OF INHOMOGENEOUS COMPACTION DEFORAMTION IN ALUMINUM FOAMS

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Inhomogeneous deformation of uniaxially compressed closed cell and open cell aluminum foams (Alporas and Duocel) is examined. The focus is on characterizing and modeling the onset of the observed deformation modes. Surface strain contour plots, produced via digital image correlation (DIC), reveal formation of elongated zones of localized axial compaction, extending laterally across part of the specimen face. These zones of concentrated strain form early in the loading process, well before peak stress, and include some concentrated shear strain. Additionally, surface displacement contour plots show lateral displacements that correspond to a column buckling-type mode, although specimen aspect ratios are 2:1 or less. In specimens loaded to 20% nominal axial strain, this buckling-type mode is easily identified visually. However, surface displacement contour maps reveal that this deformation mode begins well before peak stress; the displacements are too small to be seen visually, but are consistently observed using DIC. These findings contrast with those described by others; for example, Gong and Kyriakides [1] reported specimen buckling of polyester urethane foam, following the stress peak. In the materials examined here, it is not clear which of the deformation modes (zones of axial compaction or the buckling-type mode) initiates first, or if they form simultaneously. However, once formed, the modes often develop cooperatively under continued loading (through the stress peak and into the stress plateau); as the zones of axial compaction intensify and link to form one or two predominant bands, the buckling-type deformation becomes more pronounced.

Continuum-based theoretical models are used to examine the conditions under which each of the two observed deformation modes is possible. Conditions for the onset of the bands of axial compaction (with shear) are determined using a bifurcation approach to localization [2]. Formation of a planar band, consisting of both shear offset and deformation normal to the band, is an alterative to continued homogeneous deformation of an inelastically deforming initially homogeneous material. Predicted and estimated observed band orientations are in reasonable agreement. The angle between the loading direction and the band normal is small (typically 15 to 25 degrees), corresponding to the observed compacting shear bands (predominant axial compaction with some shear). Inelastic buckling theory reveals that buckling conditions can be satisfied prior to peak stress, however, the observed buckling-type behavior initiates at lower stresses. This is likely attributable, at least in part, to the non-uniform material mesostructure; therefore, the role of material inhomogeneity in promoting early onset of a buckling-type deformation is also examined.

References

[1] L. Gong and S. Kyriakides, “Compressive response of open cell foams Part II: Initiation and evolution of crushing,” *Int. J. Solids Struct.*, **42**, 1381-1399, 2005.
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