FOAM CONSTITUTIVE MODELS FROM COMPLEMENTARY EXPERIMENTS AND CELL-LEVEL SIMULATIONS*

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A series of complementary experiments and cell-level simulations were recently performed to characterize the mechanical response of a 20 lb/ft^3 PMDI polyurethane foam to large deformation. In the experiments, effects of load path, loading rate, and temperature were investigated. Results from these experiments indicated that, as expected, this foam exhibits significant deviatoric and volumetric plasticity when compressed. These experiments also revealed that the foam's mechanical response is extremely temperature and strain-rate dependent.

In the cell-level simulations, foam response to various load paths was investigated by subjecting a finite element model of a representative volume of foam cells to a prescribed deformation with appropriate spatially periodic boundary conditions. The prescribed deformations and resulting tractions were then used to compute the macroscopic stress-strain response of an equivalent continuum. The accuracy of these cell-level simulations was limited by the number of cells included in the finite element model and by the accuracy of our description of cell-wall material behavior. The cell-level simulations allowed us to investigate foam response to load paths that could not be obtained experimentally.

Based on these experimental and numerical studies of 20 lb/ft^3 PMDI foam behavior, a foam plasticity model which captures deviatoric and volumetric plasticity was developed. This foam has a yield surface which is an ellipsoid about the hydrostat. A variety of different yield surfaces have been proposed for different foams by previous researchers [1-7]. Similarities and differences between these surfaces will be discussed. Since the 20 lb/ft^3 PMDI foam was also found to be very strain-rate and temperature dependent, a viscoplastic foam model was developed to capture temperature and strain-rate effects.

References

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