

STRAIN LOCALIZATION IN THE PRESENCE OF MICROSTRUCTURAL EVOLUTION

John L. Bassani

Department of Mechanical Engineering and Applied Mechanics
University of Pennsylvania, Philadelphia, PA

A model is developed for a class of anisotropic elastic-plastic solids in which the orthotropic triad that characterizes the symmetry of the microstructure evolves with deformation. Microstructural spin is defined to be the difference between the material spin and plastic spin, which leads to a key relationship between plastic rate of stretching and plastic spin (derived rigorously from representation theory for tensor-valued functions). As a consequence, microstructural evolution arises from non-coaxiality between the plastic rate of stretching and the orthotropic axes, which intuitively makes sense. The resulting phenomenological theory extends classical theories of plasticity to include the evolution of the axes of material symmetry that evolve with large strain deformation. Comparisons with experimental data for polycrystals undergoing non-coaxial deformations are excellent. For loading in the plane of a textured sheet or for axial loading of a thin tube, only 2 additional material parameters are required for stressing in one of orthotropic symmetry planes. Predictions for necking, shear banding, and buckling display significant effects of microstructural evolution on strain localization. One important application of current interest arises in automotive “light-weighting” in predicting limits to sheet metal forming in Al- and Mg-alloys. Detailed simulations that include microstructural evolution in tube crushing, which show promise in developing new design concepts.