AUTOMATED SERIAL SECTIONING AND 3-D COMPUTATIONAL MECHANICS OF DISCONTINUOUSLY-REINFORCED ALUMINUM

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Microstructural details such as degree of homogeneity and spatial anisotropy of the reinforcement phase can have a profound effect on the mechanical properties of spatially-heterogeneous microstructures such as discontinuously-reinforced aluminum (DRA) and other metallic matrix composites. However, models for predicting the constitutive behavior of based on unit cell approaches generally do not possess the ability to incorporate the effects of these higher-order microstructural features. In addition, currently-available numerical models rarely encompass the volumes of material necessary to ensure statistical relevance. The present work therefore offers an alternative approach for first quantifying and then incorporating microstructural homogeneity into an elastic-plastic finite element (FEA) code, in an attempt to model both the micromechanical length scale associated with the individual reinforcement particles and the microstructural length scale associated with the homogeneity of their spatial distribution, at a greatly-reduced computational expense. DRA composites containing varying levels of microstructural homogeneity were characterized using a modified version of the Multi-Scalar Analysis of Area Fractions (MSAAF) technique originally developed by Spowart *et al*. The modified analysis leads to the definition of two separate (in-plane) homogeneous length scale parameters, L_{H1} and L_{H2}, which refer to the spatial homogeneity of the microstructures measured in the axial and transverse directions, respectively. Automated serial sectioning of the DRA composites was carried out using *Robo-Met.3D*. Finite element (FEA) models were built from the resulting 2-D and 3-D data sets, the results of which showed that L_{H1} and L_{H2} have a strong effect on both tensile elastic modulus and yield strength as well as initial strain-hardening rates. In addition, strain localization and load partitioning were identified as physical mechanisms which strongly contribute to the post-yielding behavior. This provides a clear incentive to produce DRA composites with higher levels of spatial homogeneity, in order to take full advantage of the benefits to stiffness offered by the reinforcement phase, without incurring any property debits such as low ductility caused by strain localization.

Key words: Serial sectioning; finite elements; MSAAF.