Simulation of deformation and damage of SiCp/Al composites under tensile loading

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Abstract

Particles reinforced metal matrix composites (PRMMCs) have high stiffness and strength, improved resistances to fatigue, wear and creep compared to the unreinforced metals, making them ideal structural materials for aerospace and defense industry. Deep understanding of the deformation and fracture behaviors is critical for developing advanced PRMMCs [1-3]. In order to do this, stress and strain distribution should be described clearly. In addition to experimental methods, numerical methods, especial the finite element (FE) method have been extensively used [4, 5]. However, traditional 2D models (plane stress and plane strain) have lower accuracy to characterize the distribution of equivalent plastic strain [6]. Therefore, 3D realistic models are receiving increasing attention in MMC simulations. Many approaches to construct 3D realistic microstructure models [6-9], including serial sectioning technique, X-ray tomography techniques and computer modeling technique. Compared to serial sectioning technique and X-ray tomography techniques, computer modeling technique is more efficient and exhibits higher resolution of microstructures.

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In this study, a 3D virtual microstructure model was constructed via computer modeling technique and an interface phase with an average thickness of 50μm was adopted to define the material properties of interface. Therefore, the model was composed of the matrix, the reinforcement and the interface. Based on that, comparative study was conducted to investigate the deformation, damage and failure behaviours of 17vol.% SiCp/2009Al composite by using a representative volume element (RVE) and a unit cell model. In these models, the matrix and the interface were described as elastoplastic while the reinforcement was described as elastic.

By contrast with unit cell model, the RVE model showed better computational accuracy. Using the RVE model, the calculated stress-strain curve and the morphology of fracture agreed well with the experimental results. Througth comparing the calculated results obtained from RVE models with different mesh sizes, it was found that finer mesh led to the lower predicted flow stress. Besides, the strength of the interface was discussed. It was found that lower interface strength resulted in lower flow stress and ductile damage of interface phase, leading to decreased elongation.

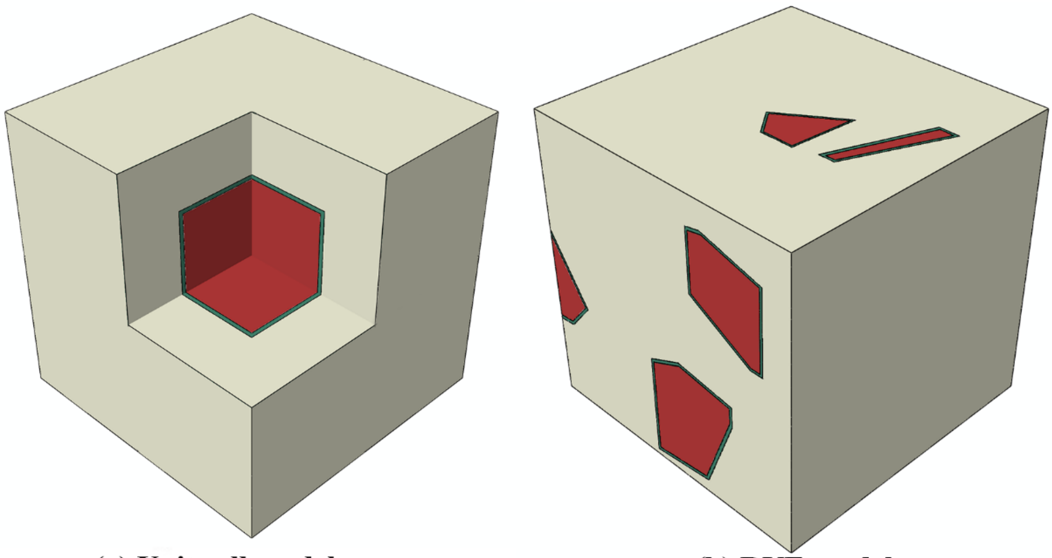

Fig. 1 The microstructure models of 17vol.%SiCp/Al composite: (a) Unit cell model and (b) RVE model with a size factor of 5.

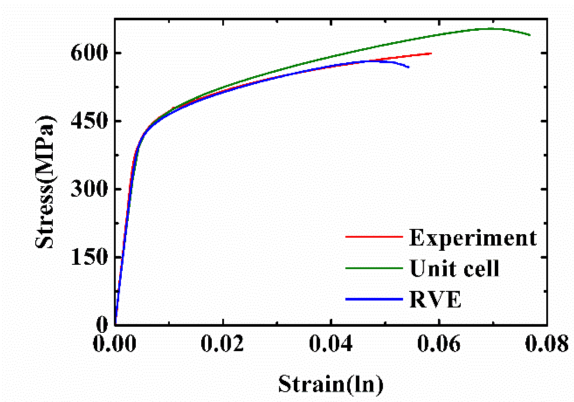

Fig. 2 The tensile strain-stress responses of RVE model and unit cell model.

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