Abstract

The fracture and fatigue properties of particle reinforced matrix composites are greatly influenced by stress concentration around the reinforcements as the failure of a structural member often initiates at regions of high stress concentration. Determining stress concentration has been the focus of number of researchers for quite some time in order to better understand the failure mechanics of structural members. The first part of the study investigates the stress concentration around a spheroidal particle that is embedded in a large elastic matrix and subjected to dynamic loading. Interaction between neighboring particles is ignored. The results are therefore valid for composites with low volume fractions. The problem is studied by extending a hybrid technique that was previously developed for axisymmetric loading. In the hybrid technique, a fictitious spherical boundary enclosing the particle is drawn. The fictitious boundary divides the entire region into interior and exterior regions. The interior region is modeled through an assemblage of conventional finite elements while the exterior region is represented by spherical wave functions. Coupling of the solutions for the interior and exterior regions is achieved by imposing the continuity of displacements and tractions along the common boundary B. This leads to a set of linear equations that enables the displacements and stresses at any point to be determined. It is found that the stress concentrations within the matrix at the matrix-particle interface are dependent on the frequency of the dynamic excitation, aspect ratio of the particle and the material properties of both matrix and a particle. The study reveals that the dynamic stress concentration can reach much higher values than the static case.

A second part of the study involved investigating the potential of using an interphase layer to reduce stress concentrations under a dynamic loading in Mg matrix surrounding a SiC particle. An interphase layer was applied between the particle and the matrix and the contact between them was assumed to be perfect. Both constant property materials and functionally graded materials were considered for the interphase. A constant property interphase was modelled as a single layer while a functionally graded interphase was divided into a number of sublayers and each sublayer was treated as having constant material properties. Numerical results reveal that the interphase layer made of a constant property material shows better stress concentration reduction than that made of functionally graded materials. An interphase layer with low values of both shear modulus and Poisson's ratio is necessary for a significant stress concentration reduction. Studies were focused on reducing the concentration that occurs over a range of frequencies.

The third part of the study investigates the size effects as the particle size reduces to nanometers. This part of the study was inspired by the current interest in nanomaterials. For instance, a quantum dot that is embedded in the matrix of a composite could introduce stress concentrations under dynamic loading. This is studied here by using the surface/interface theory of elasticity. It is found that the stress concentration values are significantly dependent on the elastic properties of the surface/interface and the frequency of excitation.

The work presented here has resulted in three publications in international journals and three conference presentations. The complete list is given below:

1. R. Paskaramoorthy, S. Bugarin and R. Reid: Effect of an interphase layer on the dynamic stress concentration in a Mg-matrix surrounding a SiC-particle. *Journal of Composite and Structures, 2009, 91, 451–460.*

2. R. Paskaramoorthy, S. Bugarin and R. Reid. Analysis of stress concentration around a spheroidal cavity under asymmetric dynamic loading. *Journal of Solids and Structures, July 2011, 48, Issues 14-15, 2255-2263.*

3. S. Bugarin, R. Paskaramoorthy and R. Reid. Influence of the geometry and material properties on the dynamic stress field in the matrix containing a spheroidal particle reinforcement. *Composite Part B: Engineering, Volume 43, Issue 2, March 2012, Pages 272-279*

4. Paskaramoorthy R, Bugarin S, Reid RG. A hybrid finite element method for stress concentration in a single fibre composite. *ASME 2011 Applied Mechanics and Materials Conference in Chicago, Illinois, USA, June 2011.*

5. Bugarin S, Paskaramoorthy R, Reid RG. A hybrid finite element method for stress analysis around an inhomogeneity under dynamic loads. *South African Conference on Applied Mechanics, 2010, University of Pretoria, South Africa.*

6. Paskaramoorthy R, Bugarin S, Reid RG. On the reduction of dynamic stress concentrations in a SiC/Mg composite using interphase layers. *Proceedings of the Sixth International Conference on Composite Science and Technology, Durban, January 2007. (ISBN: 1-86840-642-3)*