MICROMECHANICAL STUDY OF TWO PHASE COMPOSITE

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Abstract

Micromechanical modeling has been demonstrated to be a powerful tool to predict macroscopic constitutive response especially for those materials having periodic microstructure. Composite materials is assumed here as periodic microstructure and Elastic moduli and loss factors are predicted using Bridging model which includes the effect of fiber packing through the fiber packing factors. The results of Bridging model are compared with Eshelby's method, Servanos-Chamis approach, FEM/Strain energy and Hashin model. Effect of fiber packing has been studied on dynamic behavior of composite materials. Two phase composite material is modeled using standard FEM software, and loss factors and elastic moduli are obtained. Optimization of fiber packing factor has been carried out for loss factors to correlate the result with those of FEM approach. The purpose of such a study is to identify the fiber packing geometry in relation to fiber packing factor α and β employed in Bridging model.

Introduction

Micromechanical improvements in composite material damping result from changes in damping properties and geometries at or below the lamina constituent level. Micromechanical approach has been used for both continuous and short fiber-reinforced composite materials. Some important micromechanical models, with varying degree of complexity used in literature for estimation of elastic moduli are adopted to predict damping coefficients for the continuous fiber-reinforced composites.
Comprehensive review of damping studies in fiber reinforced composite has been carried out by Chandra et al., [1]. Chang and Bert [2] performed complete analytical characterization of damping and stiffness of single layer of fiber-reinforced composite based on micromechanics. Loss tangents predicted are based upon elastic-viscoelastic correspondence principle (for stiffness with explicit expression) and energy approach. Storage and loss moduli are predicted using Cox model [3] assuming negligible loss factor for fiber material. The damping in unidirectional lamina is modeled in accordance with unified micromechanical damping theory by Saravanos and Chamis[4]. Considering square packing array of fiber in the composite, damping constants ψ_{11}, ψ_{22},.ψ_{12}, and ψ_{23} are determined. Loss modulus in uniaxial tension, bending, and shear are predicted. Chandra et al., [5] presented a comparative study of micromechanical model for the prediction of damping coefficient of two-phase continuous fiber-reinforced composite. The effect of the shape of the fiber cross section and fiber volume fraction on the various damping coefficient is studied through the application of viscoelastic correspondence principle model based on Eshelby's method [6] and Mori-Tanka approach. Micromechanical approach to damping analysis for fiber-reinforced composites has provided better insight into role of damping mechanisms, effect of constituent elements (matrix, fiber) and fiber-matrix interaction in addition to the geometrical parameters. In this direction, integrated micromechanical damping theory due to Saravonos and Chamis [7] is a right step, which involves analysis and optimization for damping in fiber-reinforced composites. Chandra et al., [8] used FEM/Strain energy approach to predict loss factors η_{22}, η_{11}, η_{12}, and η_{23} in order to correlate the results with other micromechanical damping models.

Composite material is assumed here as periodic microstructure and Elastic moduli and loss factors are predicted using Bridging model [9] which includes the effect of fiber packing through the fiber packing factors. The results of Bridging model are compared with Eshelby's method, Servanos –Chamis approach and FEM/Strain energy and Hashin model [10]. Effect of fiber packing has been studied on dynamic behavior of composite materials. Optimization of fiber packing factor has been carried out for loss factors to correlate the result with those of FEM approach. The purpose of such a study is to identify the fiber packing geometry in relation to fiber packing factor α and β employed in Bridging model.

Conclusions

Longitudinal elastic modulus E_{11} increases linearly with the increase of fiber volume fraction. Longitudinal (α) and transverse (β) fiber packing factor has no effect on the longitudinal elastic modulus.

Transverse normal modulus E_{22} increases with the improvement in fiber volume fraction. It increases very less for lower value of V_f but for higher value of V_f it increases rapidly. E_{22} increases with increase in transverse fiber packing factor (β).

Longitudinal shear modulus G_{12} is sensitive to longitudinal fiber packing factor (α) for lower fiber volume fraction (V_f = up to 0.4) whereas more sensitive for higher fiber volume fractions (0.4< V_f <0.9) as fiber packing factor α decreases from 1 to 0.3.

Longitudinal loss factor η_{11} indicates decreasing trend with the increase of fiber volume fraction. Longitudinal loss factor is independent of both longitudinal and transverse fiber packing factor. There is one to one correspondence of results for longitudinal loss factor as predicted by FEM.

Transverse loss factor η_{22} and transverse shear loss factor η_{23} increases with increase of fiber packing factor β corresponding to particular fiber volume fraction.

Longitudinal shear loss factor increases with the increase of longitudinal fiber packing factor (α) corresponding to particular fiber volume fraction.

Transverse loss factor, transverse shear and longitudinal shear loss factors have been obtained using FEM methods for hexagonal and square fiber packing geometry. Using Bridging model, loss factors results are obtained and compared with FEM results and fiber packing factors α and β has been obtained with the help of optimization.

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