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EDITORIAL

Insertion of composite materials into structural components requires good characterization and evaluation of nascent composite systems in research and developmental stages, as well as during eventual production and use. During research and developmental stages of the composite, it is critical to evaluate the compatibility of different types of matrix materials with different types of fibers, and the effect of material processing conditions. Also, the suitability of the overall mechanical properties and material behavior of the composite for the intended application will have to be evaluated. On the other hand, after the composite has been designed and developed, it is imperative to ensure that the designed properties are being achieved during production and retained during use.

During the design and development of fiber reinforced composites, there is a need to design and control the formation of the fiber–matrix interphase so that the composites behave as per the material design criteria. As a result, it is essential to understand how the fiber and matrix interact. Further, such a "designed property" approach is critical to both the cost and the performance of these materials. However, for any "designed property" approach to be successful, it is imperative to have a method of interface characterization during the developmental stages of the composite.

Many destructive and nondestructive evaluation (NDE) methods are being used to evaluate the composite during its developmental process. Some of the destructive tests in use are fiber push-out, fiber pull-out, thermal and mechanical fatigue, etc. Nondestructive methods in use include X-rays, laser, ultrasound, etc. Ultrasonic NDE techniques have an excellent potential for use during all phases of the life cycle of the composite systems.

This special issue of the journal contains a collection of eleven papers discussing various aspects of interface design, characterization, and/or its influence on the overall mechanical behavior of the composites. All the papers are invited and were part of the Symposium on Fiber–Matrix Interfaces organised in conjunction with the First International Conference on Composite Engineering held in New Orleans, USA, during August 28–31, 1994. The symposium had 44 presentations and was an effort to bring together researchers in the area of material science and engineering, composite mechanics, and composite characterization. To encourage collaborations among the various fields of composite research, the symposium covered a wide range of topics in the area of fiber–matrix interfaces and are listed below:

Design and control of the interface: effect of fiber coating on the densification of the composites, control of toughness of metal matrix composites through the control of precipitation at the fiber–matrix interface, in situ *monitoring of interfacial consolidation, etc.*

Influence of the interface on the mechanical behavior of the composites, modeling and experiments: effect of interfacial wear on the fatigue failure of composites, micromechanical stress analysis for the characterization of fiber–matrix strength parameters, role of interface properties on the creep behavior of composites, determination of optimum interface properties through fracture mechanics based modeling, influence of the interface on the microcracking behavior of composites, etc.

Destructive characterization of the interface: effect of friction on the fiber pull-out tests, determination of the interfacial properties from the fiber pull-out tests, characterization of fiber–matrix interface in cement based composites, role of residual stress and specimen geometry in the fiber-push tests.

Nondestructive characterization of the interface: acoustic microscopy for interfacial assessment, fiber–matrix interface characterization using guided waves, ultrasonic evaluation of composite interface—modeling and experiments.

The eleven papers included in this special issue of the journal were selected from the 44 papers presented in the symposium and primarily deal with three aspects of fiber–matrix interface studies. The first three papers deal with the influence of the interface on the mechanical behavior of the composites, the next two papers discuss destructive characterization of the interface, and the final six papers cover various aspects of ultrasonic nondestructive characterization of the fiber–matrix interface. A brief synopsis of the papers and the issues addressed by each paper follows.

The paper by Kroupa and Ashbaugh discusses the stress-free edge effects on the response due to transverse loading of unidirectional metal matrix composites. Using a plane stress condition to represent the stress-free edge region and plane strain condition for the internal region, the authors have obtained, through numerical simulations, an insight into the complex interactions among residual stress, fiber–matrix separation, and matrix inelastic behavior in metal matrix composites. Rajesh *et al.*, in their paper, have predicted the optimum interface properties necessary to achieve a desired fracture behavior of metal matrix composites. They have based their prediction on fracture mechanics based numerical analysis with the consideration of residual stresses due to mismatch of coefficients of thermal expansion of the fiber and the matrix. They have drawn conclusions regarding the initiation and progression of the fiber–matrix debond and its influence on the overall failure mechanism of the composite. The paper by Veazie and Qu outlines the effects of fiber–matrix interphase regions on the transverse stress–strain behavior of unidirectional metal matrix composites. They have established a framework to recognize the existence of an interphase zone with distinct properties than the matrix or the fiber, and have carried out a rigorous analytical estimation as well as numerical solutions to determine the micromechanical fields of stresses and macromechanical properties of the composite, with and without partial interfacial failure. These three papers have effectively brought out the important role played by the fiber–matrix interface in the overall mechanical behavior of the composites.

The paper by Pochiraju *et al.* provides an analysis of the fiber push/pull tests which are destructive methods of fiber–matrix interface characterization. They have considered the existence of sliding friction in their analysis of the detailed stress fields caused by the fiber push/pull process, especially when the fiber–matrix interface is under compressive thermal residual stresses. With the help of example composite systems, they have verified the germane features of the local fields using finite element global analyses. The next paper, by Cordes and Daniel, outlines an experimental method of determination of the interfacial properties through *in situ* observations of progressive fiber debonding during fiber pull-out tests. Using samples made of borosilicate glass matrix and silicon carbide fibers, they have determined the relationships between the length of debond and the applied load, as well as between embedded length and the applied load. These two papers have effectively outlined many of the important issues and the involving complexities of the fiber push- and pull-out tests for the fiber–matrix interface characterization.

The paper by Yen and Tittmann is the first of the six papers in this issue dealing with ultrasonic nondestructive characterization of the fiber–matrix interface. In their paper, Yen and Tittmann have addressed the issues and methods of using ultrasound and acoustic emission to characterize carbon–carbon composites during pyrolysis. They have shown the feasibility of *in situ* monitoring of the evolution of the interface. They have also demonstrated the ultrasonic determination of the effect of microcracking on the overall mechanical properties of the composites through dynamic modulus measurement. In addition, they have used acoustic microscopy for the determination of the evolution of the microstructure as a function of temperature. The paper by Rattanawangcharoen *et al.* deals with the modeling for the investigation of the interphase region between the matrix and the fiber using ultrasonic guided waves. They have studied the case of radial homogeneity of the interphase zone using the Rayleigh–Ritz finite element derivation of the dispersion equation governing the guided wave propagation in a composite cylinder. Balasubramaniam *et al.* have used, in their paper, an effective elastic property model to study the influence of the fiber–matrix interphase region on the propagation of ultrasonic waves in the composites. They have used a three-phase micro-mechanics model to study the modulation of wave propagation due to the interphase properties. The paper by Karpur *et al.* deals with the characterization of the elastic behavior of the fiber–matrix interface using the shear back reflectivity (SBR) technique. They have provided an outline of a theoretical model and details of experimental determination of the "shear stiffness coefficient" of the interface in metal matrix and ceramic matrix composites. Rokhlin *et al.* have outlined in their paper a method of determination of fiber–matrix interphase elastic moduli through the measurement of ultrasonic phase velocity and attenuation. They provide detailed analytical and numerical modeling and supporting experimental data of the interphase property estimation in metal matrix and ceramic matrix composites. They also demonstrate the effectiveness of the technique in the determination of the evolution of oxidation damage in these composites. The paper by Bashyam outlines an ultrasonic method of measurement of stiffness coefficients in ceramic matrix composites and the use of this method to monitor the degradation of the composite. The collection of these six papers has brought out the potential and the need for ultrasonic method of composite evaluation, as well as fiber–matrix interface characterization.

The editors would like to thank all the authors and the reviewers of the papers included in this special issue. We would also like to thank the International Conference for Composites Engineering for providing a forum for the presentation of these papers, as well as the remaining 33 papers that were presented in the symposium.

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