Thermal and Mechanical Behavior of Metal Matrix and Ceramic Matrix Composites

Kennedy/Moeller/Johnson

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Foreword

The symposium on Thermal and Mechanical Behavior of Metal Matrix and Ceramic Matrix Composites was held in Atlanta, Georgia, 7–8 November 1988. ASTM Committee D-30 on High Modulus Fibers and Their Composites and ASTM Committee E-24 on Fracture Testing sponsored the symposium. John M. Kennedy, Clemson University, Helen H. Moeller, Babcock and Wilcox, and W. S. Johnson, Nasa Langley Research Center, are editors of this publication.

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Overview

In the past twenty five years, Committee D-30 of ASTM has provided a major forum for promoting the transfer of information on advanced composite materials. Similarly, for the past thirty years, Committee E-24 has been involved in fracture testing, both developing standards and transferring information. This publication and the Symposium on Thermal and Mechanical Behavior of Ceramic and Metal Matrix Composites which was held in Atlanta, Georgia on 7–8 November 1989 were sponsored to continue these efforts. Twenty three papers were presented at the symposium, and this publication contains sixteen peer reviewed articles on the subject.

As history has shown, the advancement of technology in many cases is limited by the availability and understanding of materials. This is certainly true for today's technology. The government is currently supporting programs such as the National Aerospace Plane which will require new materials with thermal/mechanical operating conditions which are far beyond the capability of materials currently used in production of high-temperature components. To support this program and numerous others, industry and government are developing new material systems which can satisfy the material design requirements. In many cases, it appears that ceramic or metal matrix composites are the only viable material systems. Before these materials can be extensively used in DOD, NASA, and commercial systems, optimized cost effective material processes must be developed. In developing these processes and also after the materials are commercially available, extensive material characterization programs must be conducted to provide a database so that the end user of the material will have confidence in the performance of the material.

Developing test methods and generating design data for materials which will be used in thermomechanical environments is extremely expensive. High-temperature composite materials cost much more than homogenous materials or standard resin matrix composites. Equipment for testing at elevated temperature is highly specialized and very expensive. Specialized test methods must be developed which take into consideration thermal stresses, stress gradients, measurement capabilities, gripping methods and limited material quantities. It is therefore important that test methods be carefully developed and standardized so that accurate data are generated and duplication of test data is avoided in test programs.

The papers contained in this proceedings provide current results of research and development programs on ceramic and metal matrix composites. The papers are divided into four categories:

1. Analysis and Modeling
2. Behavior of Ceramic Matrix Composites

3. Behavior of Metal Matrix Composites
4. Test Methods

The sections include papers which address both continuous and discontinuous ceramic and metal matrix composites. The Analysis and Modeling section includes papers on plasticity analysis of composite laminates during thermomechanical loading, micromechanical stress analysis of continuous reinforced metal matrix composites, creep models for discontinuous and laminated metal matrix composites, and simulation of the cyclic behavior of metal matrix composites. The section on Behavior of Ceramic Matrix Composites includes papers on fracture of whisker reinforced ceramic composites, mechanical characterization of ceramic fibers, frictional stresses at the fiber/matrix interface of ceramic composites, and mechanical behavior of selected ceramic matrix composites. The papers in the section on Behavior of Metal Matrix Composites address mechanical and thermal behavior of continuous and discontinuous reinforced metal matrix composites. Experimental results were reported from static and fatigue tension test programs as well as fracture studies. Another paper presented an indentation test method to derive the optimal manufacturing process of metal matrix composites. The paper included in the section on Test Methods addressed specific test methods and experimental hardware which may be applied to either ceramic or metal matrix composites.

With this symposium and the resulting special technical publication, ASTM has made another stride forward by providing a wealth of information on ceramic and metal matrix composites which will assist the research and design community in better understanding the behavior of these materials. This information will be also invaluable as test methods are developed for ceramic and metal matrix composites.

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