Thermal and Mechanical Test Methods and Behavior of Continuous-Fiber Ceramic Composites

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Foreword

This publication, *Thermal and Mechanical Test Methods and Behavior of Continuous-Fiber Ceramic Composites,* contains papers presented at the symposium of the same name held in Cocoa Beach, Florida on 8-9 Jan. 1996. The symposium was sponsored by ASTM Committee C28 on Advanced Ceramics, ASTM Committee E08 on Fatigue and Fracture, and the American Ceramic Society, Engineering Ceramics Division. Michael G. Jenkins, University of Washington, Edgar Lara-Curzio, Oak Ridge National Laboratory, Stephen T. Gonczy, Gateway Materials Technology, Noel E. Ashbaugh, University of Dayton Research Institute, and Larry P. Zawada, Wright Laboratory, presided as symposium cochairmen and are also the editors of the resulting publication.

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Overview

In the ten years since its establishment in 1986, ASTM Committee C28 on Advanced Ceramics has provided a major forum for promoting standardized terminology, guides, classifications, practices, and test methods for advanced (namely, structural, fine, and technical) ceramics. Similarly, for the past 30 or more years, ASTM Committee E08 on Fatigue and Fracture and its predecessors have been involved in fracture and fatigue activities, both in developing standards and transferring information primarily for metallic materials, but also in advanced and newly emerging materials such as advanced ceramics. The American Ceramic Society for over 100 years has promoted, educated, disseminated, and conferred on a variety of topics related to ceramic materials including processing, manufacturing, characterizing, and utilizing.

This publication and the Symposium on Thermal and Mechanical Test Methods and Behavior of Continuous-Fiber Ceramic Composites, which was held in Cocoa Beach, Florida, 8–9 Jan. 1996, were cosponsored by these organizations to continue all their past efforts. Twenty-six papers were presented at the symposium, and this publication contains nineteen peer-reviewed articles on a special subset of advanced ceramics: continuous-fiber ceramic composites.

The advancement of technology is often limited by the availability and understanding of materials. In today's technology, the U.S. Government is currently supporting programs such Enabling Propulsion Materials and the Continuous Fiber Ceramic Composite (CFCCs) programs that target specific new materials such as CFCCs for a broad range of applications from chemical processing to stationary heat engines to power generation to aerospace vehicles. Such applications require that still-emerging materials such as CFCCs be refined, processed, characterized, and manufactured in sufficient volume for successful widespread use under the proposed aggressive thermal/mechanical operating conditions. Concurrently, as the materials are refined, designers must have access to material properties and performance databases to integrate the material systems into their advanced engineering concepts. Without extensive materials characterization, producers of materials cannot evaluate relative process improvements nor can designers have confidence in the performance of the material for a particular application.

Developing and verifying appropriate test methods as well as generating design data for advanced materials is expensive and time-consuming. High-temperature ceramic composites cost more to process than monolithic ceramics because of both the cost of constituent materials in addition to extra, labor-intensive fabrication steps. Equipment for testing at elevated temperatures is highly specialized and expensive. Unique and novel test methods must be developed to take into account thermal stresses, stress gradients, measurement capabilities, gripping methods, environmental effects, statistical considerations, and limited material quantities. It is therefore imperative that test methods be carefully developed, standardized, verified, and used so that accurate data are generated, and duplication of test data can be minimized in test programs.

The papers in this STP provide current results of research and development programs on continuous-fiber ceramic composites. The papers are divided into five categories:

(1) Room-Temperature Test Results/Methods,
(2) High-Temperature Test Results/Methods,

(3) Nondestructive Characterization,
(4) Modeling and Processing, and
(5) Testing of Tubes.

In the different sections, various types of continuous-fiber ceramic composites including those processed with chemically infiltrated, polymer-impregnated, sintered, melt-infiltrated, or viscous glass-infiltrated matrices are addressed. The Room-Temperature Test Results/Methods section includes papers on the influence of various test parameters on the tensile behavior, high-strain rate effects on tensile behavior, shear properties, and unloading-reloading sequences and their effects. The section on High-Temperature Test Results/Methods includes papers on the effect of hold times on fatigue behavior, high-temperautre crack growth, tensile and fatigue at a particular temperature, fatigue crack growth, creep rupture behavior, and retained tensile properties after exposure to elevated temperatures. In the Nondestructive Characterization section, the characterization of damage progression using an integrated testing system, an infrared-based method for determining thermal properties and defects, and measurements of orthotropic properties using impulse resonance are addressed. In the section on Modeling and Processing, papers are included on optimal design of laminates, modeling of creep response, and the secondary processing effects of abrasive water jet cutting. The section on Testing of Tubes includes burner rig testing of a hoop subelement.

With this symposium and the resulting STP, ASTM has made another stride forward by providing a wealth of information on continuous-fiber ceramic composites that will assist the research, processing, and design community in better understanding the behavior of these materials. This information will also be invaluable as test methods continue to be developed and verified for continuous-fiber ceramic matrix composites.

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