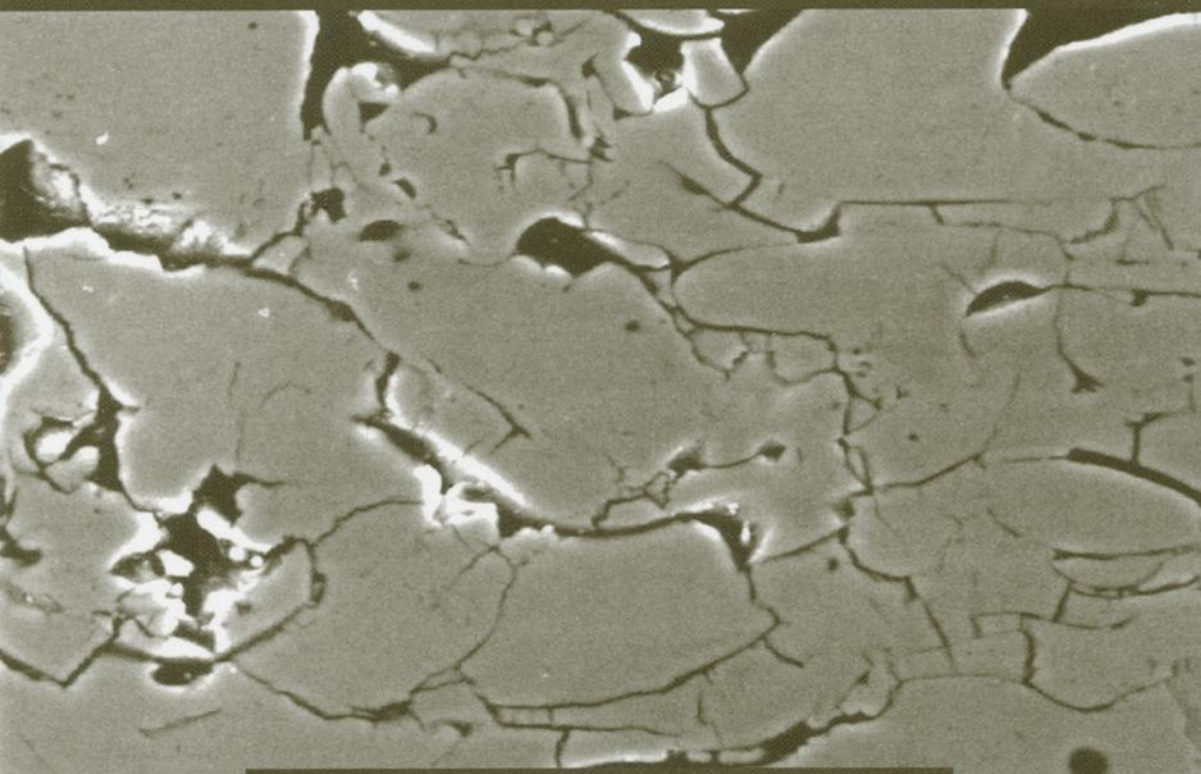
Fatigue and Fracture Mechanics

31st Volume



Gary R. Halford and
Joseph P. Gallagher, editors

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Foreword

This publication, *Fatigue and Fracture Mechanics, 31st Volume,* contains papers presented at the symposium of the same name held in Cleveland, Ohio, on 21-24 June 1999. The symposium was sponsored by ASTM Committee E08 on Fatigue and Fracture. The symposium co-chairmen were Gary R. Halford, NASA Glenn Research Center at Lewis Field, Cleveland, OH, and Joseph P. Gallagher, University of Dayton Research Institute, Dayton, OH.

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Overview

The Thirty-First National Symposium on Fatigue and Fracture Mechanics sponsored by ASTM Committee E08 on Fatigue and Fracture was held in Cleveland, Ohio, June 21-24, 1999. Papers were solicited in several broad subject areas:

- advances in analysis and predictive capability
- behavior of new and emerging materials
- design tools and approaches to control failures
- accelerated testing involving interactions
- assessment of the risk and remaining durability of aging systems
- integrity and durability in a range of industrial applications

Twenty-nine papers were accepted for publication in this volume. They represent a wide range of fatigue- and fracture-related topics. In addition to the contributions from the United States, papers were also contributed from Japan, Korea, Germany, Australia, and Canada. Half of the papers came from universities, while the other half were divided between industry and government.

Following the **Jerry Swedlow Memorial Lecture,** given this year by Professor Norman E. Dowling of Virginia Polytechnic Institute and State University, Blacksburg, the ensuing papers are arranged into four sections: **Keynote Tributes to George Irwin, Cyclic Stress-Strain and Fatigue Resistance, Elastic-Plastic Fracture Mechanics,** and **Crack Analyses and Application to Structural Integrity.**

Professor Dowling's paper addresses the undergraduate educational needs in the area of fatigue and fracture. Rather than rely on standard information presented in material science courses (e.g., Goodman curves and knock-down factors), Dowling suggests that the educator should provide a better introduction to all the modern methods that an engineer must use to attack typical mechanical failure problems.

Dr. James C. Newman, Jr. and Professor John D. Landes provided **Keynote Tributes to George Irwin.** Their papers summarize some of the most important contributions of Dr. George R. Irwin, the father of modern fracture mechanics, who passed away in October 1998. The papers recognize Dr. Irwin's vision and wisdom along with a description of his attempts to develop and gain technical acceptance for understanding the conditions that controlled fracture behavior using the concepts of similitude of the local crack tip conditions and a crack tip stress model. The authors also remember this scientist, educator, and practitioner as a gentle and generous man.

The **Cyclic Stress-Strain and Fatigue Resistance** section consists of a half dozen papers, each providing experimental or analytical insight into approaches for the evaluation of the cyclic durability resistance of engineering materials. Among the issues addressed are: (a) multiaxiality of stress-strain states and how to track cycles and damage accumulation under generalized or specific loading conditions; (b) correlation and evaluation of the influences of primary metallurgical processing variables on the low-cycle fatigue crack initiation and growth resistance of a powder metallurgy gas turbine disk alloy; (c) an analytical technique for computing welding residual stress based on use of eigenstrain distributions following nondestructive removal of weld reinforcement; and (d) experimental evaluation and analytical modeling of the non-linear cyclic stress-strain response of anisotropic porous ceramics such as used in thick thermal barrier coatings for high-temperature turbine components.

In the section on **Elastic-Plastic Fracture Mechanics** (EPFM), eight papers make substantial contributions to our understanding of how best to apply this technology to low-

strength structural materials used in most civil, oceanographic, power plant, and automotive applications. The papers cover topics that: (a) expand the application of analytical methods to stable crack tearing; (b) provide justification for changing the size requirements in ASTM Standard E-1820; (c) identify the level of constraint associated with surface flaw cracks; (d) extend the application of the slice synthesis technique to estimate elastic-plastic behavior by using a strip yield model; (e) develop a procedure for using uniaxially loaded crack data to predict the behavior of shallow surface flaws subjected to biaxial loading conditions; (f) adapt a time-temperature model for crack tip stresses to estimate fracture initiation behavior under dynamic loading conditions; (g) develop a scheme for removing notch root radius bias from apparent fracture toughness estimates generated using non-precracked notched round bar specimens; and (h) present a physics-based understanding of the fracture behavior of pressure vessel steels, respectively.

In the section on **Crack Analyses and Application to Structural Integrity,** twelve papers provide information on advances in crack analyses, fatigue crack growth behavior, and structural applications. The first three papers provide advances in crack analysis methods for non-self similar and branching cracks, for Greens Functions for arbitrary-shaped internal flaws, and for finite element methods used to characterize complex cracks, respectively. The next four papers focus on fatigue crack growth behavior and address: (a) the growth of cracks in compressor disks, (b) models for time-dependent retardation at high temperature, (c) the influence of stress history on the fatigue crack growth rate threshold, and (d) accelerated test methods for generating fatigue crack growth rate threshold data using surface flaw specimens. The final five papers in this section focus primarily on applications. These application papers discuss: (a) approaches to establishing the fatigue strength of weld repairs to an overhead crane, (b) a cohesive zone model for describing thin sheet aluminum alloy fracture behavior for aircraft fuselage structure, (c) a crack tip opening angle (CTOA) model for determining the residual strength of a typical aircraft fuselage riveted joint when multiple site damage (MSD) is present, (d) modeling parameters associated with bonded repairs of fuselage structure, and (e) effects of moisture on the durability of adhesively bonded joints constructed from wood and composite materials.

Cash prizes for the two best student papers were awarded to Stephanie TerMaath of Cornell University, Ithaca, and Ed Rejda of the University of Illinois at Urbana-Champaign. Thanks go to judges Drs. John Landes, Mike Mitchell, Bob Van Stone, Ravi Chona, and Jim Newman.

The efforts of the authors, manuscript reviewers, session chairs, and Robert "Jim" Goode of the Committee on Publications are greatly appreciated. The staff of ASTM must also be recognized for their untiring contributions to making the symposium and this volume a professional success. In particular, the valued assistance of Dorothy Savini, Eileen Gambetta, Bode Buckley, Kathy Dernoga, Helen Mahy, and Hanna Sparks is greatly appreciated.

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