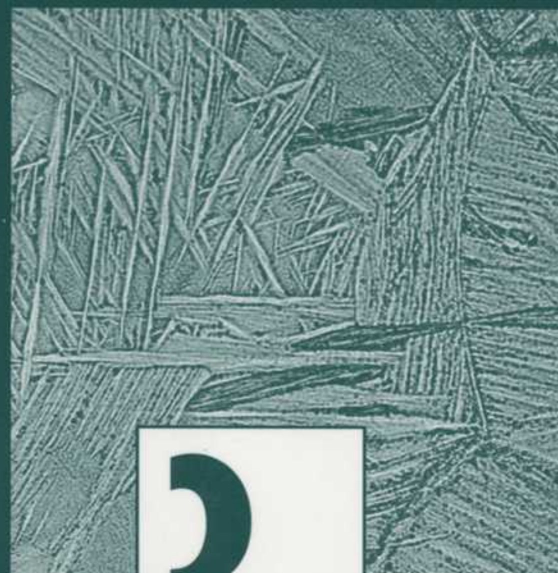
Advances in Fatigue Lifetime Predictive Techniques



3rd volume

M. R. MITCHELL
R. W. LANDGRAF
editors

ASTM STP 1292

STP 1292

Advances in Fatigue Lifetime Predictive Techniques: 3rd Volume

M. R. Mitchell and R. W. Landgraf, editors

ASTM Publication Code Number (PCN):
04-012920-30

ASTM
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959

Printed in the U.S.A.

Library of Congress Cataloging-in-Publication Data

ISSN: 1070-1079
ASTM Publication Code Number (PCN): 04-012920-30
ISBN: 0-8031-2029-X

Peer Review Policy

Each paper published in this volume was evaluated by three peer reviewers. The authors addressed all of the reviewers' comments to the satisfaction of both the technical editor(s) and the ASTM Committee on Publications.

The quality of the papers in this publication reflects not only the obvious efforts of the authors and the technical editor(s), but also the work of these peer reviewers. The ASTM Committee on Publications acknowledges with appreciation their dedication and contribution to time and effort on behalf of ASTM.

Printed in Ann Arbor, MI
January 1996

Foreword

This publication, *Advances in Fatigue Lifetime Predictive Techniques: 3rd Volume,* contains papers presented at the Third Symposium on Advances in Fatigue Lifetime Predictive Techniques, which was held in Montreal, Quebec on 16–17 May 1994. The symposium was sponsored by ASTM Committee E-08 on Fatigue and Fracture and by Subcommittee E08.05 on Cyclic Deformation and Fatigue Crack Formation. Symposium co-chairmen were M. R. Mitchell, Rockwell Science Center, Thousand Oaks, CA, and R. W. Landgraf, Virginia Polytechnic Institute and State University, Blacksburg, VA.

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Overview

This volume, the third in a series on fatigue lifetime predictive techniques [see *ASTM STP 1122* (1991) and *STP 1211* (1993)], continues the tradition of providing a cross-disciplinary forum bringing together researchers and practitioners representing industry, universities, and government for the purpose of sharing knowledge and experiences associated with the important technological issue of understanding and controlling fatigue failures in components and structures. With the continuing trends toward structural weight reduction, performance optimization, and the application of tailored materials and structural elements, fatigue analysis has become an integral part of engineering design. Indeed, the availability of reliable life prediction methods can prove invaluable in developing durable products more quickly and at lower cost—issues of considerable concern for achieving global competitiveness.

As in past volumes, topical coverage among the 17 papers is broad and includes treatment of fundamental fatigue mechanisms as well as the development and application of fatigue design and analysis strategies. Composite materials continue to command the attention of researchers. The first two papers deal with the complexities of metal matrix composites exposed to combined mechanical and thermal environments. Neu and Nicholas present two analysis methods that account for multiple failure mechanisms as influenced by frequency, temperature, phasing, and environmental kinetics. Tamin and Ghonem discuss a combined analytical-experimental approach for studying cyclic and creep loading with emphasis on strain compatibility and the development and stability of thermal residual stresses.

The paper by Strait et al. explores thermo-mechanical fatigue in polymer matrix composites demonstrating the significant effect of level of constraint on system response and damage development. Elastomer composites are the subject of the paper by Liu and Lee in which a variety of nondestructive methods for detecting damage are evaluated.

Damage mechanics is another active area of research. Two papers deal with general computational fracture mechanics methods for life prediction. Chow and Wei extend a two-damage surface model in conjunction with finite element analysis to predict crack propagation in aluminum plates. Energy concepts are employed by Chang et al. to develop a general method for predicting crack initiation and growth using only uniaxial tensile data.

Crack initiation and growth at notches is the subject of papers by Hou and Lawrence, and Prakash et al. The first treatment involves a plasticity modified strip-yield model to account for the observed crack growth retardation following an overload. The second paper, employing fractographic and replication techniques to chart cracking behavior under spectrum loading, presents a growth model allowing for interaction of multiple cracks. In an experimental investigation of crack growth from a surface flaw under biaxial stress cycling, Zamrik and Ryan quantify the effect of biaxial ratio and a transition from Mode I to Mode II crack growth.

Microstructural effects on fatigue cracking behavior is the subject of the next two papers. Hardy investigates short crack behavior in a near α-titanium with emphasis on the early, microstructure-dependent behavior for which LEFM is not applicable and presents a two-stage empirical model that includes crack opening loads and identifies critical crack sizes above which fracture mechanics techniques do apply. Evans et al. likewise deal with a titanium alloy in developing a comprehensive database approach to component life estimation that considers microstructural interactions and local plasticity in establishing an initial flaw size for calculations.

The final set of papers highlight the development and application of design methods for dealing with fatigue in components and structures. Bunch et al. detail the fatigue analysis methods used during the design and development of the B-2 bomber, while Sundar and Prakash consider lug joint performance under spectrum loading. Sheppard presents a continuation of her work on spot weld fatigue, extending the range of applicability to a variety of specimen types and notch profiles, including those subjected to post-weld treatments, and to the development of guidelines for selective thickening. Fatigue of coiled tubing, as used in oil drilling, is the subject of Tipton's paper in which he develops a damage parameter based on multiaxial plasticity analysis to predict combined pressurization and coiling events.

Reliability methods are employed by Kliman et al. to compute fatigue life distribution functions under time-varying loading sequences. Finally, the paper by Kalluri et al. addresses the often important influence of prestraining of components, as a result of manufacturing or service overstrains, on damage accumulation.

Taken as a whole, the papers in this volume provide ample evidence that important progress continues in our efforts to better understand and, hence, to control fatigue failure in a range of engineering structures. There is a clear trend among researchers toward confronting the many complexities of "real world" material systems, structural configurations, and service environments in arriving at more powerful tools for fatigue design and analysis. Further, the transfer of this new technology to engineering practice, long a challenge, appears to be proceeding in a timely manner. It is the derived practical benefits from past research efforts that provide an important impetus for further studies.

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ISBN 0-8031-2029-X