Fatigue And Fracture Mechanics

Thematerialsusedinmanufacturingtheaerospace,aircraft,automobile,andnuclear parts have inherent aws that may grow under uctuating load environments during the operational phase of the structural hardware. The design philosophy, material selection, analysis approach, testing, quality control, inspection, and manufacturing are key elements that can contribute to failure prevention and assure a trouble-free structure. To have a robust structure, it must be designed to withstand the envir- mental load throughout its service life, even when the structure has pre-existing aws or when a part of the structure has already failed. If the design philosophy of the structure is based on the fail-safe requirements, or multiple load path design, partial failure of a structural component due to crack propagation is localized and safely contained or arrested. For that reason, proper inspection technique must be scheduled for reusable parts to detect the amount and rate of crack growth, and the possible need for repairing or replacement of the part. An example of a fail-sa- designed structure with crack-arrest feature, common to all aircraft structural parts, is the skin-stiffened design con guration. However, in other cases, the design p- losophy has safe-life or single load path feature, where analysts must demonstrate that parts have adequate life during their service operation and the possibility of catastrophic failure is remote. For example, all pressurized vessels that have single load path feature are classi ed as high-risk parts. During their service operation, these tanks may develop cracks, which will grow gradually in a stable manner.

On Fracture Mechanics A major objective of engineering design is the determination of the geometry and dimensions of machine or structural elements and the selection of material in such a way that the elements perform their operating function in an efficient, safe and economic manner. For this reason the results of stress analysis are coupled with an appropriate failure criterion. Traditional failure criteria based on maximum stress, strain or energy density cannot adequately explain many structural failures that occurred at stress levels considerably lower than the ultimate strength of the material. On the other hand, experiments performed by Griffith in 1921 on glass fibers led to the conclusion that the strength of real materials is much smaller, typically by two orders of magnitude, than the theoretical strength. The discipline of fracture mechanics has been created in an effort to explain these phenomena. It is based on the realistic assumption that all materials contain crack-like defects from which failure initiates. Defects can exist in a material due to its composition, as second-phase particles, debonds in composites, etc. , they can be introduced into a structure during fabrication, as welds, or can be created during the service life of a component like fatigue, environment-assisted or creep cracks. Fracture mechanics studies the loading-bearing capacity of structures in the presence of initial defects. A dominant crack is usually assumed to exist.

This book introduces the field of fracture mechanics from an applications viewpoint. Then it focuses on fitness for service, or life extension, of existing structures. Finally, it provides case studies to allow the practicing professional engineer or student to see the applications of fracture mechanics directly to various types of structures.

Fracture and Fatigue Control in Structures

37th Volume

Applications of Fracture Mechanics

Fracture Mechanics

Advances in Fatigue and Fracture Mechanics Analyses for Metallic Aircraft Structures

Fatigue and Fracture of Weldments

Micromechanisms of Fracture and Fatigue forms the culmination of 20 years of research in the field of fatigue and fracture. It discusses a range of topics and comments on the state of the art for each. The first part is devoted to models of deformation and fracture of perfect crystals. Using various atomistic methods, the theoretical strength of solids under simple and complex loading is calculated for a wide range of elements and compounds, and compared with experimental data. The connection between the onset of local plasticity in nanoindentation tests and the ideal shear strength is analysed using a multi-scale approach. Moreover, the nature of intrinsic brittleness or ductility of perfect crystal lattices is demonstrated by the coupling of atomistic and mesoscopic approaches, and compared with brittle/ductile behaviour of engineering materials. The second part addresses extrinsic sources of fracture toughness of engineering materials, related to their microstructure and microstructurally-induced crack tortuosity. Micromechanisms of ductile fracture are also described, in relation to the fracture strain of materials. Results of multilevel modelling, including statistical aspects of microstructure, are used to explain remarkable phenomena discovered in experiments. In the third part of the book, basic micromechanisms of fatigue cracks propagation under uniaxial and multiaxial loading are discussed on the basis of the unified mesoscopic model of crack tip shielding and closure, taking both microstructure and statistical effects into account. Applications to failure analysis are also outlined, and an attempt is made to distinguish intrinsic and extrinsic sources of materials resistance to fracture. Micromechanisms of Fracture and Fatigue provides scientists, researchers and postgraduate students with not only a deep insight into basic micromechanisms of fracture behaviour of materials, but also a number of engineering applications.

Second part of the proceedings of the Sixth International Symposium held in Karlsruhe, Germany, July 18-20, 1995.

Mechanics of Fatigue addresses the range of topics concerning damage, fatigue, and fracture of engineering materials and structures. The core of this resource builds upon the synthesis of micro- and macro-mechanics of fracture. In micromechanics, both the modeling of

mechanical phenomena on the level of material structure and the continuous approach are based on the use of certain internal field parameters characterizing the dispersed micro-damage. This is referred to as continuum damage mechanics. The author develops his own theory for macromechanics, called analytical fracture mechanics. This term means the system cracked body - loading or loading device - is considered as a mechanical system and the tools of analytical (rational) mechanics are applied thoroughly to describe crack propagation until the final failure. Chapter discuss: preliminary information on fatigue and engineering methods for design of machines and structures against failures caused by fatigue fatigue crack nucleation, including microstructural and continuous models theory of fatigue crack propagation fatigue crack growth in linear elastic materials subject to dispersed damage fatigue cracks in elasto-plastic material, including crack growth retardation due to overloading as well as quasistationary approximation fatigue and related phenomena in hereditary solids application of the theory fatigue crack growth considering environmental factors unidirectional fiber composites with ductile matrix and brittle, initially continuous fibers laminate composites Mechanics of Fatigue serves students dealing with mechanical aspects of fatigue, conducting research in fracture mechanics, structural safety, mechanics of composites, as well as modern branches of mechanics of solids and structures.

Current Status, Future Prospects

Fundamentals and Applications, Third Edition

Fundamentals of Fatigue and Fracture Mechanics

Thermomechanical Fatigue and Fracture

Including an Introduction to Fatigue

Fracture Mechanics of Ceramics

Failures of many mechanical components in service result from fatigue. The cracks which grow may either originate from some pre-existing macroscopic defect, or, if the component is of high integrity but highly stressed, a region of localized stress concentration. In turn, such concentrators may be caused by some minute defect, such as a tiny inclusion, or inadvertent machining damage. Another source of surface damage which may exist between notionally 'bonded' components is associated with minute relative motion along the interface, brought about usually be cyclic tangential loading. Such fretting damage is quite insidious, and may lead to many kinds of problems such as wear, but it is its influence on the promotion of embryo cracks with which we are concerned here. When the presence of fretting is associated with decreased fatigue performance the effect is known as fretting fatigue. Fretting fatigue is a subject drawing equally on materials science and applied mechanics, but it is the intention in this book to concentrate attention entirely on the latter aspects, in a search for the quantification of the influence of fretting on both crack nucleation and propagation. There have been very few previous texts in this area, and the present volume seeks to cover five principal areas; (a) The modelling of contact problems including partial slip under tangentialloading, which produces the surface damage. (b) The modelling of short cracks by rigorous methods which deal effectively with steep stress gradients, kinking and closure. (c) The experimental simulation of fretting fatigue.

This book presents the proceedings of one of the major conferences in fatigue, fracture and structural integrity (NT2F). The papers are organized and divided in five different themes: fatigue and fracture mechanics of structures and advanced materials; fatigue and fracture in pressure vessels and pipelines: mechanical behavior and structural integrity of welded, bonded and bolted joints; residual stress and environmental effects on the fatigue behavior; and simulation methods, analytical and computation models in fatigue and fracture.

With its combination of practicality, readability, and rigor that is characteristic of any truly authoritative reference and text, Fracture Mechanics: Fundamentals and Applications quickly established itself as the most comprehensive guide to fracture mechanics available. It has been adopted by more than 100 universities and embraced by thousands of professional engineers worldwide. Now in its third edition, the book continues to raise the bar in both scope and coverage. It encompasses theory and applications, linear and nonlinear fracture mechanics, solid mechanics, and materials science with a unified, balanced, and in-depth approach. Reflecting the many advances made in the decade since the previous edition came about, this indispensable Third Edition now includes: A new chapter on environmental cracking Expanded coverage of weight functions New material on toughness test methods New problems at the end of the book New material on the failure assessment diagram (FAD) method Expanded and updated coverage of crack closure and variable-amplitude fatigue Updated solutions manual In addition to these enhancements, Fracture Mechanics: Fundamentals and Applications, Third Edition also includes detailed mathematical derivations in appendices at the end of applicable chapters; recent developments in laboratory testing, application to structures, and computational methods; coverage of micromechanisms of fracture; and more than 400 illustrations. This reference continues to be a necessity on the desk of anyone involved with fracture mechanics.

A Symposium

30th Volume

Fatigue and Fracture Mechanics of High Risk Parts

Basic Fracture Mechanics

Mechanics and Mechanisms of Fracture

31st Volume

The seventh Jerry L. Swedlow Memorial Lecture presents a review of some of the technical developments, that have occurred during the past 40 years, which have led to the merger of fatigue and fracture mechanics concepts. This review is made from the viewpoint of 'crack propagation.' As methods to observe the 'fatigue' process have improved, the formation of fatigue micro-cracks have been observed earlier in life and the measured crack sizes have become smaller. These observations suggest that fatigue damage can now be characterized by 'crack size.' In parallel, the crack-

growth analysis methods, using stress-intensity factors, have also improved. But the effects of material inhomogeneities, crack-fracture mechanisms, and nonlinear behavior must now be included in these analyses. The discovery of crack-closure mechanisms, such as plasticity, roughness, and oxide/corrosion/fretting product debris, and the use of the effective stress-intensity factor range, has provided an engineering tool to predict small- and large-crack-growth rate behavior under service loading, conditions. These mechanisms have also provided a rationale for developing, new, damage-tolerant materials. This review suggests that small-crack growth behavior should be viewed as typical behavior, whereas large-crack threshold behavior should be viewed as the anomaly. Small-crack theory has unified 'fatigue' and 'fracture mechanics' concepts; and has bridged the cap between safe-life and durability/damage-tolerance design concepts. Newman, James C., Jr. Langley Research Center...

This book provides a comprehensive and thorough guide to those readers who are lost in the often-confusing context of weld fatigue. It presents straightforward information on the fracture mechanics and material background of weld fatigue, starting with fatigue crack initiation and short cracks, before moving on to long cracks, crack closure, crack growth and threshold, residual stress, stress concentration, the stress intensity factor, J-integral, multiple cracks, weld geometries and defects, microstructural parameters including HAZ, and cyclic stress-strain behavior. The book treats all of these essential and mutually interacting parameters using a unique form of analysis.

Fracture, Fatigue, Failure and Damage Evolution, Volume 7 of the Proceedings of the 2017 SEM Annual Conference & Exposition on Experimental and Applied Mechanics, the seventh volume of nine from the Conference, brings together contributions to this important area of research and engineering. Session organizers include: Jay Carroll, Shuman Xia, Allison Beese, Ryan Berke, Garrett Pataky, Samantha Daly, Kavan Hazeli, Antonios Kontsos, Omer Ozgur Capraz, Scott Grutzik, Onome Scott-Emaukpor The collection presents early findings and case studies on a wide range of areas, including: Mechanics of Energy & Energetic Materials Vibration Effects in Fracture & Fatigue Fracture & Fatigue of Additively Manufactured Materials In Situ Techniques for Fatigue & Fracture Microscale & Microstructural Effects on Mechanical Behavior Fracture & Fatigue of Composites Integration & Validation of Models with Experiments Fracture & Fatigue in Extreme Environments Novel Experimental Methods for Fatigue and Fracture Fracture of Brittle & Ductile Materials Interfacial Fracture

The IBESS Approach for the Determination of the Fatigue Life and Strength of Weldments by Fracture Mechanics Analysis

34th Volume

Micromechanisms of Fracture and Fatigue

36th Volume

Mechanics of Fatigue

This book presents the proceedings of Fatigue Durability India 2016, which was held on September 28–30 at J N Tata Auditorium, Indian Institute of Science, Bangalore. This 2nd International Conference & Exhibition brought international industrial experts and academics together on a single platform to facilitate the exchange of ideas and advances in the field of fatigue, durability and fracture mechanics and its applications. This book comprises articles on a broad spectrum of topics from design, engineering, testing and computational evaluation of components and systems for fatigue, durability, and fracture mechanics. The topics covered include interdisciplinary discussions on working aspects related to materials testing, evaluation of damage, nondestructive testing (NDT), failure analysis, finite element modeling (FEM) analysis, fatigue and fracture, processing, performance, and reliability. The contents of this book will appeal not only to academic researchers, but also to design engineers, failure analysts, maintenance engineers, certification personnel, and R&D professionals involved in a wide variety of industries.

This text covers the leading research, in computational methods and experimental measurements, in thermal and mechanical fatigue problems. One of the fracture problems found in engineering components, such as pressure vessels, high temperature engines and interfaces in computer technology.

This paper reviews some of the advances that have been made in stress analyses of cracked aircraft components, in the understanding of the fatigue and fatigue-crack growth process, and in the prediction of residual strength of complex aircraft structures with widespread fatigue damage. Finite-element analyses of cracked metallic structures are now used to determine accurate stress-intensity factors for cracks at structural details. Observations of small-crack behavior at open and rivet-loaded holes and the development of small-crack theory has lead to the prediction of stress-life behavior for components with stress concentrations under aircraft spectrum loading. Fatigue-crack growth under simulated aircraft spectra can now be predicted with the crack-closure concept. Residual strength of cracked panels with severe out-of-plane deformations (buckling) in the presence of stiffeners and multiple-site damage can be predicted with advanced elastic-plastic finite-element analyses and the critical crack-tip-opening angle (CTOA) fracture criterion. These advances are helping to assure continued safety of aircraft structures.Newman, J. C., Jr.Langley Research CenterAIRCRAFT STRUCTURES; CRACKS; FINITE ELEMENT METHOD; FRACTURE MECHANICS; STRESS ANALYSIS; METALS; CRACK PROPAGATION; METAL FATIGUE; STRESS INTENSITY FACTORS; RESIDUAL STRENGTH; CRACK CLOSURE; DAMAGE; STRESS CONCENTRATION; RIVETED JOINTS; PLASTIC PROPERTIES

Fracture, Fatigue, Failure and Damage Evolution, Volume 7

Fracture and Fatigue in Wood

33rd Volume

The Merging of Fatigue and Fracture Mechanics Concepts

For Fatigue and Fracture Mechanics Allowables
Fatigue and Fracture Mechanics of Offshore Structures

Etube (mechanical engineering, University College London) presents novel research and the results of wave-induced stress on the operational life of offshore structures. Using the results of an investigation undertaken to assess the fatigue and fracture performance of steels used in the industry, the five chapters discuss details of the methodology to develop a typical jack-up offshore standard load history (JOSH); factors that influence fatigue resistance of structural steels used in the construction of jack-up structures; methods used to model the relevant factors for inclusion in JOSH, with emphasis on loading and structural response interaction; results and details of experimental variable amplitude corrosion fatigue tests conducted using JOSH; and a novel generalized methodology for fast assessment of offshore structural welded joints. Distributed by ASME. c. Book News Inc.

Fracture Mechanics: Current Status, Future Prospects presents the remarkable increase in the number of tools available for engineers to deal with cracked structures in a quantitative manner. This book discusses the acceptance of the stress intensity factor as a distinguishing similitude parameter that properly accounts for the applied mechanics near crack tips in several cases of practical interest. Organized into nine chapters, this book begins with an overview of the competing micromechanics of fracture, including cleavage, rupture, ductile fracture, and intergranular creep fracture. This text then reviews the characterization of crack tip stress fields by the stress intensity factor. Other chapters consider the analysis of fatigue cracking in a large generator rotor. This book discusses as well the use of Green's functions in the determination of stress intensity factors. The final chapter deals with the size effect with regard to extension of sharp cracks in technological materials. This book is a valuable resource for environmental and mechanical engineers.

The application of methods of fracture mechanics to the prediction of fatigue life presupposes the existence of a single flaw of 'critical' size the slow propagation of which, under repeated cyclic loading, represents the relevant damage mechanism that governs 'fatigue' until the flaw has grown to unstable size. The conditions under which this approach to fatigue provides a reasonable model of real behavior are, however, exactly the conditions that should be avoided by adequate fatigue design. Thus the merit of fracture mechanics with respect to fatigue is not in the realistic modeling of the fatigue process in its various aspects, but in the delimitation of the conditions under which this process approaches the model too closely for purposes of design. The paper discusses the different aspects of the fatigue process in relation to the basic concepts of fracture mechanics. (Author).

Understanding the Basics
A Solution Guide
An Introduction
Application of LEFM & FMDM Theory
A Historical Perspective
Proceedings of the 17th International Conference on New Trends in Fatigue and Fracture

"This book emphasizes the physical and practical aspects of fatigue and fracture. It covers mechanical properties of materials, differences between ductile and brittle fractures, fracture mechanics, the basics of fatigue, structural joints, high temperature failures, wear, environmentally-induced failures, and steps in the failure analysis process."--publishers website.

The basic tenet of LEFM is that the stress intensity factor, K, is the key controlling parameter for fatigue crack growth and fast brittle fracture under monotonic loading. This research program examined whether or not this fundamental assumption formed an effective basis for an engineering technology. And, as needed, suggested directions for an improved technology. Keywords: Fatigue, Fracture, Mechanics. (JES).

Damage in wood is principally the result of fatigue. Fatigue is the process of progressive localised irreversible change in a material, and may culminate in cracks or complete fracture if conditions that initiated or propagated the process persist. Comprehensive understanding of fatigue and fracture in engineered wood components must be founded on a proper understanding of the damage processes. Although wood is the world's most widely used structural material, whether measured by volume consumed or value of finished construction, its behaviour is not well understood even by people who have spent their careers studying it. * What is known about failure processes comes almost entirely from empirical evidence collected for engineering purposes. * Hypotheses about behaviour of wood are based on macroscopic observation of specimens during and following tests. * With only limited resources and the need to obtain practical results quickly, the timber engineering research community has steered away from the scientific approach. * Forestry practices are changing and are known to influence characteristics of wood cells therefore there is a need to periodically reassess the mechanical properties of visually graded lumber the blackbox approach. Fatigue and Fracture of Wood examines the above issues

from a scientific point of view by drawing on the authors' own research as well as previously published material. Unlike the empirical research, the book begins by examining growth of wood. It briefly examines its structure in relation to how trees grow, before assessing the fatigue and fracture of wood and discussing the scientific methods of modelling fatigue. * Covers from macro to micro behaviour of wood * Presents direct evidence of how wood fractures using Scanning Electron Microscopy * The first book to present a physically correct model for fracture in wood * Provides experimental proof of so-called memory in wood (i.e. dependence of fatigue behaviour on the loading sequence) * Givse practical illustrations of how theories and models can be applied in practice An essential resource for wood scientists/engineers, timber-engineering practitioners, and graduate students studying wood and solid mechanics.

In a Multi-scale Context

Problems of Fracture Mechanics and Fatigue

Proceedings of the 2017 Annual Conference on Experimental and Applied Mechanics

Fatigue, Composites, and High-Temperature Behavior

38th Volume

Fatigue and Fracture

Problems of Fracture Mechanics and FatigueA Solution GuideSpringer Science & Business Media

BASIC Fracture Mechanics: Including an Introduction to Fatigue discusses the fundamentals of fracture and fatigue. The book presents a series of Beginner's All-purpose Symbolic Instruction Code (BASIC) programs that implement fracture and fatigue methods. The first chapter reviews the BASIC, while the second chapter covers elastic fracture. Chapter 3 deals with the stress intensity factors. The book also tackles the crack tip plasticity and covers crack growth. The last chapter in the text discusses some applications in fracture mechanics. The book will be of great use to engineers who want to get acquainted with fracture mechanics.

In the preliminary stage of designing new structural hardware that must perform a given mission in a fluctuating load environment, there are several factors the designers should consider. Trade studies for different design configurations should be performed and, based on strength and weight considerations, among others, an optimum configuration selected. The selected design must be able to withstand the environment in question without failure. Therefore, a comprehen sive structural analysis that consists of static, dynamic, fatigue, and fracture is necessary to ensure the integrity of the structure. During the past few decades, fracture mechanics has become a necessary discipline for the solution of many structural problems. These problems include the prevention of failures resulting from preexisting cracks in the parent material, welds or that develop under cyclic loading environment during the life of the structure. The importance of fatigue and fracture in nuclear, pressure vessel, aircraft, and aerospace structural hardware cannot be overemphasized where safety is of utmost concern. This book is written for the designer and strength analyst, as well as for the material and process engineer who is concerned with the integrity of the structural hardware under load-varying environments in which fatigue and frac ture must be given special attention. The book is a result of years of both acade mic and industrial experiences that the principal author and co-authors have accumulated through their work with aircraft and aerospace structures.

27th Volume

Twenty-ninth Volume

Proceedings of Fatigue, Durability and Fracture Mechanics

Mechanics of Fretting Fatigue

Fatigue and Fracture Mechanics

Case Histories Involving Fatigue and Fracture Mechanics