

Article

Using Direct Current Potential Drop Technique to Estimate Fatigue Crack Growth Rates in Solid Bar Specimens under Environmental Assisted Fatigue in Simulated Pressurized Water Reactor Conditions

Sergio Arrieta ^{1,*}, Francisco Javier Perosanz ², Jose Miguel Barcala ³, Maria Luisa Ruiz ⁴ and Sergio Cicero ¹ 

- ¹ LAD9CIM, Laboratory of Materials Science and Engineering, Universidad de Cantabria, E.T.S. de Ingenieros de Caminos, Canales y Puertos, Av./Los Castros 44, 39005 Santander, Spain
- ² Combustion and Gasification Division, Energy Department, Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), Avenida Complutense 40, 28040 Madrid, Spain
- ³ Scientific Instrumentation Division, Technology Department, Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), Avenida Complutense 40, 28040 Madrid, Spain
- ⁴ Advanced Biofuels and Bioproducts Unit, Energy Department, Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), Avenida Complutense 40, 28040 Madrid, Spain
- * Correspondence: sergio.arrieta@unican.es

Abstract: The direct current potential drop (DCPD) technique may be used in crack propagation tests to measure the crack growth rate (CGR). Potential probes attached to the specimen allow the variation of the crack length to be estimated. In this research, the DCPD technique using one single potential probe was applied to solid bar specimens (i.e., without any initial notch or crack) subjected to low-cycle fatigue testing in a simulated pressurized water reactor (PWR) environment. This particular analysis had two associated difficulties, the first one being the fact that crack initiation sites are not known beforehand, and the second one consisting in the experimental difficulties and conditioning factors associated with the simulation of the PWR environment. Nine solid bar specimens were tested to fatigue failure under different strain amplitudes and frequencies, while also measuring the corresponding DCPD signal during the fatigue process. It was observed that the initiation of multiple cracks was detected by the DCPD measurements. Moreover, as fatigue continued, one of the cracks became dominant and progressed to cause the specimen failure. The DCPD technique allowed the average CGR of the dominant crack to be estimated. Finally, the obtained average CGRs were validated by comparing them with average CGRs derived from striation spacing measurements, obtained from scanning electron microscopy (SEM) and from literature values gathered in the NUREG/CR-6909 document.

Keywords: direct current potential drop; fatigue; environmental assisted fatigue; crack growth rate; pressurized water reactor



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1. Introduction

The direct current potential drop (DCPD) technique is commonly used to measure the crack length in fatigue crack propagation tests [1,2]. Its use is particularly indicated for extensometric measurements in conductive materials tested in aggressive environments, where other conventional laboratory techniques cannot be used. Here, DCPD has been used in fatigue testing under simulated pressurized water reactor (PWR) conditions, at 300 °C and 150 bar, for the detection of crack initiation and growth.

The physical principle of this technique is based on Ohm's law and the corresponding evolution of the specimen resistance: the reduction of the cross-sectional area caused by the crack propagation is directly associated with an increase in the electrical resistance of the specimen. Moreover, the resulting potential drop is linked to a densification of the potential

Environment Assisted Fatigue

E.E. Gdoutos



Environment Assisted Fatigue:

Environment Assisted Fatigue (EGF 7) P. Scott, R. A. Cottis, 1990 Environment Assisted Fatigue or corrosion fatigue is a complex subject attracting researchers with backgrounds in chemistry metallurgy and mechanical engineering The conference held at Sheffield University in the Spring of 1988 in this subject was no exception to this multi disciplinary trait

Effects of the Environment on the Initiation of Crack Growth William Alan Van der Sluys, Robert S. Piascik, Robert Zawierucha, 1997 Comprehensive Structural Integrity Ian Milne, R. O. Ritchie, B.L. Karihaloo, 2003-07-25 The aim of this major reference work is to provide a first point of entry to the literature for the researchers in any field relating to structural integrity in the form of a definitive research reference tool which links the various sub disciplines that comprise the whole of structural integrity Special emphasis will be given to the interaction between mechanics and materials and structural integrity applications Because of the interdisciplinary and applied nature of the work it will be of interest to mechanical engineers and materials scientists from both academic and industrial backgrounds including bioengineering interface engineering and nanotechnology The scope of this work encompasses but is not restricted to fracture mechanics fatigue creep materials dynamics environmental degradation numerical methods failure mechanisms and damage mechanics interfacial fracture and nano technology structural analysis surface behaviour and heart valves The structures under consideration include pressure vessels and piping off shore structures gas installations and pipelines chemical plants aircraft railways bridges plates and shells electronic circuits interfaces nanotechnology artificial organs biomaterial prostheses cast structures mining and more Case studies will form an integral part of the work Environment Assisted Fatigue Crack Growth in Trip Steels Li-Chung Jea, 1974

Environment-sensitive Fracture S. W. Dean, E. Neville Pugh, G. M. Ugiansky, 1984 Engineering Fundamentals and Environmental Effects H. Liebowitz, 2014-05-12 Fracture An Advanced Treatise Volume III Engineering Fundamentals and Environmental Effects provides information pertinent to the engineering fundamentals and environmental effects pertaining to various types of fracture This book focuses on the fracture design of structures as well as the engineering fundamentals of fracture and environmental effects Organized into 12 chapters this volume begins with an overview of the analytical aspects of linear fracture mechanics which are complete relative to basic formulation and two dimensional static problems This text then reviews the fundamental equations of the statics of solids with emphasis on the idealization of behavior into elastic plastic or viscoelastic types Other chapters consider a notch analysis of fracture This book discusses as well the three phases of the fracture process The final chapter deals with environment cracking under static load This book is a valuable resource for engineers students and research workers in industrial organizations education and research institutions and various government agencies Hydrogen Embrittlement and Stress Corrosion Cracking Alexander Robert Troiano, Ronald Gibala, R. F. Hehemann, 1984-01-01 **Scientific and Technical Aerospace Reports**, 1989-07 **Basic Fracture Mechanics and its Applications** Ashok Saxena, 2022-12-27

This textbook provides a comprehensive guide to fracture mechanics and its applications providing an in depth discussion of linear elastic fracture mechanics and a brief introduction to nonlinear fracture mechanics It is an essential companion to the study of several disciplines such as aerospace biomedical civil materials and mechanical engineering This interdisciplinary textbook is also useful for professionals in several industries dealing with design and manufacturing of engineering materials and structures Beginning with four foundational chapters discussing the theory in depth the book also presents specific aspects of how fracture mechanics is used to address fatigue crack growth environment assisted cracking and creep and creep fatigue crack growth Other topics include mixed mode fracture and materials testing and selection for damage tolerant design alongside in depth discussions of ensuring structural integrity of components through real world examples There is a strong focus throughout the book on the practical applications of fracture mechanics It provides a clear description of the theoretical aspects of fracture mechanics and also its limitations Appendices provide additional background to ensure a comprehensive understanding and every chapter includes solved example problems and unsolved end of chapter problems Additional instructor support materials are also available

Gaseous Hydrogen Embrittlement of Materials in Energy Technologies Richard P Gangloff, Brian P Somerday, 2012-01-16 Many modern energy systems are reliant on the production transportation storage and use of gaseous hydrogen The safety durability performance and economic operation of these systems is challenged by operating cycle dependent degradation by hydrogen of otherwise high performance materials This important two volume work provides a comprehensive and authoritative overview of the latest research into managing hydrogen embrittlement in energy technologies Volume 1 is divided into three parts the first of which provides an overview of the hydrogen embrittlement problem in specific technologies including petrochemical refining automotive hydrogen tanks nuclear waste disposal and power systems and H₂ storage and distribution facilities Part two then examines modern methods of characterization and analysis of hydrogen damage and part three focuses on the hydrogen degradation of various alloy classes With its distinguished editors and international team of expert contributors Volume 1 of Gaseous hydrogen embrittlement of materials in energy technologies is an invaluable reference tool for engineers designers materials scientists and solid mechanicians working with safety critical components fabricated from high performance materials required to operate in severe environments based on hydrogen Impacted technologies include aerospace petrochemical refining gas transmission power generation and transportation Summarises the wealth of recent research on understanding and dealing with the safety durability performance and economic operation of using gaseous hydrogen at high pressure Reviews how hydrogen embrittlement affects particular sectors such as the petrochemicals automotive and nuclear industries Discusses how hydrogen embrittlement can be characterised and its effects on particular alloy classes *Hydrogen Embrittlement in Metals and Alloys* Pasquale Cavaliere, 2025-03-06 This book provides a complete description of hydrogen technologies from the basic theoretical underpinnings to the different production routes for various applications It summarizes the most recent

research findings with respect to theory and the broad array of industrial technologies currently in place as well as those under development with high potential Special attention is given to the hydrogen embrittlement mechanisms at room and high temperatures as well as problems related to hydrogen in liquid and high pressure compressed states The author further describes the hydrogen diffusion embrittlement issues related to different types of metallic materials from steel to light alloys to nickel based superalloys **Advances in Fracture Resistance and Structural Integrity** V.V. Panasyuk,M.C.

Pandey,O.Ye. Andreykiv,J.F. Knott,P. Rama Rao,R. O. Ritchie,D.M.R. Taplin,2012-12-02 The 8th International Conference on Fracture ICF8 held in Kyiv Ukraine attracted 550 delegates from 30 countries with over 700 papers presented This volume contains a representative selection of 72 articles of the highest standard from internationally renowned experts in the field Principal topics covered include mechanics and criteria of fracture stress strain analysis in solids with cracks physics and mechanics of fracture dynamic fracture environmental effects temperature influence on fracture advanced and special purpose materials engineering applications of fracture mechanics fracture mechanics and strength of welded joints and structures testing techniques and failure diagnostics For anyone working in fracture mechanics and the performance of materials this volume provides a valuable snapshot of the major recent developments in the field Mathematical Modelling of Weld Phenomena: No. 5 H. Cerjak,2024-12-20 Contains the papers presented at the fourth International Seminar

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