James Earthman - Research

Mechanical Behavior of Open Cellular Materials at Ambient and Elevated Temperatures

The goal of the present research is to develop a better understanding of the tensile response of open-cellular aluminum 6061 - T6 alloy. Both tensile and compression samples of this metallic foam were tested under constant strain rate conditions at 293, 423, and 523 K. Scanning electron microscopy was performed on individual struts to assess the modes and mechanisms associated with fracture. Theoretical models are being evaluated and developed which predict the behavior of the open cell structure from the mechanical properties of the fully dense alloy. Funded by a grant from the Department of Energy in collaboration with Lawrence Livermore National Laboratory.

Mechanisms of Corrosion Fatigue Damage in Implant Materials

This research is aimed at investigating the characteristics of the surface damage processes that lead to fatigue cracking in a titanium alloy, cobalt-base superalloy and polymer specimens used in biomedical implants. The research utilizes a recently developed scattered light scanning system to monitor crack formation and coalescence in-situ. The present methodology takes both microcrack length and density into account. The present approach promises to provide improved predictions of corrosion fatigue failure over those based on conventional crack detection techniques. Funded by Gifts for Research from Baxter Healthcare – Cardiovascular Division.

Fatigue Deformation and Damage Mechanisms in Bimetal Fasteners

Riveted joint assemblies are common sites for the early onset of fatigue damage in aircraft structures. Fatigue and corrosion-fatigue damage at these sites is often complicated by the fact that multiaxial stresses are inherent to joint structures. Fatigue specimens consisting of a plates joined together with several bimetal rivets are currently being tested in the present research program. An computer-controlled servo-hydraulic testing machine is being used to test rivet joint samples under carefully controlled fatigue loading conditions. State of the art diagnostic instruments are also being investigated in an effort to develop better methods of monitoring fatigue crack initiation and growth in the joint structures. Finite element models are also being developed to better understand the nature of the fatigue stresses generated in these structures. The goal of the research is to develop a better understanding of fatigue mechanisms in riveted joints with fatigue life that will lead to increased fatigue life. Supported by Textron Fasteners, Inc. in Irvine, CA.

COLLABORATIVE RESEARCH

Role of Impurities on Superplastic Flow and Cavitation

The primary objective of the investigation is to develop a better understanding of the ways in which impurity segregation at interfaces influences the characteristics of superplastic flow at low stresses. The experimental approach involves a detailed examination of the effect of selected impurity elements on dislocation motion, plastic instability, interfacial sliding, microstructure, and cavitation processes. In particular, cavity nucleation and the relationships between deformation and cavity growth are closely investigated. Funded by NSF. [Role: Co-PI, PI: Professor F. A. Mohamed]

Energy Dissipation in Dental Implant Materials and Structures

Recent clinical findings indicate that an optimum amount energy dissipation is a critical to maintain the proper positioning of teeth integrated into dental implant structures. The amount of energy dissipated is determined by the design of the implant structure and the mechanical properties of the materials used. As a result of both aesthetic and medical constraints, the freedom to alter the design of dental implants is limited. However, the proper selection of materials makes it possible to achieve the desired energy dissipation by the implant structure. The activities of the present work are threefold. First, I invented a new materials testing technique for this work that performs quantitative determinations of energy dissipation under typical occlusal conditions. A patent has been issued for this novel instrumentation (Patent No. 6,120,466). Second, optimum energy dissipation is determined by measuring the mechanical response of the natural tooth complex. Third, the mechanical response of dental implant structures is assessed and the energy dissipation is being characterized. Finally, new implant materials are being selected and assessed based on the experimental results to achieve the optimum mechanical response. Funded by Gifts for Research from Steri-Oss Inc. [Role: PI, Associate Researcher: C. G. Sheets, DDS]

Biological Methods for Controlling Corrosion in Service Water Systems

The primary objectives of the present research are twofold:

(1) to evaluate and develop biological methods that prevent, or significantly reduce, abiotic corrosion and microbiologically influenced corrosion (MIC) in power plant service water systems, and (2) to develop a simple diagnostic kit that will identify the bacteria present in the biofilm before and after the biological treatment. Sidestream systems have been developed that are capable of combined testing approaches involving microbiology, electrochemistry, and surface chemistry, which are being used to provide insight into complex interactions between biofilms and metal surfaces in service cooling water. One of these systems is stationed at the UCI Central Generating Facility. Multimedia microbiological cultures, biochemical assays and genetic probes are being used to investigate the presence of specific types of bacteria. Electrochemical techniques, including electrochemical impedance spectroscopy (EIS), linear polarization resistance

(LPR), electrochemical noise analysis (ENA) and DC techniques are being used to investigate the corrosion behavior of various engineering alloys under service water conditions. News articles describing our research have appeared in several periodicals including *Scientific American*. Funded by EPRI. [Role: PI, Co-PI: Dr. P. J. Arps]