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Overview

This book contains the manuscripts of eleven papers that were presented at the Second Symposium on Fractography of Modern Engineering Materials held in May 1992. The numerous advances in materials science in the six year period following the First Symposium dictated this second meeting. Not only had new materials been developed in the intervening years, but understanding of older materials had also progressed. Similarly, advances in the technology and the techniques of fractography had occurred. The objective of the symposium was to extend the colloquy on fractography to include these many advances.

The papers may be divided into three sections: Unique Fractographic Techniques; Metallic Materials; Polymeric and Composite Materials. The section titles reflect the diversity of materials discussed in the meeting. The range of materials included cross-linked polyethylene, AISI 52100 steel, 2024 aluminum, and a variety of organic and metal matrix fibrous composites. The case studies presented also covered a wide range. They included failure investigations of an antenna used in deep space exploration and chemical storage tanks. Advances in the techniques of fractography were also reflected in a number of presentations; quantitative techniques and expert systems were also subjects of presentations.

A short precis of each paper is included here to assist the readers in identifying works of particular interest.

Unique Fractographic Techniques

As in other technologies, the computerization of the workplace has had a profound effect on fractography and failure analysis.

Using digital image analyses of fracture profiles, Gokhale et al., for example, were able to estimate fracture surface topographic parameters such as roughness, and anisotropy via quantitative fractographic techniques. The authors indicate that these parameters can, in turn, be related to material toughness to establish relationships of structure to properties.

In a related paper, Drury and Gokhale addressed issues of implementing profilometric studies. They specifically focused on the statistical aspects of measuring surface roughness, fractal dimension, and other geometric descriptors. The results of this work led to the proposal of a profilometry sampling criteria which could serve as guidelines for future quantitative fractographic studies.

The final paper in this section discusses the development of an expert system that guides the user in establishing potential failure modes in fiberglass-reinforced polymeric materials used in the automotive industry. The authors, Saliba and Saliba, also developed a computerized atlas which displays photomicrographs for user-specified materials, environmental conditions, and failure modes.

Metallic Materials

Fatigue crack growth was a theme common to all three papers presented in this section on the failure analysis of metallic materials.

Ranganathan et al. discusses a quantitative analysis of fatigue fracture surfaces they developed by studying 2024 T351 aluminum specimens subjected to constant amplitude and variable amplitude loading. The effects of applied stress intensity factor, K, and the stress ratio, R, can be quantified using this technique.

The paper by DiGiorgio and Hsieh demonstrates a holistic approach to failure analysis of complex systems. This approach looks at the overall system in which the component failed to find the full real reasons for failure. In the failure of roller bearings on a radio telescope system, the authors established fatigue as the initiating cause of fracture of the roller. Stress raisers at a center through-bore hole accentuated the applied load. The authors were able to relate modifications in the radio telescope system to increased loads that pushed inherent flaws beyond the critical level for the roller bearing material.

Sundar et al. conducted a fractographic study of short crack growth in notched 2014 T5511 aluminum alloy. They studied the fracture surfaces using both optical microscopy and transmission electron microscopy of replicas. Their work showed that short notch root fatigue cracks will open at considerably lower stress levels than the stress associated with the onset of crack closure.

Polymeric and Composite Materials

The widespread application of polymeric and composite materials in industry was reflected in the number of papers that discussed these materials.

Wachob et al. reviewed their failure analyses of cross linked polyethylene (XLPE) storage tanks used for long-term storage of chemically active solutions. The physical, mechanical, and chemical evidence they gathered indicated that XLPE can be severely oxidized and degraded when concentrated industrial bleach or oxidizing acids decompose or react with it.

The tensile and tension-tension fatigue fractures of continuous γ-Al_2O_3 fiber reinforced aluminum-based metal matrix composites were the subject of the investigation reported by Komai et al. They examined a number of 0°, 90°, 0°/90°, and ±45° laminates tested at both room temperature and at 573°K and identified the controlling failure mechanisms.

Macheret et al. studied damage development in aramid fiber-reinforced aluminum laminates made of thin aluminum sheets alternated with plies of epoxy prepreg containing unidirectional aramid fibers. They presented fatigue crack growth data on surface notch and open hole initiated fatigue cracks. Their failure analysis revealed that the surface initiated cracks propagated only in the outer aluminum layer; the fibers remained intact. Cracks initiated at the open hole, on the other hand, propagated through the laminate thickness in all aluminum layers. This, they noted, could lead to complete fiber failure depending on the laminate residual stress state.

Pinell et al. investigated the axial compression response of two different quasi-isotropic graphite epoxy layups, [0/+45/90/−45]s and [0°/±60°]s, using both a miniature sandwich specimen and an all-laminate specimen. They were able to identify the initial damage mechanisms and define the sequence of failure events through a combination of fractographic and mechanical analyses.

The final paper reviews the results of an investigation of the fracture surfaces of Cracked Lap Shear Coupons made of graphite epoxy and graphite polyetheretherketone (PEEK) composite material. In this work, Fortson and Armanios applied quantitative fractographic techniques to track the area fractions of four fracture morphologies as a function of position on the fracture surface. Their efforts support the validity of the specimen configuration as a test specimen.

In closing, it is hoped that the papers presented in this volume will aid investigators in conducting failure investigations. It is also hoped that additional symposia will be held as this body of knowledge continues to be developed.

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