Overview

Based on the success of the first symposium on this topic in 1990 (published as *ASTM STP 1122*), this follow-up symposium was again intended to review recent progress in our understanding of fatigue phenomena and in the development and application of methods for predicting the fatigue performance of materials and structures in service environments. Topical content was purposely kept broad in an effort to represent the efforts and viewpoints of a range of researchers and practitioners who often participate in more specialized forums. This strategy, it is felt, provides an excellent opportunity for cross-fertilization and establishment of common ground between the various disciplines and interest groups.

A cursory scan of the contents clearly reveals the breadth of coverage. The 15 papers included in the volume cover:

- fundamental issues in damage development and crack growth,
- behavior in both low- and high-cycle regimes, under constant amplitude and spectrum loading conditions,
- the performance of advanced materials in hostile environments, including creep-fatigue and thermomechanical fatigue, and
- predictive techniques for the real-world environment.

It is clear that fatigue problems show no sign of disappearing from our increasingly complex and technologically driven society. Thus the need to have in hand more powerful and effective techniques for assuring the mechanical integrity of our structures, machines, and devices would seem more urgent than ever. The continuing high level of activity in fatigue related technologies serves to substantiate the criticality of this failure mode in engineering practice. Because of these ongoing efforts, we continue to see notable improvements in both our experimental and computational capabilities and, more frequently, in their productive interplay. Indeed, well-conceived and executed experiments establish the behavioral database for intelligent model development and also provide the requisite validation tool for fine-tuning newly developed analytical tools.

General approaches to damage accumulation and life prediction are the subject of the first three papers. The complexities of composite systems are highlighted in the first paper and a critical element model is presented that provides predictions of effective strength that account for the operative failure mode in a given cyclic environment. Of note is the establishment of guidelines to help tailor a composite for a desired performance objective. The next two papers provide a comprehensive damage assessment method that, in one diagram, combines initiation, short crack, and long crack growth responses. This approach is shown to be particularly relevant for the analysis of notch root cracks under spectrum loads.

Three papers focus on the important problem of overload effects on fatigue crack growth. Here, advanced experimental techniques (e.g., acoustic emission, DC potential drop, striation spacing) are helping to provide new insights into crack closure behavior as it affects retardation or acceleration, or both. Particularly encouraging is the development of mechanics models detailing the crack tip deformation responses as an effective means for predicting fatigue performance.

Material performance in nonambient environments is the subject of three papers. Creep-fatigue responses in a metal matrix composite is interpreted using a microstructural model

based on cavity growth. Next, a nonlinear kinematic hardening stress-strain model is used to relate damage to strain energy density for thermomechanical fatigue of an austenitic stainless steel under both in-phase and out-of-phase loading modes. Finally, a damage curve approach is applied to the cumulative damage analysis of a nickel-base alloy under two-level and multiblock loading sequences. A productive combination of careful experimentation and innovative model development is apparent in these efforts.

Valuable insights into sequence effects on damage accumulation is provided by a paper detailing studies of crack density development in three alloys under a variety of loading profiles. Rational for the departure from linear damage concepts for these loading patterns is clearly demonstrated. Long-life fatigue behavior at ultrasonic frequencies (20 kHz) is next studied using a unique dynamic strain gage and SEM observations as a means to evaluate the potential of such test techniques for accelerated testing programs. Detailed documentation of results for three alloys will be of interest to the experimentalist.

The final four papers in the volume provide evidence of the successful application of advanced predictive techniques in engineering practice. A design approach for the difficult problem of spot weld fatigue is developed using finite element methods in conjunction with linear elastic fracture mechanics. Encouraging results for a variety of practical weld configurations are presented. Using a local plasticity analysis for notched components, the next paper provides guidelines for developing optimal proof load levels for engineering structures. Cost-effective test procedures for aircraft tires provide the focus of an investigation of real time monitoring techniques, (dynamic creep, temperature rise, and acoustic emission) as indicators of damage development in reinforced polymeric materials. The use of rate theory to project the long-term performance (100 years) of polymeric materials used in earth structures and waste containment is critically examined in the last paper. The many problems associated with such methods are clearly articulated.

In summarizing the symposium content, a number of interesting trends can be identified. Out of necessity, interdisciplinary approaches are increasingly being employed to develop more realistic damage models for use in design applications. The growing success record of modern analytical tools in engineering practice has served to further establish the credibility of predictive methods, thereby providing an impetus for further developments. In this vein, one can sense improved rapport between researchers and practitioners as they combine efforts to deal more effectively with fatigue on an applied level. A conscious attempt has been made to perpetuate such alliances through forums of this type. Perceived benefits include identification, by consensus, of key problem areas for research planning and, through collaborative efforts, the formulation of improved strategies for technology transfer.

Finally, the co-editors are pleased to report that the ASTM Committee E–9 Award for Best Symposium Paper for 1992 was presented to Sheri Sheppard and Michael Strange for their paper "Fatigue Lifetime Estimation in Resistance Spot Welds: Propagation Phase." We congratulate the authors for their fine contribution.

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