Multiaxial Fatigue—ASTM STP 853, K. J. Miller and M. W. Brown, eds., American Society for Testing and Materials (ASTM), Philadelphia, PA., 1985, 741 pp.

This is a "peach" of a book. It contains a great deal of material which is of great concern to engineers and research scientists. Applied multiaxial stress-strain state decides the fatigue life time and may be imposed by either the component geometry itself of multiple loading. The present generated laboratory material data under restrained conditions cannot be employed in actual practice without resorting to some multiaxial standard. By introducing stresses in 2 or 3 axes in fatigue experiments, this furnishes valuable information as to micromechanics of fatigue crack formation and growth. This also imposes limitations on the application of multiaxial correlation factors.

Recently, two important developments have emerged. They are a knowledge of plastic deformation and fracture mechanics. The range of plastic deformation is crucial since inelastic strains occur in low cycle fatigue and advanced elastic-plastic fracture mechanics. A number of problems still exist. Fatigue cracks are always accompanied by notches or surface defects. They frequently experience aggressive environments. As stated by the editors, "This volume shows significant progress has been achieved towards predicting finite fatigue life behavior." This should provide a useful set of interpreting failures and understanding the mechanics of fatigue.

This volume contains 9 groups comprising a total of 39 papers. They are broken down as follows:

(0) General Discussion (1)
(I) Multiaxial Fatigue Testing (3)
(II) Determination of Behavior and Stress Analysis of Cracks (8)
(III) Propagation of Long Fatigue Cracks (5)
(IV) Formation and Growth of Short Cracks (5)
(V) Damage Accumulation in Composite Materials (3)
(VI) Life Prediction Techniques for Plain and Notched Components (6)
(VII) Nonproportional Loading Effects (5)
(VIII) Elevated Temperatures (3)

In the general discussion, the presenter considers "planes of maximum shear strain" is contrary to accepted definitions. It should be "planes of maximum shear strains."

Section I describes advanced testing machines. They have a great advantage over present limited range of biaxial stress machines. Section II points out the complexities of analyzing multiaxial conditions. The papers report on (*a*) a review of the use of plastic deformation theories for cycle loading, (*b*) uniaxial cyclic stress behavior in describing the response of materials to uniaxial loading, (*c*) incorporation of elastic plastic deformation theories. At crack tip, this encounters both Modes I and II fracture.

Section III allows the endurance of materials to be completely akin to crack growth behavior. Short cracks develop rapidly during the beginning phase of life. The initial 3 papers concentrate on Mode I cracks with the resultant mixed mode growth (Mode I with Modes II and III). Furthermore, the emphasis on crack tip plasticity tends to control crack speed. It indicates that crack growth rates are faster than LEFM suggested predictions. LEFM is only useful to stresses below 1/3 of yield stresses. Higher stress levels require further experimentation in accounting for biaxial effects. The last 3 papers recount Mode III crack growth and difficulty in maintaining it for long cracks. At high stress levels, large crack tip plastic zones allow Mode III extension. The choice of crack paths seems to rely upon mean stress and material dependence.

Section IV examines behavior of short cracks. Papers within this section report on (*a*) correspondence between initiating growth of cracks (small) generated by torsion loading of smooth specimens, (*b*) microstructure plays an important role in initial crack process, (*c*) local multiaxial stress field adjacent to notches subject to uniaxial loads. This indicates that the growth rate of short cracks may be tempted by 3-dimensional considerations, (*d*) use of fretting to produce short cracks adjacent to notch subject to uniaxial loads, (*e*) testing of wire under tension and shear. This allows one to study the effects of material anisotropy on fracture.

Section V opens with a review of multiaxial fatigue testing of fiber-reinforced plastics. The next paper covers biaxial fatigue of fiber-reinforced polyestive resins. It is shown that biaxial stresses produce a shift in the fatigue crack propagation rate with a resultant decrease in Paris exponent and an increase in the biaxial factors. A number of problems arise in testing of composite materials. Work needs to be accomplished on gripping methods and suitable reinforcement in assuring satisfactory stress transfer. Test procedures must still be developed in generating biaxial stress fields without affecting that mode of failure.

The initial paper in Section VI focuses on high cycle fatigue. Tests were conducted on 2 different biaxial stress fields. The stress state stems from the influence on material properties on fatigue limit behavior. The next paper considers the classifical approach to complex problems of cumulative damage in notched shafts. The third paper states that mean stress can be extended to low cycle of fatigue since uniaxial stress does not represent biaxial stress. The other paper examine the slopes of the Coffin-Manson and Basquin plots and the need to extend multiaxial fatigue studies to notched components. The last paper shows that the strain ellipse and plastic work approaches furnish the best life statements.

Section VII begins with a review on out of phase torsion and bending. It is also indicates that Tresca and Von Mises criteria are inappropriate. It does provide a simple rule for predicting long life fatigue strength. The next paper extends the classical deformation approach to fracture process but has difficult in accommodating torsional fatigue data. The following paper finds a cyclic variation of critical biaxial stress parameters when loaded by two modes. The greatest fatigues life reduction occurs when differences of applied frequencies are small. The concluding paper considers the involvement of different strain wave forms at elevated temperatures. No single method can predict the behavior of material under certain conditions. However, in each case, greater cycle work hardening was natural during nonproportional loading.

The initial paper in Section VIII indicates that fatigue life is reduced due to triaxiality factors. Much work still needs to be done. The next two papers state that two parameters governing failure can be combined into an equivalent shear strain in order to furnish a Manson-Coffin-type law. The next paper specifically shows that the current creep fatigue needs to be reasoned. This results from the showing in some material, damage, is highly directioned. The final paper studies the dual combination of rapid thermal transients and mechanical loading. Crack initiation can be studied in the traditional manner. Crack propagation results point out that cracks can grow much speedier than predicted by LEFM. A more detailed treatment is required for this nature of biaxial stresses.

In summary, this is an excellent book. Although low cycle fatigue is stressed in combined tension-torsion tests, life predictions must be considered by incorporating the effects of fatigue limits and thresholds. More testing is deemed necessary for diagnosing some of the more complex stress situations. The reviewer recommends this volume to research and design engineers plus material analysts.

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