



Book Reviews

Metal Fatigue in Engineering (1980), H. O. Fuchs and R. I. Stephens, John Wiley & Sons, Inc., 318 pp., \$29.95

REVIEWED BY H. SAUNDERS¹

Metal fatigue occupies a position of importance in our everyday existence and has been a structural scourge since time immemorial. Wohler in the 1850's was the first man to study fatigue on a systematic basis. His constant amplitude fatigue testing on railway axles opened a new avenue of study. During the past 1-1/4 centuries, we have constantly improved, progressed and furthered our knowledge, but we are still a long way from comprehending the mysteries surrounding fatigue. This book, written in simple language, not disguised by abstract mathematical covers, goes a long way in providing the reader with an understanding of metal fatigue. It contains 13 chapters and two appendices.

The first two chapters cover a historical overview and fatigue design methods, i.e., conforming to codes, safe line design, inspection, probabilistic design and reliability.

Chapters III-IV discuss micro/macro aspects of fatigue. This includes total strain range representation (elastic and plastic) plus an introductory consideration of fatigue mechanisms (slip, slip bands and crack formation). Also provided are the fundamentals of Linear Elastic Fracture Mechanics (LEFM) with a direct application to fatigue growth and fracture. Stress intensity fracture in Mode I, fracture toughness (K_{Ic}), and plane strain fracture toughness (K_{IIc}) are then examined. Ample pictures of fracture surfaces compliment the discussions.

Chapter V considers constant amplitude fatigue testing. This falls into high cycle (importance of mean stress) and low cycle. The latter is considered in light of Manson-Coffin equation. Crack growth in the light of the relationship first proposed by Paris is also discussed. The chapter concludes with mean stress effects (Forman Equation), scatter and statistical aspects of fatigue, i.e., Sinclair-Dolan statistical fatigue study and Weibull's 3-parameter model.

A discussion of metal fatigue without including the effects of notches is unrealistic. Chapter VI supplies information concerning stress concentrations and fatigue reduction factors, Peterson's approximate formula and short references to the Kuhn-Hardrath approach. However, no mention is

made of Neuber's elliptical notch representation. The chapter concludes with illustrations of good and bad design stress concentrators.

Chapter VII dwells upon self-stresses (residual) and the beneficial effects of shot peening and surface hardening. Notch strain analysis is exemplified by an informative example of the well known Neuber rule which tends to be conservative when compared to experiment.

Chapters VIII-IX present life estimates based on constant amplitude loading. The use of Haigh diagram and the LEFM approach are considered. Multi-axial stresses and strains are also discussed, i.e., Sine's method, crack initiation and Langer's method.

Chapter X focuses upon variable (random) loading and is more representative of true life since it is directly influenced by prior loading and sequence effects. Variable amplitude loading has irregular load histories and one must resort to counting methods. The most popular and correct are rainflow and range pair methods. The senior author uses a variation of the former which is entitled "racetrack counting" and is supposed to reduce counting time when compared to the above methods. The more sophisticated methods of life prediction are considered with emphasis upon the Wheeler model, Elber crack closure model and the Willenborg model. In the reviewer's opinion, the authors skimp on random fatigue and it is entirely too short a chapter for proper digestion.

Chapter XI considers corrosion fatigue, stress corrosion cracking in terms of Paris' fatigue crack growth equation. Other important topics considered are fretting, fretting corrosion, fretting fatigue, low temperature fatigue and lastly, high and low cycle fatigue.

Chapter XII points out the good and bad fatigue behavior of weldments. This includes the harmful effects of its inherent stress concentrations and induced tensile residual stresses in the heat-affected zone. Examples are furnished showing means of increasing weld life by reducing geometrical discontinuities and including compressive self-stresses and proper welding techniques.

The last chapter covers the fatigue of metal components, i.e., springs, roller bearings and gears. Spalling fatigue is a by-product of the use of gas carbonization surface treatment.

This is an excellent text and is especially valuable for the "do's and don'ts" at the end of most chapters. This makes for better designs. The reviewer feels that the addition of "J Integral Method" would enhance the value of this book.

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