



# Book Review

**FAILURE OF MATERIALS IN MECHANICAL DESIGN,**  
J. A. Collins John Wiley & Sons, New York (1981) 628 pp.  
\$39.95

REVIEWED BY H. SAUNDERS

Failure of metals still exists in our midst. This problem has been around for many a year and yet no full explanation exists. We have made great strides in understanding its many component parts but the path is still strewn with a number of obstacles. Fatigue consists of a number of different facets which require a combined effort of analysis and experimentation. This unique book covers a number of different members of the fatigue family and goes into detail on a number of them.

The book consists of 17 chapters, each chock full of information.

The initial chapter considers the role of failure prevention in mechanical design and provides some of the prime design objectives. Chapter 2 discusses the various modes of mechanical failure. Chapter 3 is the heart of the book and treats the strength and deformation of engineering materials. This includes elastic and plastic response, fracture and a good section on dislocation theory. The author touches upon elastic fracture and elasto-plastic fracture mechanics. No mention is made of J integral which is an important aspect of plastic fracture mechanics. Chapter 4 treats state of stress and various parts making up this important concept. Chapter 5 focusses upon relationships between stress and strain. The author illustrates the relationships between elastic and plastic stress-strain.

The author then spends time in developing the combined stress theories of failure. This includes the maximum normal stress theory, Tresca-Guest theory, Beltrami theory, Von-Mises Hencky (distortion energy) theory and Mohr's failure theory. This is a very well "put-together" chapter, concise but informative.

Chapter 7, the most lengthiest, treats high cycle fatigue. Beginning with the nature of fatigue and fatigue loading, it progresses to S/N relationships and the various factors which affect the S/N curves. This includes geometrical considerations, size effects, residual stress effects with brief mention of corrosion and fretting. We next delve into nonzero mean stress and multiaxial fatigue stresses. The chapter concludes with the uses of the various components of multiaxial fatigue stresses as applied to fatigue stresses. This is an excellent chapter and should be read by all concerned parties.

Chapter 8 dwells upon the concept of cumulative damage life prediction and fracture control. The author expounds upon the various cumulative damage theories i.e., Marco-Starkey, Henry, Gatts, Cortin-Dolan, Marin and Manson double linear rule. The chapter concludes with fracture mechanics approach to crack propagation, damage tolerance and fracture control. This chapter fascinated the reviewer who found it very digestible.

Chapter 9 reports upon the use of statistics in fatigue analysis. The various aspects of statistical design are considered, i.e., sampling, population distribution, confidence limits, properties of good estimation and sizes for design confidence. These topics are explained in simple terms and made understandable to the mechanical designer.

Chapter 10, although short in pages, treats fatigue testing and statistical interpretation of data. The author mentions contact stress level, probit method (response of survival method), Prot method and staircase method. A great deal of information packed in very few pages.

Chapter 11 discloses the various aspects concerning low cycle fatigue. The basic concepts are introduced via Coffin-Manson (CM) equation. The author develops various constants used in the CM equation. Loading spectrum for short performance occupies a very concise section. This leads to the well-known rainflow method concept. The reviewer believes this section is too concise and more coverage should have been given to a basic understanding of the effect of frequency in low-cycle fatigue plus an illustrative example showing the use of the rainflow method in determining mean (static) stresses.

Chapter 12 considers stress concentration and provides a basic understanding of the common geometries. It does include a double stress concentration which is a welcome addition. The chapter concludes with notch sensitivity and  $K_f$  (fatigue reduction factor). An excellent example is fully explained and shows  $K_f$  applied to a uniaxial state of stress. The reviewer would have preferred seeing an application of combined alternating and mean stresses using either a Goodman or Gerber diagram.

Chapter 13 focusses upon a "hot" subject, i.e., creep, stress rupture in fatigue. Beginning with the initial stages of creep, the author progresses to various methods of determining creep. The Larson-Miller and Manson-Haferd parameters are initially considered we then encounter the uniaxial and multiaxial state of stress and cumulative creep concepts. Considering the allocated number of pages, the author provides an admirable account of the latter. This chapter "makes" good reading as an introduction to the more advanced aspects of creep and stress rupture.

Chapter 14 exposes fretting, fretting fatigue and fretting wear in a very favorable light. Fretting is not fully comprehended by designers. The author introduces fretting by exploring the more important variables which play an important role. We continue with fretting fatigue and their

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combinations having good, intermediate and poor fretting corrosion resistance. The chapter concludes with a brief summary preventing or minimizing fretting damage.

Chapter 15 introduces shock and impact. This includes stress wave propagation, stress wave behavior, spalling and effect of stress and stress concentration under impact loading conditions. A good chapter but mention should have been given to acoustic fatigue of panels.

Chapter 16 considers buckling and instability whereas the concluding chapter elaborates upon previous considerations given to wear and corrosion. Although brief, the author explains the various factors which cause corrosion, i.e.,

chemical or electrochemical interaction with the environment.

In summary this is an excellent book. It contains a number of excellent examples which furnish better understanding of the principles of fatigue. The reviewer believes that the reference stress method (RSM) in creep and an increased section on stress concentrations would greatly enhance the book. By including a section on vibration, this should augment the shock and impact chapter. This book impressed the reviewer by its "down to earth" explanations plus the accompanying examples and recommends it to all readers. It belongs on the shelf or desktop of all mechanical designers and material people.