Book Reviews

Fatigue: What It Is, Why It Matters

L. Pook

Springer, PO Box 17, 3300 Dordrecht, The Netherlands. 2007. 264pp. Illustrated. £61.50. ISBN 978-1-4020-5596-6.

Les Pook has spent many years studying the nature and consequences of metal fatigue, and has a wealth of experience to impart. Rightly or wrongly, he states that no recent book on fatigue appeals to the engineer and feels unable to recommend any recent publication to his students at University College or to those new to the field. He has compiled this work: 1) to explain current terminology, 2) to describe the mechanisms of fatigue, 3) to elucidate the bases of fatigue resistant design, 4) to provide a sound foundation from which those studying metal fatigue at a higher level may build.

The Introduction, Chapter 1, is woven around five non-descript photos of components which have obviously failed, but show no 'tell-tale' signs that fatigue is the cause (See figures 3.15, 3.16 and 3.17 for a more lucid explanation). The main message is that catastrophic fatigue failures are now rare – lesser failures, which cause inconvenience and expense, being far more common.

Chapter 2 provides a brief account of metal fatigue in a historical context. One early idea was that metals (like humans) simply tire of carrying load, but that was before the importance of load reversal was recognised. The term metal fatigue is often attributed to a Mr Braithwaite (1851) or to a Mr Field. The chapter comprises several short sections on the development of experimental testing techniques from the time of Wöhler – who tested railway axles in rotating cantilever bending – on to the improved four point bending method, through to the advent of computer assisted analysis of experimental results.

The analytical study of fatigue begins in Chapter 3, where constant amplitude sinusoidal fatigue is considered. The notion of mean and alternating stress is explained and figures 3.5 and 3.6 show authentic stress/cycle (S/N curves) for a carbon steel and a high strength aluminium alloy respectively. The Basquin power law (c1910) is said to give a reasonable mathematical fit to these curves, when cycles are plotted on a log scale. The author describes fatigue as a random process and suggests that the Gaussian (normal) distribution gives an adequate fit to the wide scatter of lives (which may vary by a factor of 10 to 1 in some cases) and it is therefore important that the tyro reader does not miss a sentence (at the bottom of page 21): 'Distributions of fatigue lives of metallic specimens do not conform to the Normal distribution …'. Other distributions used in modern work are subsequently considered. Mechanisms and metal fatigue and fatigue crack initiation and propagation are better and more clearly explained in section 3.4. Constant amplitude sinusoidal fatigue is a useful but very simplistic mathematical model, rarely representative of the practical case.

Nevertheless the author begins Chapter 4 – on variable amplitude fatigue – by returning to the relevance of the Gaussian statistical distribution applied to the constant amplitude sinusoidal case. Narrow band, broad band and block loadings are also considered. A worked example of Miner's rule, using the method of weighted average stress is useful, but as the author rightly points out, a cycle counting method is needed to reduce a broad band process to a discrete number of cycles. The peak counting method and the rain flow method are noted and references given. Standard load histories: FALSTAFF (fighter aircraft loading standard for fatigue) and WASH (wave action standard history) are two standards cited. A 6-page study of multiaxial fatigue concludes the chapter.

The author acknowledges that 'Fatigue Design', his chosen title for Chapter 5, is a misnomer and in a further statement confuses the analysis of an existing component failure with the design detail synthesised by thought, knowledge and know-how, input by the designer before a product is built. Nebulous topics such as situations, philosophies, product liability, The Consumer Protection Act and Enforcement Authorities are sections, which although important in a different setting, have nothing whatsoever to do with the geometrical features of a component designed to resist fatigue. Such issues belong in an Appendix.

Most readers will know that any abrupt change in cross section (called a notch) causes a localised increase in stress which can be many times higher than nominal. It is from such stress concentrations that fatigue cracks often begin. Yet no Peterson stress concentration factors are given (see page 91). The author makes a clear distinction between fatigue crack initiation and fatigue crack propagation and treats the uncracked and the cracked situations as separate effects. The use of Gerber, Goodman and Soderberg diagrams is explained and the notion of notch sensitivity and notch insensitivity is treated with some reservation. The effect of flaws unintentionally introduced during manufacture along a known path (which lend to Stage II crack propagation in Mode 1) is next considered in Chapter 7. It is suggested that crack direction may be obtained from periodic inspection or assumed to take a likely path through a line of rivets, for example.

The macroscopic tracking of crack paths is introduced in Chapter 8. Fig 8.1 (the only aeronautical example in the book) shows the path and time history of a crack; in what looks like an inboard wing spar doubler, but referred to as a fighter aircraft centre section. The figure has potential but discussion is brief. Why, for instance, does it take 238 hours for the crack to pass from one side of a rivet hole to the other? Why at another rivet does it take little more than half the time? Is this difference due to the current rate of crack growth? Are readers aware that a small hole drilled at the tip of a crack arrests its progress? If yes, do they know why? Such questions are neither posed nor answered. We do learn however, that broadly speaking there are two classes of cracks. Cracks, which generally propagate in Mode 1, at right angles to the maximum principal stress, and maximum, shear dominated cracks, which propagate in either Modes II or III. Crack paths in two and three dimensions and mixed mode thresholds are considered.

Chapter 9, 'Why Metal Fatigue Matters' is a five page lightweight précis of little value. There are however three substantial Appendices and these are much more useful. Appendix A on 'Fracture Mechanics' is descriptive, mathematical and sound. Appendix B on 'Random Load Theory and RMS', extends the text in a worthwhile direction. Appendix C on 'Non-Destructive Testing' covers Visual Inspection, Magnetic Particle Inspection, Dye Penetrant, Radiographic, Ultrasonic and Electromagnetic Methods.

There is an impressive list of over 250 references, 42 of which are attributed to Pook between 1960 and 2004

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Bistatic Radar: Emerging Technology

Edited by M. Cherniakov

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The subject of bistatic radar – essentially a radar system in which the transmitter and receiver are in separate locations – is currently receiving a great deal of interest, since most of the practical problems that have stood in the way of the realisation of practical systems are now soluble and several novel applications of the technique – both civil and military – are now becoming apparent.

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