The Fatigue Endurance Limit: A Myth

Robert Errichello

The well-known fatigue endurance limit is a convenient myth.

That's the thesis presented by Claude Bathias and Paul C. Paris in their *Gigacycle Fatigue in Mechanical Practice*.

Whether a real fatigue endurance limit exists continues to be a controversy. The no-limit side is represented in industry standards such as AGMA 2001, which gives an S-N curve that continually slopes downward after 10^7 cycles. However, other standards, such as ISO 6336, maintain the existence of an endurance limit.

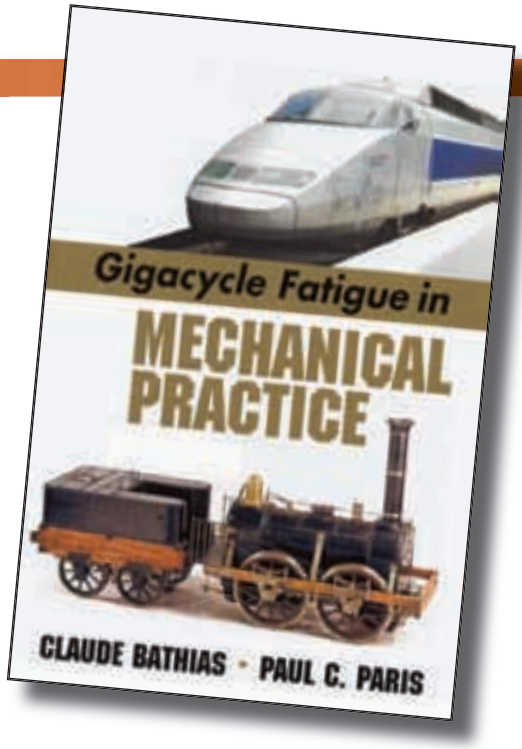
Supporting the no-limit side, Bathias and Paris present important experimental data, including many examples that prove fatigue failures may not occur till well beyond 10^7 cycles and even after 10^{10} cycles.

Bathias, who holds a doctorate in mechanical engineering, is director of the Institut des Technologies et des Matériaux Avancés, Conservatoire National des Arts et Metiers, in Paris, France, and is a Fellow of the American Society of Materials.

His co-author, Paris, is senior professor of mechanics at Washington University in St. Louis, MO. Known for his contributions to fracture mechanics, Paris has received awards from the American Institute of Aeronautics and Astronautics and the American Society for Testing and Materials.

Besides examples, the authors also provide excellent guidance on the intricate details of ultrasonic fatigue testing. In addition, their many useful facts on fatigue phenomena include:

- For a large number of alloys, fatigue crack initiation may occur beyond 10^7 cycles, and the fatigue strength may decrease by 50–200 MPa between 10^6 and 10^9 cycles.
- When fatigue occurs beyond 10^7 cycles in steels, the origin of the fracture is usually not at the surface but in the interior of the specimen.
- Low cycle fatigue cracks are the result of local plastic flow around surface discontinuities, whereas gigacycle fatigue cracks initiate from the interior at inclusions or microstructural defects.
- When fatigue failure occurs at 10^4 cycles, there are multiple crack origins at the surface; at 10^6 cycles, there is a single origin at the surface; and at 10^9 cycles, cracks initiate in the interior of the specimen.
- Equations are given that quantify the effect of nonmetallic inclusions on fatigue strength.
- Corrections are given to account for the different stress states in rotating-bending and tension-compression fatigue tests. After the correction, fatigue data give the same S-N curves regardless of the different loading methods.
- Low temperature causes a shift of the fatigue crack growth curves to higher stress intensity. This is explained by increased tensile properties.



Gigacycle Fatigue in Mechanical Practice,
Claude Bathias and Paul C. Paris,
ISBN: 0824723139,
Marcel Dekker, 2005, 304 pages,
$139.95.

- Gigacycle fatigue tests show the fatigue crack growth threshold ΔK_{th} determined by conventional fatigue testing is reliable for engineering design.
- Equations are given for correcting the fatigue crack growth threshold ΔK_{th} for the effects of the stress ratio $R = \sigma_{min}/\sigma_{max}$.
- A table of threshold stress intensity factors, ΔK_{th}, obtained by ultrasonic fatigue tests, is given for many materials.
- Many useful data are given for fretting fatigue that show fretting can reduce fatigue strength by a factor of three.

Gigacycle Fatigue provides a good overview of recent findings from ultrasonic fatigue testing and discusses many parameters that must be considered when designing machine components for long fatigue life. Given all the above, this book would be an excellent addition to a gear engineer's library.

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Robert Errichello *is a gear consultant and founder of GEARTECH, a consultancy specializing in gear failure analysis. He's also a technical editor for* Gear Technology *and has more than 45 years of experience in the gear industry.*

*As of Oct. 12, 2005, there were no copies in stock. Interested readers may be able to buy copies from other sources via the Internet, such as *www.amazon.com*.