TO LIVE FOREVER

Fatigue simulation can increase product life, reduce costs and decrease risk.

By Bence Gerber, Lead Product Manager, ANSYS, Inc.

Fatigue failure is insidious. It might be happening to your product right now, but you don't know it yet. Cyclic loadings cause changes to the surface of a part that can be seen only at a microscopic level. After long-term repetitive compression and tension, a visible crack appears, and then the part quickly fails.

Fatigue is the failure of a part subjected to repeated loading and unloading at stress values lower than the part material's yield strength. Simple tension tests identify only failure caused by loadings that exceed the yield strength; without physical testing, such as a shaker test, the result is false confidence in a part's durability. However, physical testing is time consuming, expensive, and often impractical or impossible for large and/or complex products. Whether or not a product will fail is a function of the shape of the product, quality of the surface, materials used, and severity of the loading history.

Failure from repetitive stress-based phenomena has been recognized since the industrial revolution, but the term "fatigue" was not coined until the mid-19th century. During most of the 20th century, engineers performed fatigue calculations by hand or with a spreadsheet, making it difficult to gain a complete understanding of how structures fail from fatigue. Results of tests for large numbers of loading cycles (10^4 to 10^8) are often characterized by a semi-logarithmic graph with stress on the y-axis and life in cycles based on a logarithmic scale along the x-axis, referred to as an S–N curve or Wöhler graph. These charts are the basis for material models used to determine when material failure will occur.

Now, by combining two computational methods, design teams can calculate the time to failure for predetermined loadings with reasonable accuracy. Using finite element methods, a product's response to loadings can be simulated, and the resultant maximum stresses and strains determined. These results can be combined with one or more loading histories, which can be predicted using mathematical functions to represent the loading and unloading or based on test data that was gleaned, for example, from a test car equipped with a number of strain gauges and accelerometers. Using material data (S–N curves) collected from experiments and stored as part of a material library, it is easy to determine the number of loading cycles at which point the part fails from fatigue. This represents product life.

A unique and powerful fatigue process is enabled by combining the best-in-class structural simulation tool, ANSYS Mechanical, with ANSYS nCode DesignLife, a leading durability software that works within the integrated ANSYS Workbench environment. Workbench uses parameters to evaluate design options as well as design exploration for

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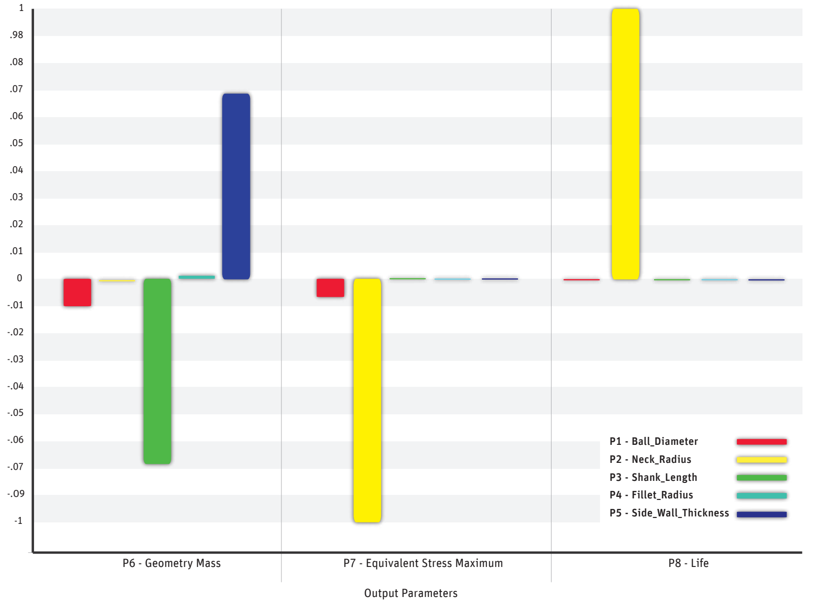


Fatigue life optimization based on neck radius for a trailer hitch full optimization. This fatigue process automates the steps in evaluating product life; it reduces errors when compared with the manual calculation method. Within the Workbench project, an expert can define a workflow process that can be used repeatedly by designers who are not fully trained fatigue specialists. Because the process can be stored, it can be reused long after the initial design if a redesign is necessary.

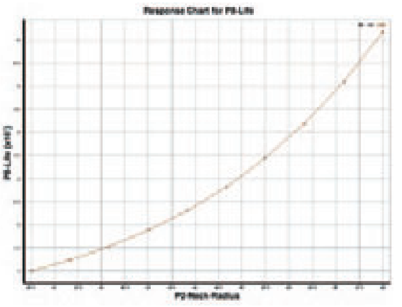
Simulation of fatigue allows product designers to make informed decisions in evaluating trade-offs, such as using different geometries and materials, to achieve desired product life. The traditional way to eliminate product failure is through the use of conservative engineering. In today's economy, with growing pressures to reduce manufacturing costs, improve performance and efficiency, and decrease risks associated with product failure, optimization through simulation provides a competitive advantage; it may soon become a necessary tool for survival.

Simulation not only assists with the evaluation of numerous design options, it provides insight into the physical phenomena taking place inside a product during its lifecycle. When attempting to understand fatigue failure, testing provides only a yes-or-no result. If the product does not fail, testing does not provide any indication of how close it is to failure and the potential for some minor additional load to cause failure. If in fact the product does fail during testing, it is impossible to determine if failure would have occurred with significantly less loading or with a shorter loading cycle at higher loads.

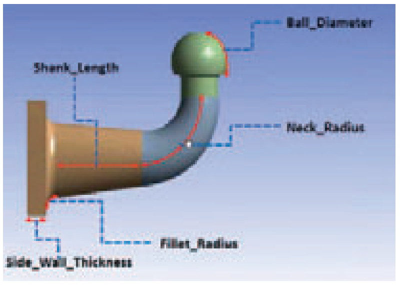
The aerospace industry was among the first to adopt fatigue simulation, because aircraft undergo high cycle loadings from vibrations and pressurization of the fuselage. Jet engines and landing gear also are exposed to repeated loads. A key factor in this industry is weight reduction, as designs that are too conservative (and, therefore, too heavy) are more costly to operate. In the automotive industry, manufacturers are pressured to increase fuel efficiency while decreasing weight. In the energy industry, environmental concerns are fueling the installation of wind turbines, which undergo repeated cyclic loading while rotating. Simulating fatigue can assist a wide range of organizations in addressing these concerns.

Failure from fatigue can have dire consequences for most companies. Monetary costs can be huge, including legal liabilities; maintenance, redesign and warranty expenses; and a damaged brand. Thanks to modern simulation technologies, product developers can greatly reduce the probability of failure while enabling the creation of more competitive, more profitable and more sustainable products.

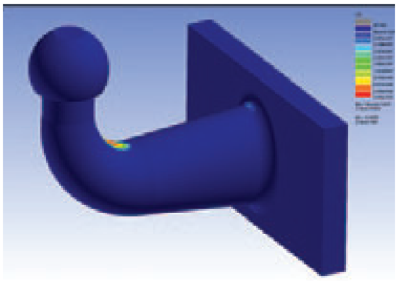
Bicycle crank fatigue failure from cyclic loading



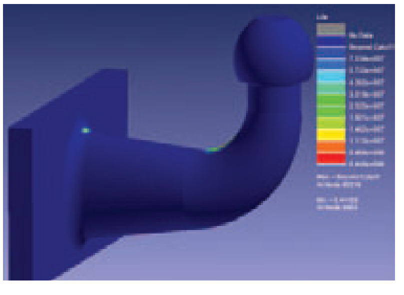
Sensitivity of life to optimization parameters for trailer hitch



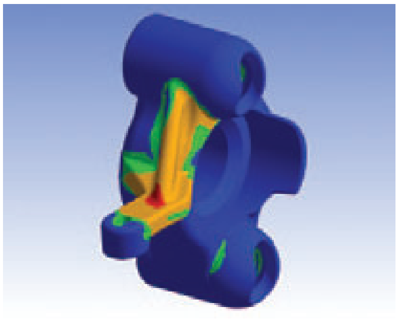
Design parameters used for optimization



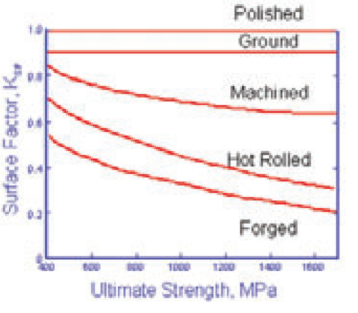
Life contour of trailer hitch identifying shortest life spot



Optimized fatigue life of trailer hitch



Safety factor contour for a given fatigue life of gear



Influence of surface quality on fatigue properties