nCode

Managing Durability

FE-Fatigue™ Release 5.0

Manage durability in your FEA environment

When designs are subjected to cyclic loading, failure can occur even if the resulting stresses are well within static safety levels. This failure mode, known as fatigue, often dominates structural design.

FE-Fatigue™ enables engineers to quickly and accurately manage the fatigue performance of their designs early in the development cycle. And, FE-Fatigue has an intuitive interface that guides users through fatigue analysis from within popular FE environments.

More durable designs

With increased pressure to reduce warranty and recall costs, there is more need than ever to design products right the first time. When asking the question "how long will it last," finite element analysis only gives part of the answer. FE-Fatigue is an industry proven tool designed to get more and better durability information from FEA.

Easy to learn and use

A natural extension of your current FEA tools, FE-Fatigue is easily incorporated into your existing engineering process. FE-Fatigue provides fatigue analysis with a wide range of standard CAE tools including NASTRAN, ABAQUS, ANSYS, HyperMesh, and I-DEAS. Plus, FE-Fatigue includes direct links to MTS and ADAMS, integrating loads from real and virtual tests.

▲ *General Motors has selected nCode as their strategic durability supplier, and uses FE-Fatigue worldwide.*

Wide applicability

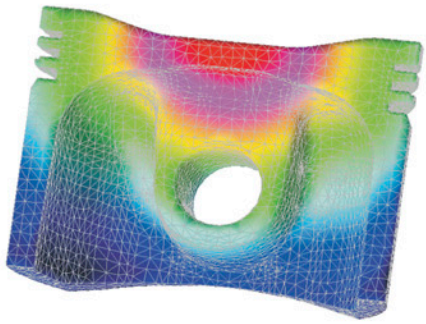
Powered by nCode fatigue technology, the de facto standard in the industry, FE-Fatigue provides fast and reliable results. FE-Fatigue enables a very wide range of real industry applications; from the fatigue of small components to complete vehicle structures and from safety factor calculations to elastic-plastic multiaxial fatigue life predictions. Release 5.0 includes new features for the fatigue analysis of welds (spot and seam welds), vibration induced fatigue and temperature corrections for applications such as engine components.

Integrate your requirements

If you already have a fatigue process, FE-Fatigue can integrate and extend that process with easy to use customization features. From batch automation, to report generation, to adding custom menus, FE-Fatigue can streamline your current fatigue process for improved productivity and lower internal costs.

Integrated Durability Solutions

Key Features



With FE-Fatigue, you can take into account the effects of temperature on the fatigue life of your product.

Identify critical spot weld and seam weld locations early in the design process.

Inside your FEA Tool

Now you don't have to learn a new product to do meaningful fatigue analysis. FE-Fatigue provides fatigue analysis with the leading CAE tools. Once the analysis is defined, you launch the fatigue calculation and review results, including contour plots of life, log life, damage, and safety factors, all from within your familiar FE environment.

Easy and Scaleable

FE-Fatigue provides an easy method for basic users, and is scaleable to address the needs of more advanced users. FE-Fatigue includes a constant amplitude option, often the first fatigue analysis you'll want to consider. More complex problems require that multiple time histories of load are combined simultaneously with many stress load cases. FE-Fatigue also includes a spreadsheet interface that makes it easy to setup the analysis of a complete durability schedule or duty cycle. In this way, the contribution of multiple events to the total fatigue damage can be directly assessed.

Material Matters

While it's fairly easy to find basic linear elastic properties for most materials, it's more difficult to find fatigue-related data. FE-Fatigue includes nCode's database of standard material fatigue properties, which contains nearly 200 materials, and which also allows users to easily add their own data. 'What-if' scenarios can be quickly performed to assess the effect of changing the material or surface finish. When exact data is not known, FE-Fatigue can generate fatigue properties from static data for an approximate analysis. When considering materials selection, you can also use the FE-Fatigue database to review and compare material properties with data plots and overlays.

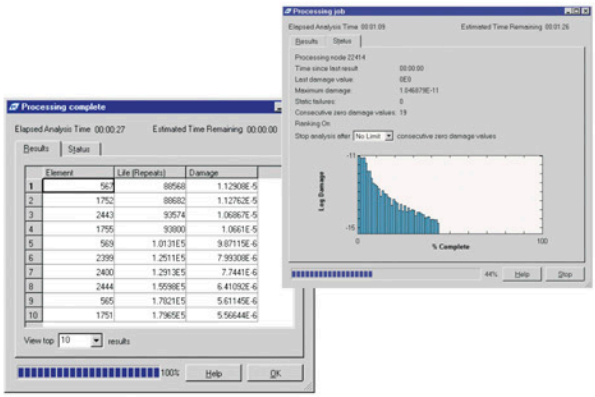
Integrating Loads

Durability assessment has a rich history in testing and measurement, and is increasingly being driven by loads from leading multi-body dynamics software, such as ADAMS. With FE-Fatigue, you can access and re-use loads data from a variety of sources, including RPC and ADAMS. Advanced users will also appreciate direct application of loads via rainflow matrices.

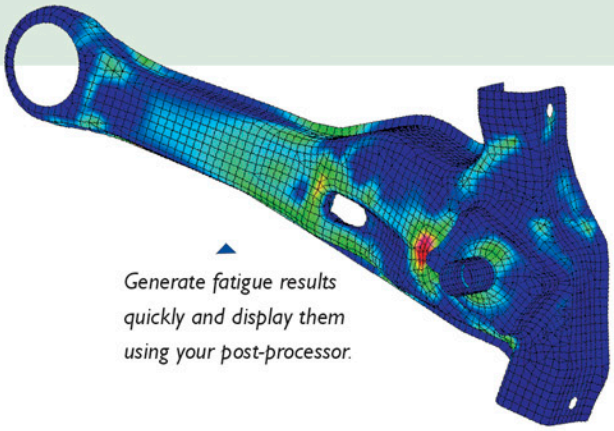
The Correct Approach

nCode technologies have been refined through significant research and close cooperation with leading companies that require durability assessment as a strategic competency. FE-Fatigue includes analysis options for strain-life, stress-life and safety factor calculations.

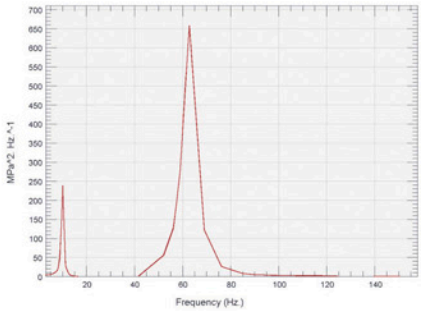
Strain-life methods include both uniaxial and non-proportional multiaxial damage and plasticity models. Options are included for mean stress and temperature corrections. A virtual strain gauge capability enables elastic or elastic-



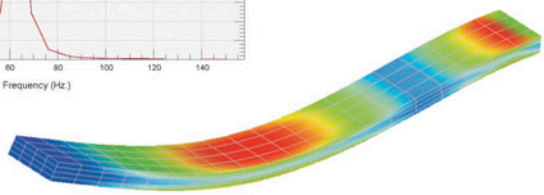
The results monitor provides constant feedback on results as analysis progresses.



Generate fatigue results quickly and display them using your post-processor.



Calculate fatigue damage from PSD stress data in the frequency domain.



$$\frac{\Delta\varepsilon}{2}\sigma_{max} = \frac{\sigma_f'^2}{E}(2N_f)^{2b} + \varepsilon_f'\sigma_f'(2N_f)^{b+c}$$

plastic strain data to be exported from FE-Fatigue to allow direct correlation with measured strain gauge rosette data.

Stress-life analysis provides solutions for a range of nominal stress problems including the fatigue of spot and seam welds using industry proven methods. The seam weld technology was developed jointly with Volvo Cars specifically for joints in thin sheet structures. FE-Fatigue also enables fatigue analysis from the results of a random vibration stress analysis to directly simulate, for example, physical PSD shaker tests. For S-N analysis, there are again options to correct for the effect of mean stress and temperature.

Safety factor methods are provided for longer life problems and multiaxial safety factor methods have particular application in engine component design.

And, FE-Fatigue comes "out of the box" with a solid set of default settings so you don't have to become an expert before you can effectively use the product.

High Speed Calculations

FE-Fatigue includes several methods to accelerate the solution process. In many large structures, over 80% of the structure may be experiencing little or no damage. Automated elimination methods ignore very low stressed nodes or elements prior to a time-consuming fatigue analysis. In addition, time history decimation shortens load histories by removing small cycles while still retaining phase across all channels. During the fatigue analysis, a results monitor gives constant feedback so you no longer need to wait for an analysis to finish before reviewing the results for critical regions.

Example Customers

FE-Fatigue users include ground vehicle manufacturers such as General Motors, DaimlerChrysler, Ford Motor Company (including Jaguar, Land Rover, and Volvo Cars), Deere & Company, and PACCAR; major automotive suppliers including ArvinMeritor, Auto Chassis International, Benteler Automotive, Tower Automotive, and Visteon Corporation; and aerospace companies such as BAE Systems, General Electric, Goodrich Aerospace, Honeywell, and Messier-Dowty.

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About nCode

nCode provides sophisticated engineering software and services to enable customers to effectively manage durability in their engineering process. nCode takes an open approach and fosters close cooperation with leading suppliers to meet customer needs. nCode maintains active relationships with MSC.Software. MTS, PTC, Altair Engineering, SDRC, ANSYS, and HKS, among others. Several leading products, including MSC.Fatigue, Pro/MECHANICA Fatigue Advisor and MTS RPC-Pro are powered by nCode technology for fatigue life prediction.

nCode is a member of the AEA Technology plc group of companies, a diverse science and engineering services business with over 4,000 employees worldwide.

For more information

In the United States and Canada call us toll-free at 1 877 737 4242.

In other countries please contact your nearest nCode representative.

For information on other nCode products visit our web site at **www.ncode.com**.

Detailed Specifications

FE modeling integration
- HyperMesh
- SDRC I-DEAS
- ANSYS (via RST)
- NASTRAN (via OP2)
- ABAQUS (via FIL)
- MEDINA
- ADAMS/Durability
- FEDEM
- Pro/MECHANICA

FE data supported
- Elastic stress and strain
- Elastic-plastic stress and strain
- Static, transient and modal superposition
- PSD stress
- Nodal and elemental results
- Shell and solid elements
- Bar and hexa spot weld elements

Load history formats
- nCode DAC
- MTS RPC III
- ASCII

Loads supported
- Multiple simultaneous time histories
- Constant amplitude
- Rainflow matrix

Solution speed-up
- Time history reduction using peak-valley slicing with cycle based gating
- Auto-elimination to remove low stress nodes or elements
- User specified locations or groups
- Rapid feedback of results during analysis

Multiple events
- Spreadsheet GUI to set up durability schedule or duty cycle
- Automatically sums damage from repeats of multiple events
- Auto-elimination across multiple events
- Summary of damage per event for each node or element

Materials
- Multiple material definitions
- Searchable and user extensible material database provided
- Material data plots and overlays
- Material data generation available within fatigue analyzer
- BS7608/BS5400 weld curves

Stress-life method
- S-N with mean stress corrections using Goodman, Gerber or none
- Interpolate multiple S-N curves to correct for different levels of mean stress
- Temperature corrections of fatigue properties
- Seam weld analysis
- Spot weld analysis
- Vibration fatigue using PSD stress

Strain-life method
- E-N with mean stress corrections using SWT, Morrow or none
- Biaxial corrections using Hoffman-Seeger or Parameter Modification
- Temperature corrections of fatigue properties
- Uniaxial elastic-plastic corrections using Neuber
- Multiaxial notch and plasticity modeling (Mroz-Garud)
- Non-proportional multiaxial strain-life methods including Fatemi-Socie and Wang-Brown

Safety factor
- Reference stress based safety factor (including Goodman correction)
- Multiaxial safety factor using Dang Van or McDiarmid methods

Solution options
- Combination methods including maximum principal, signed shear and others
- Critical plane
- Surface finish/treatment correction
- Fatigue strength reduction factor
- Certainty of survival based on material data scatter
- Back calculation on scale factor for target life

Results
- Contour plots of life, damage and safety factors
- Log options and equivalent units
- Multiaxial assessment plots
- Time series export of stress or strain
- Matrix export of rainflow cycles
- Spreadsheet listing and sorting

General
- Interactive GUI or full batch mode
- nSoft capability for data processing including display, rainflow counting, etc.
- Customization language (nCL) for macros, integration of proprietary methods and automation
- Direct integration with nCode FATIMAS software

Computer platforms supported
- PC: Windows 95/98/2000/ME/XP or Windows NT 4.0 (SP 3 or later)
- UNIX: HP, Sun, IBM and SGI

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