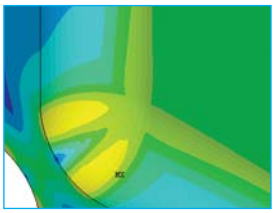
Customer Success Brief

fe-safe™

Helping Cummins get closer to reality



"In engine cylinder heads, with high assembly stresses, significant compressive stresses, and peculiar behaviours of gray cast iron, fe-safe™ software plays a vital role in helping us develop reliable, cost effective designs."

Jeff Jones, Technical Advisor.

Challenges:

- Develop a deterministic approach to predicting product life considering complex materials and loading
- Reduce internal costs of software development and maintenance
- Access appropriate fatigue theories

key fe-safe™ Capabilities:

- Comprehensive and user configurable materials library
- Integration with Cummins' Finite Element (FE) software and proprietary loading libraries
- A range of fatigue methods, including Smith-Watson-Topper (SWT) with Neuber correction

Conclusions:

- While internal software over predicted product life in some cases and under predicted it in others, fe-safe™ results correlated very well with Cummins' industry experience
- Using fe-safe™ opens up oportunities to further increase reliability and reduce costs
- Better understanding of fatigue can help improve design innovation

Innovation in power

In developing cutting edge design solutions, diesel engine manufacturer Cummins Inc, uses a deterministic approach for predicting product life, one that considers complex materials and loading. Its current solution incorporates technology from proven software leaders, but the path to this approach is not a straight line.

A recognised technology leader in the diesel engine market, Cummins faces increasingly stringent design requirements as it develops cutting edge solutions. The company's roots are planted in soil nourished by innovation. For example, the company was among the first to see the commercial potential of diesel engine technology. Even before the advent of commercial software tools, Cummins' engineers developed internal software for thermal, structural and design applications to ensure that its engine designers were cost effective, reliable and durable. Today, Cummins is no longer just an engine business, but a global power leader with more than $11 billion in annual sales.

Staying ahead of the curve

In the late 1970s Cummins continued its pioneering efforts becoming one of the first companies to embrace commercial tools for Finite Element analysis, standardising on the ANSYS mechanical analysis solver. Cummins has been an active member of the ANSYS Advisory Board for more than a decade.

However, when it came to specialised tools, such as fatigue analysis software, Cummins was reluctant to make the move. Commercial software in this area had been lacking in a number of areas, such as a wide range of fatigue theories, support for proprietary materials and loads, and integration with FE software. However, in 2002 Cummins turned to Safe Technology Limited, developer of fe-safe™, the technical leader in the design and development of durability software, having recognised that Safe Technology Limited had developed a suite of fatigue software that was no longer constrained by these limitations. Cummins has since continued to play a vital role in the long term development of fe-safe™.

A unified approach?

To verify that fe-safe™ offered accurate life prediction capabilities, Cummins executed a sophisticated test plan to compare fe-safe™ results to internal fatigue analysis software. The test plan included four FE models:

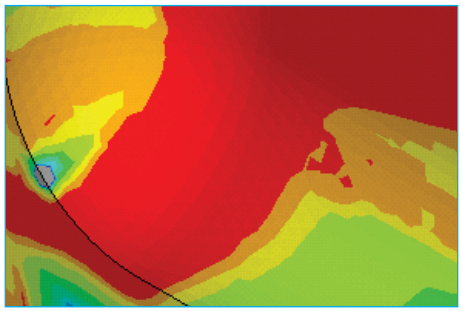
- Simple 2D, plane stress, uniaxial model
- Moderate 3D, biaxial stress model
- Fully featured engine block
- Fully featured engine head

Each model was subject to a number of different and appropriate loading scenarios. By using a range of models, Cummins were able to gain fundamental insights into the technology and compare predictions against field data.

Stress-based vs strain-based analysis

For load cases dominated by tensile stresses, the Goodman-based internal software provided results that were consistent with the SWT approach. However, in the biaxial case dominated by compressive stress, the internal software predicted much more damage than fe-safe™, implying that a stress-based approach in this case may result in an overly conservative design.

Complex, real world models of a cylinder block and head, considering standard proprietary loading conditions, produced more noticeable differences. Stress situations for two complex load cases were compared at over 20 locations for which considerable test experience existed. In nearly all cases, fe-safe™ results were in-line with expectations, while the Goodman-based approach predicted less damage at several locations (thus over predicting product life). A closer review at three critical locations revealed that for cases with high mean, low alternating stresses, fe-safe™ provided results that agreed very well with test and field experience.



Conclusions

- While internal software over-predicted product life in some cases and under-predicted it in others, fe-safe™ results consistently correlated very well with Cummins' industry experience
- Even with modifications, older stress-based approaches for predicting fatigue were limited when compared with modern, strain-based methods
- Use of ANSYS mechanical solver and fe-safe™ offered opportunities to further increase reliability and reduce costs
- A better understanding of fatigue facilitates design innovation

A winning combination

A noted contributing factor to the successful outcome of the testing was the tight integration between fe-safe™ and ANSYS Mechanical. Using fe-safe™, the ANSYS results (.rst) file is read, material properties and fatigue cycle (combinations of load steps) are specified, and the fatigue damage is calculated and written back to an ANSYS results file for display in ANSYS Mechanical. Fatigue results may be plotted as contours of life (i.e cycle or time to failiure) or factors of strength (i.e. design margin). Another important factor was the ability to use comprehensive and user configurable libraries, facilitating use of internal, proprietary materials data with minimal effort.

Today at Cummins, fe-safe™ is used to perform fatigue analysis for all its cylinder blocks, cylinder heads, pistons, connecting rods and main bearing caps. Advanced fatigue analysis using fe-safe™ helps to get designs right first time and reduce development costs.

safe technology limited

Safe Technology Limited is the technical leader in the design and development of durability software and is dedicated to meeting its customers' most demanding applications.

As a private company, Safe Technology is able to take a long-term view of software development and the research and industry collaboration needed to address real world, industrial applications. Its independence and focus enables quick response to customer feedback so that its software genuinely reflects the industrial and commercial requirements of engineers and designers.

In-depth knowledge of fatigue combined with expertise in software development allows Safe Technology to provide outstanding service - with standard and advanced training, software support, and consulting services provided by fatigue experts.

Safe Technology develops, markets and supports its software products directly from offices in the UK and USA, by a network of independent distributors worldwide and via the worldwide SIMULIA network.

To learn more, please visit our website where you can learn about our software products and related services, and register to download technical papers by our users on real world applications. You can also find the contact details for your local office or representative.

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