Husqvarna Group: Leveraging MSC Nastran Embedded Fatigue **Significantly Increases Result Precision**

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Durability analysis, including material fatigue life prediction, is a very important part of Computer Aided Engineering. It provides valuable information about the product service life, which highly influences customer experience and satisfaction. Husqvarna Group, global leading producer of outdoor power products, count on MSC Software's Nastran Embedded Fatigue (NEF) as the heart of an optimized, efficient process for fatigue analysis.

Fatigue in any part of the product is caused by vibrations from the two-stroke engine, which drives for example a chainsaw or a handheld power cutter (figure 1). A clear understanding of this phenomena is needed before going into production. That is why virtual prototyping is used to assess where the material could fail and to strengthen the part structural integrity accordingly. For virtual prototyping, a system model of the device is created consisting of the engine, housing and surrounding parts like fuel tank and covers. Boundary conditions represent the handle and how the force is transferred to the operator's hands.

This article focuses on showing how we are able to count on MSC Software's Nastran Embedded Fatigue as the heart of an optimized, efficient process for fatigue analysis. Optimized Nastran Embedded Fatigue process created considerably smaller amount of data and hence the large intermediate results files, with their tedious re-import, are no longer needed.

Figure 1 Husqvarna Handheld Power Cutter

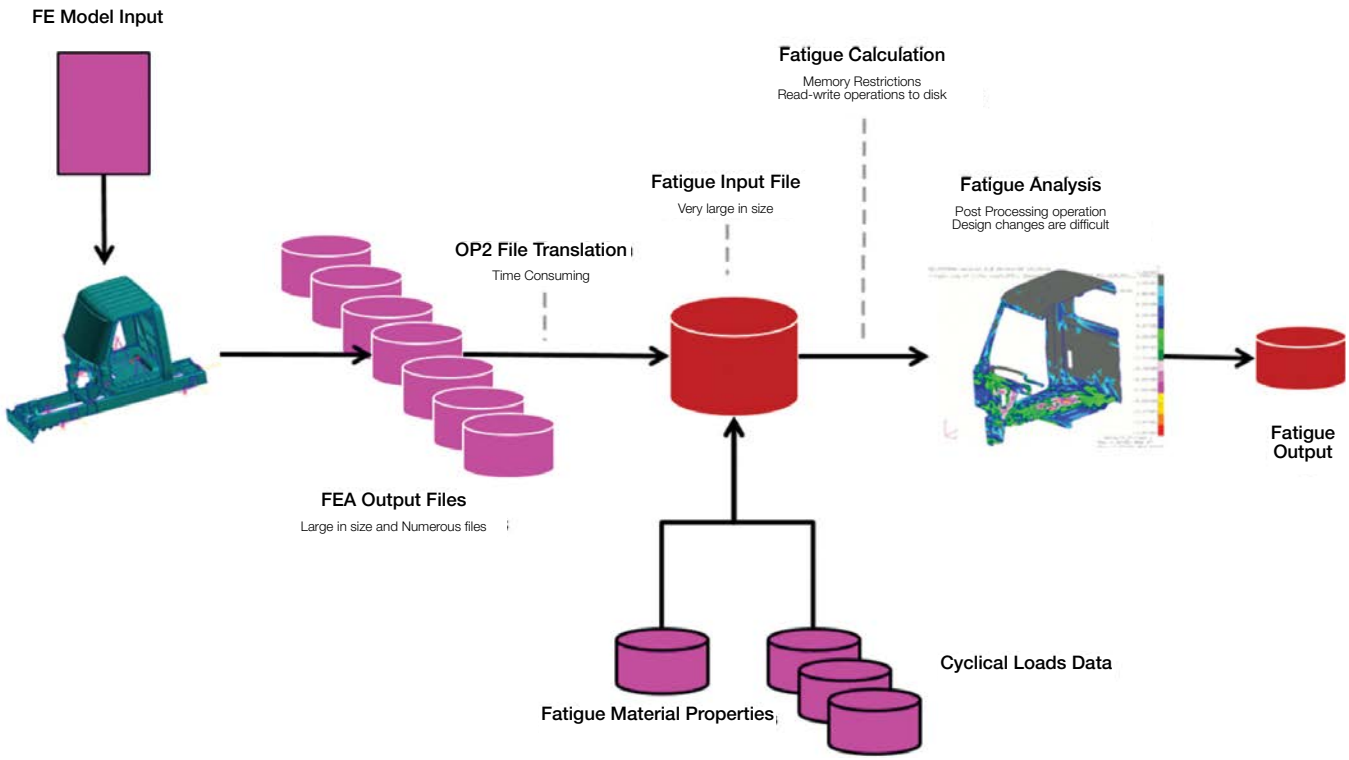

Figure 2 Traditional Fatigue Analysis Workflow

Traditional Fatigue Analysis Process

Structural vibration analysis with MSC Nastran has a long tradition at Husqvarna. It has been constantly improved, for example by increasing the complexity of the models. But fatigue analysis initially posed some difficulties for the engineers.

Conventional strength and fatigue analysis consists of several steps:

1. Finite Element model definition
2. Structural Vibration analysis
3. Analysis output which may contain large results files
4. MSC Nastran Results file import into a separate fatigue software, which is very time-consuming
5. Many read and write operations that can lead to memory problems
6. Postprocessing of fatigue life results

This is a tedious process which does not easily allow design optimizations. We were only able to optimize short time intervals, more precisely, just one engine revolution. The limitation is caused by the extraction of the stress data, which means large results files and therefore long run times.

The MSC Nastran – Adams process yields the modal deformations, stress time histories and stress peaks. Actually, we wanted to analyze a period of 1 second, but could only manage one stroke. We had to reduce the number of output steps to 40 and already reached 40 GB of results file size, giving the example of a crankcase analysis. Moreover, the resolution was not high enough to ensure to hit the maximum of the stress history.

Analyzing longer periods of time is important to assure that a specific system mode of interest is excited by any multiple of the engine revolution speed. This governs a more robust analysis regarding modeling uncertainties. The workflow had already been significantly accelerated by the close coupling of the motion solver (Adams) and the Finite Element Analysis tool (MSC Nastran). Using NEF, Husqvarna was able to enhance the process even further.

At the beginning of the systematization of the NEF process at Husqvarna, first there was no clearly defined workflow for durability analysis. This changed when MSC's Nastran Embedded Fatigue became available. After a year of intensive evaluation, we decided to use NEF in productive operation for vibration analysis.

Nastran Embedded Fatigue – Innovation and Disruption

The difference between Nastran Embedded Fatigue (NEF) and the traditional process is that NEF does not need to

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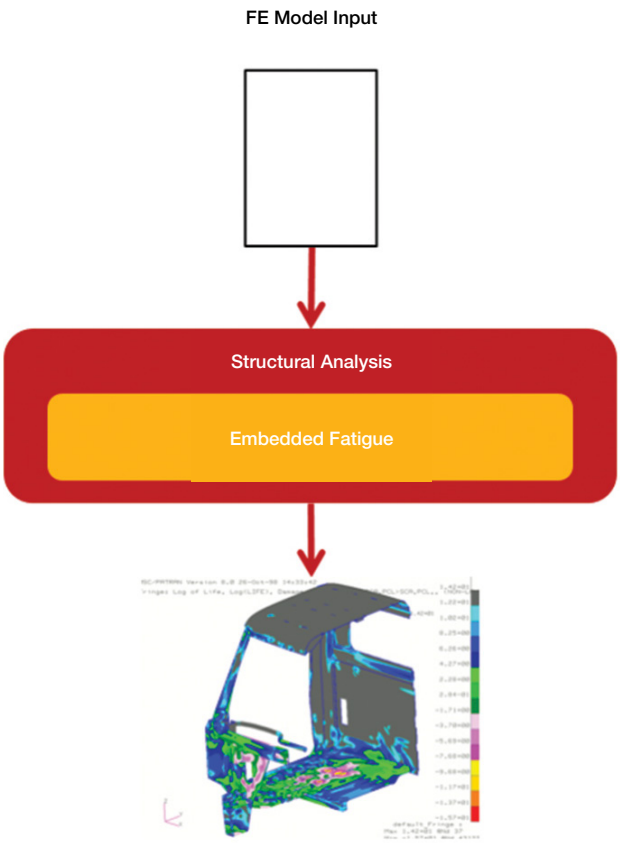


Figure 3 Nastran Embedded Fatigue Process

export and import large binary results files, as the fatigue analysis is done directly in MSC Nastran - a considerable gain in efficiency. (Figure 3)

To illustrate that, let’s look again at the example of the above-mentioned crank case: today it consists of 250,000 shell elements, 200 strokes, 30,000 output steps and a universal output results file of just 50 MB size. In contrast to the traditional process, which had 250,000 shell elements, only 1 stroke, and 40 output steps, but a 40 GB output results file. A longer time, for example 200 strokes – about 1 second – can now be analyzed with ease, leading to a significant increase in result precision.

Fatigue Material Data and Reality

Of course we know well that our modelling is not perfect. Imprecisions must be taken into account. For example, the analysis assumes a uniform temperature, though there may be a significant temperature distribution in a component. Another simplification is the modelling of attachments. Thus, the calculated Eigen frequencies may deviate from the true values. Also, some assumptions are made concerning the engine revolution speed. On the other hand, this gets easier because a longer time can be simulated now, which helps to even out fluctuations.

The fatigue life result is improved by calibrating the input fatigue material data (the S-N curve) to real life testing. We

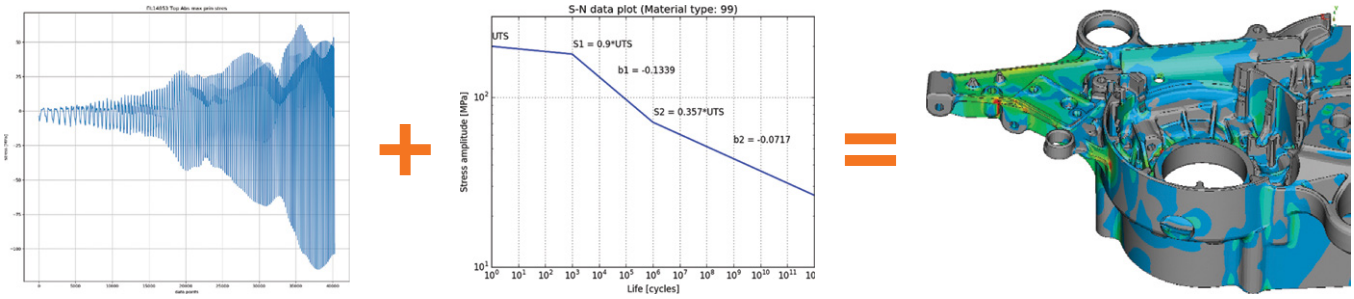


Figure 4 Nastran Embedded Fatigue Process: Structural Analysis Results + S-N Data Plot = Fatigue outputs such as stress, Damage, Life

modelled a physical fatigue test and the stress range was transformed via the Goodman relation for adjustments of the S-N curve. The Goodman relation (Haigh diagram) is used to quantify the interaction of mean and alternating stresses on the fatigue life.

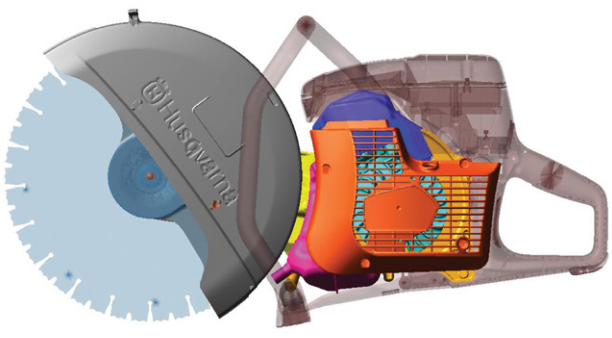
What was Achieved?

The optimized Nastran Embedded Fatigue process creates a considerably smaller amount of data. The large intermediate results files, with their tedious re-import, are no longer needed.

“We can analyze the whole load cycle, not only the immediate surrounding of load peaks,” Fälth says. The process has proven to be robust to changes in the excitation. Data transfer takes much less time, because there are only MB of data instead of GB. NEF has useful functionality to automatically generate S-N curves from a smaller amount of input data.

Also, the system model is now created by a black-box approach. Adams runs in a scripted environment. This means a democratization of analysis and simulation: Far more simulation engineers than before can do the high-end durability analysis, as they don’t need to understand the exact details of the process. The geometry of Husqvarna products can be optimized in very efficient iteration cycles.

When cutting through hard materials like concrete, the professional power cutter experiences unsteady exterior forces. The influence of this behavior on durability and potential fracture of the power cutter can be evaluated in much more detail with the help of NEF. The analysis is comprised of 250 strokes (2 s), 140 force pulses acting on the structure, and 60 000 stress output steps.



About Husqvarna

Husqvarna Group is a global leading producer of outdoor power products for forest, park and garden care. Products include chainsaws, trimmers, and robotic lawn mowers and ride-on lawn mowers.

The Group also produces machines for the construction and stone industries. The Group’s products and solutions are sold under brands including Husqvarna, Gardena, McCulloch, Poulan Pro, Weed Eater, Flymo, Jonsered, Diamant Boart, and RedMax.