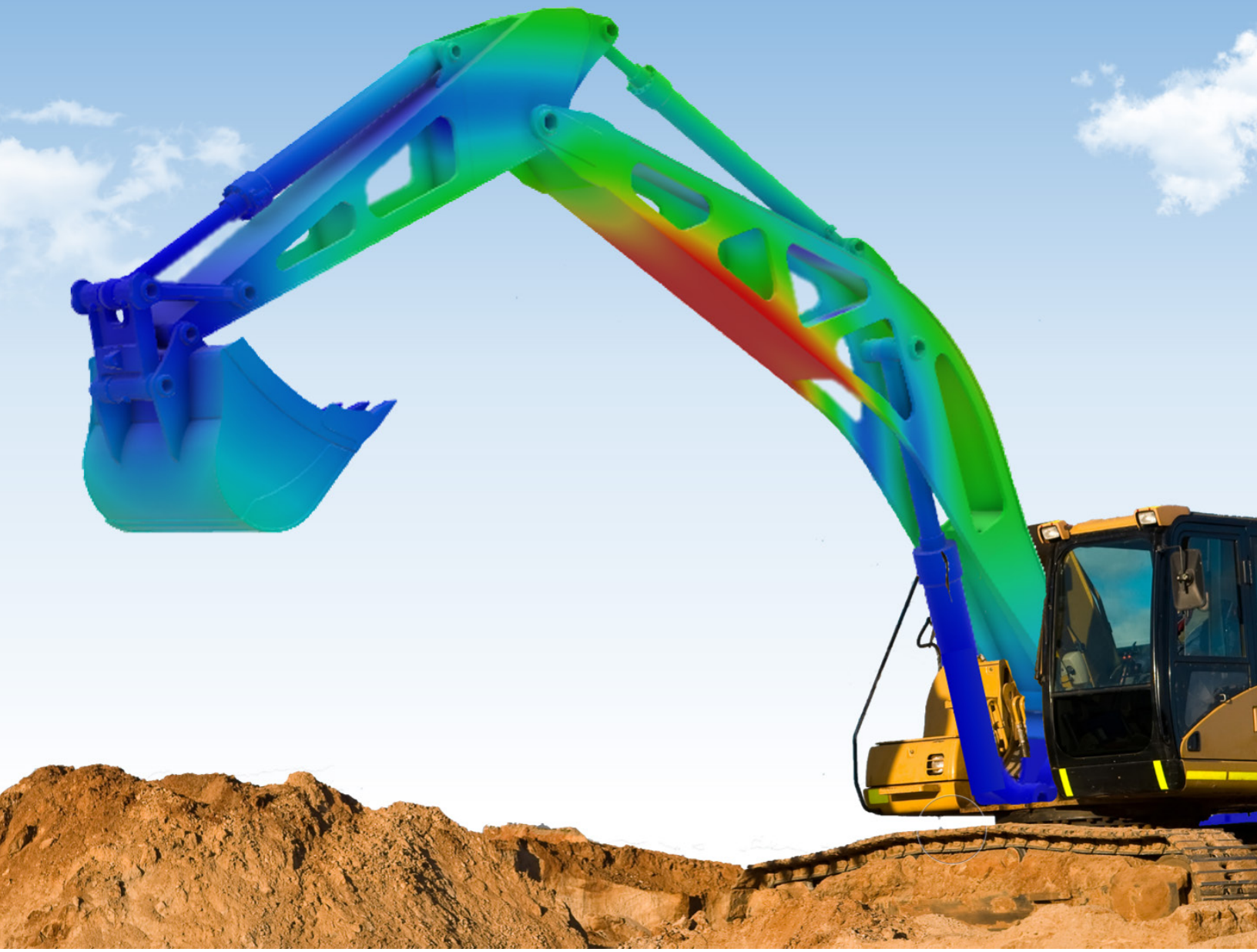
SIMULIA

3DEXPERIENCE®

ENSURING EQUIPMENT STRENGTH AND DURABILITY WITH SIMULATION



DASSAULT SYSTEMES

EXECUTIVE SUMMARY

From a performance and reliability perspective, industrial equipment is one of the most challenging sectors of mechanical engineering. Depending on the application, machinery might have to be able to operate in real world conditions under very heavy loads, operate at incredible speeds without overheating, or run for extremely long operating cycles without succumbing prematurely to wear and fatigue. The cost to manufacturers of repairing or replacing a failed unit under warranty, plus the reputational damage caused by unreliability, means that companies working in the industrial equipment space need to be sure their products will work reliably in real-world conditions before committing to production.

Simulation allows engineers to model equipment operation virtually. Implementing multi-physics, multi-scale simulation in the design process can accelerate product development, reduce costs, allow more product variants, and minimize the risk of product failure. This whitepaper explains how the simulation tools from SIMULIA, a brand of Dassault Systèmes, haven been integrated into the industrial equipment design process by leading manufacturers to evaluate product failures and minimize warranty costs life for single component or large assemblies, including welded structures.

BENEFITS OF SIMULATION WITH SIMULIA

The simulation tools from SIMULIA, a brand of Dassault Systèmes, allow companies to overcome the challenges of industrial equipment design. SIMULIA offers a broad range of simulation technology covering many different fields of physics, including structural, thermal, fluid dynamics and electromagnetics. The powerful structural simulation tools calculate structural integrity subject to both static and dynamic loads and to evaluate the lift of the equipment with different loading cycles, while the link to other types of simulation enables specialist applications such as induction hardening and lubrication to be analyzed.

The biggest challenge for any industrial equipment manufacturer is to avoid product failure to reduce the service downtime and warranty costs. Heavy machinery is prone to wear and fatigue from operating under heavy loads over long periods, and any failure can be not only very expensive but also pose a safety hazard to people working around the equipment. Often, this means overdesigning to guarantee safety, but this increases manufacturing costs and can reduce performance.

As most industries are entering a period of disruption from new smart manufacturing methods, operators are demanding more sophisticated machinery. Industrial equipment manufacturers need to innovate quickly while still keeping costs down and maintaining or even bettering the standards of reliability and performance that customers expect. As well demanding higher performance and increased reliability, customers are also increasingly demanding more customized equipment tailored to their own requirements. This has led to an increase in product variants and equipment combinations and an explosion in the number of design concepts engineers need to analyze.

Virtual testing with simulation reduces the number of prototypes needed, reducing development time and cost and allowing more product variants to be studied. It also makes it possible to analyze structural integrity and fatigue over the entire lifecycle rapidly, and to model the performance of the equipment in a challenging real world environment such as a construction site or mine. SIMULIA customers have seen a 12% reduction of total product development time and a 100% increase production capacity.

Simulation doesn't just allow existing designs to be analyzed, it also suggests new design ideas. Alongside its simulation tools, SIMULIA offers optimization software as well, which can be used to increase the durability of a part or to find places where material be reshaped or removed without affecting the structural integrity. This avoids the need for over-engineering, reduces costs, allows lighter and stronger designs, and accelerates innovation. One SIMULIA customer was able to achieve a 50% weight reduction in the truck tray using structural simulation.

SIMULIA tools are integrated both with each other and with other Dassault Systèmes products such as CATIA on the **3D**EXPERIENCE® platform. Dedicated workflows for model and simulation set-up allow non-experts to run their analysis and extract useful results quickly, and the

connection to the design tools means that changes to the design can be seen immediately in the simulation model and the optimized geometry can be exported back. Customers have seen between 10% and 40% speed-up in simulation model set-up and have found that updating the simulation after a design change is over 10 times faster. The **3D**EXPERIENCE platform also allows designs and simulation results to be shared among the team while retaining control over sensitive and confidential data.

SECTORS

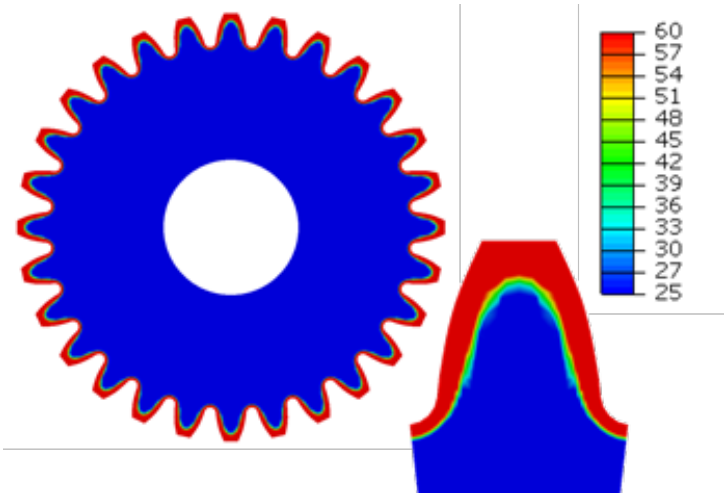
Industrial machinery

For industrial machinery, there are usually numerous precisely machined parts in close contact, and wear is a major concern. Many SIMULIA workflows for this sector involve the structural analysis of components such as threaded joints, bearings and gears, while others involve simulating industrial processes such as extrusion, welding and shot peening.

Best-in-class general contact capabilities provide accurate structural simulation results followed by fatigue life prediction, and adaptive meshing technology along with user subroutine UMESHMOTION, allows incorporation of general wear laws to predict wear behavior accurately. Coupled structural, thermal and electromagnetic simulation allows the physics of complex induction hardening process to be captured. As an example, we illustrate the benefits of SIMULIA solutions in the context of induction hardening.

Induction hardening is a very powerful contactless method for increasing the hardness of materials in a selective and controlled way. It is a complex manufacturing process whose process parameters are often determined by trial and error method and are based on the process engineer's experience. Unfortunately, trial and error methods reveal little about the underlying physics and when cracks begin to appear post-hardening engineers hit a dead wall in pinpointing the issues. Simulations reveal the true nature of the underlying complex multiphysics providing ready insights on how different choices for process parameters affect the hardening of various components.

SIMULIA provides solutions for analyzing the various stages of an induction hardening process. Process engineers can perform fully coupled electromagnetic-thermal-structural co-simulations

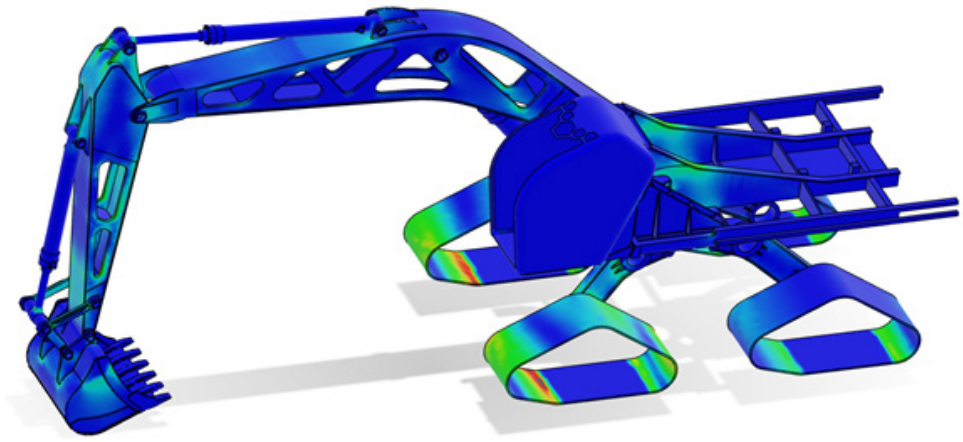


Hardness in a gear treated by dual-frequency induction hardening

to accurately account for the material phase transformations and the intertwined effects on the electromagnetically induced heat. The engineers have the ability to restart simulations from a previous stage to evaluate the effect of process parameters in any given stage. The engineers can analyse the residual stress, predict fatigue life while accounting for the thermal management of induction coils all at once in a single simulation. Many different types of induction hardening processes such as pulsed and dual frequency hardening can be modelled while also accounting for various coil designs for better localization of induced heat.

Heavy mobile equipment

Important considerations in this field include the attachment of components such as buckets, the strength of the wheels or tracks, and fatigue in the thin-welded structures of the body. The interaction with the environment is also critical, and SIMULIA offers workflows for simulation material handling and the interacting of digging equipment with the ground.



Excavator arms are one application where thin welded structures have to bear enormous strain.

This sector lies on the intersection of the industrial equipment and automotive industries, and many of SIMULIA's transportation and mobility workflows such as suspension performance and tire engineering are also relevant here.

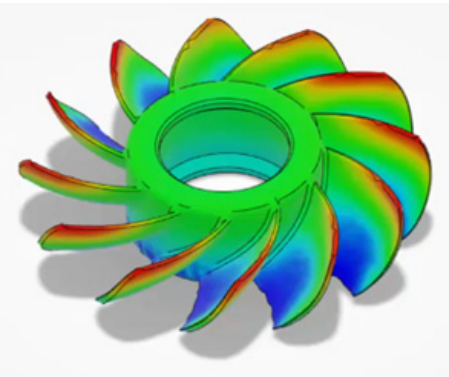
Weld fatigue is a common concern across many types of industrial equipment, as vibration is the primary cause of weld fatigue. Transient modal dynamics is an efficient way to capture the stress strain variation on the structures. SIMULIA software can be used to analyze the fatigue life of welded joints, using vibration loads from either simulation or test data.

The support for mid-surface and weld line extractions makes geometry clean-up and mesh creation faster. The geometric associativity of these extractions means that any changes to geometry get automatically reflected in the extracted surfaces, saving a huge amount of time for simulation analysts.

Because SIMULIA software is available in the **3D**EXPERIENCE platform, design requirements can be tracked in a **3D**EXPERIENCE dashboard alongside the simulation. This makes it easier to compare the results of the simulation against the specifications and ensure that targets and regulations are met.

Turbomachinery

Rotating components are the primary concern when designing turbomachinery, and SIMULIA provides best-in-class tools for rotodynamic analysis. Turbine blades and pump impellers experience especially strong dynamic forces from fluid flow, and there are special workflows for analyzing stress and fatigue life in these components. Turbocharger impellers can even be optimized to improve fatigue life. Heating is another concern, and coupled thermal and structural simulation can calculate the temperature distribution and resulting stress in components such



The heat produced in cooling fan impellers in operation can require thermal stress analysis

as rotors and cooling fans. The life of turbine components is often measured in the hundreds of thousands or millions of cycles, so fatigue life optimization is also key to ensuring components can meet this without over-engineering.

Shot peening is often used to shape and strengthen components such as crankshafts and turbine blades. The impact of tiny particles on the surface compresses and tenses the metal, and can make it more resistant to fatigue. The shot peening process can be simulated in SIMULIA tools by the discrete element method (DEM), which is developed to model the behavior of large numbers of small discrete particles. SIMULIA simulation tools can be used to assess the performance of the shot peening process and verify that fatigue life targets can be met.

Powertrain

Powertrain components are subject to massive forces and torques and often operate at great speed. SIMULIA simulation tools can be used to calculate the stress within rotating and reciprocating components, and the heating of the powertrain assembly. However, they can also be used to model the lubrication between components, with thin-film elastohydrodynamic analysis and as well as sealing analysis of joints. Thermal fatigue can also be analyzed to calculate fatigue life at high temperature, and optimization can improve the fatigue life of the powertrain.

CONCLUSION

SIMULIA offers a full package of simulation tools for the design, analysis and optimization of industrial equipment. The linkage of SIMULIA tools and other Dassault Systèmes software on the **3D**EXPERIENCE platform facilitates the sharing of information between team members and departments, and means that design data can be quickly converted into a simulation project and run without having to be a simulation specialist. From validating manufacturing processes to assessing performance in deployment, simulation reduces costs, accelerates development and mitigates safety and reliability issues at every step of the design process.

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