SIMULIA Strategy for Turbomachinery Innovation

Realistic Simulation, Design Optimization, and Simulation Lifecycle Management

Jack Cofer, Turbomachinery Industry Lead, SIMULIA Technical Marketing

Image courtesy of Alstom

Turbomachines have been at the heart of human industry for thousands of years—from the early Roman water wheels of the first century B.C. to the modern pumps, turbines, and aircraft engines of today. Turbomachinery engineers continue to strive for the same goals as their Roman ancestors—to improve efficiency and reliability to meet the needs of society within an increasingly challenging marketplace.

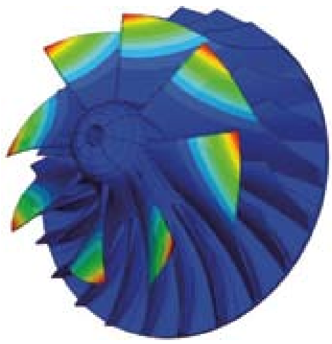
Turbomachines are used in many industries and designed in many shapes and sizes, from the tiny millimeter-scale gas turbines being developed to power cell phones and laptops to the massive steam, gas, and hydro turbines found in power plants all over the world. Whether the purpose of the turbomachine is to pump fluids through pipes, compress gases in industrial processes, or generate thrust for an aircraft, designers share a common need to design the most efficient and reliable product at the lowest cost, in the shortest amount of time.

Realistic Simulation Solutions

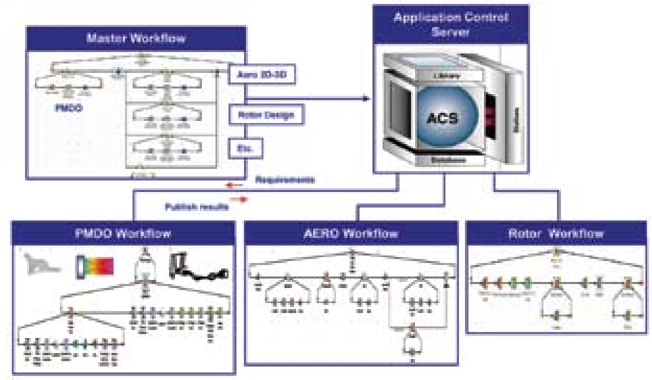
Most turbomachines operate in extreme conditions of temperature, pressure, and stress. Operational forces are extremely high in the rotating components. This environment puts many engineering disciplines in conflict, such as aerodynamics, stress and vibration, and durability. SIMULIA is providing leading-edge simulation, automation, and optimization technologies to enable turbomachinery companies to design competitive machines that achieve the optimum balance between efficiency requirements, mechanical reliability, and manufacturing cost.

Our Abaqus Unified FEA product suite provides a comprehensive set of capabilities including static, dynamic, thermal, acoustic, linear, and nonlinear analyses. These capabilities are well-suited for many common turbomachinery design tasks, including stress and vibration analysis for blading, structural design of rotors, and creep and fracture analysis. The enhanced XFEM capability in Abaqus 6.9 is especially useful for investigating the formation and propagation of cracks in stationary and rotating components.

In this issue's cover story, Alstom Power describes their use of Abaqus to rapidly evaluate and minimize steam turbine start-up time without exceeding stress limits in the rotor. Turbocharger companies are using Abaqus, coupled with CFD codes, to determine centrifugal impeller blade vibration characteristics caused by unsteady flow interactions between the compressor and the vaned diffuser-volute. Aircraft engine companies use it for such applications as analyzing the blade/wheel connections for both compressor and turbine blades, predicting stresses and life for combustor liners, and performing failure analyses in disks. Steam and gas turbine companies use it for applications including stress, vibration, and probabilistic high-cycle fatigue analyses in stationary and rotating blades. Wind turbine companies increasingly rely on Abaqus for composites modeling and simulation to develop lightweight blades with high strength and durability over a wide range of operating conditions.



In this example, calculated mode shapes are shown for a centrifugal compressor impeller. Image courtesy of ABB Turbo Systems Ltd., from ASME paper GT2009-59046.



This is an example of an aircraft engine design process integrated with Isight. With the addition of SLM and an application control server (ACS), multiple processes located on servers at different company sites can be linked together and the process models and simulation data can be managed and shared in a collaborative environment. Image courtesy of Pratt & Whitney.

Automation and Optimization

Turbomachinery design engineers face an inherently multidisciplinary optimization problem with many conflicting design objectives and constraints. To meet this challenge, many turbomachinery companies are using Isight to automate highly complex simulation-based design processes and apply advanced numerical optimization methods to improve performance and reliability. Isight was developed in the 1980s for aircraft engine optimization, and since then has been used by more than 80 companies for many design tasks including cycle optimization, preliminary design and stage layout, and aero/mechanical design of axial airfoils and centrifugal impellers. Isight is used to link together in-house and commercial CAD and simulation codes to automate design and simulation process flows. Expert design rules and constraints are captured in these process flows, enabling various optimization strategies to be applied. Engineers are able to use advanced numerical optimization methods—including DOE, Monte Carlo, and Design for Six Sigma—to explore design envelopes and automatically search the design space to optimize their design for performance goals such as stress, weight, and cost.

Dramatic improvements in performance and reliability can be achieved along with cycle-time reductions of 5 to 10 times compared to traditional manual methods. As exemplified in the article from Rolls-Royce on page 4 of this issue, many companies are now using Isight to achieve robust designs that are insensitive to uncertainties and variability in such things as manufacturing tolerances, material properties, and loading conditions. When combined with SIMULIA SLM and the SIMULIA Execution Engine (formerly called Fiper), extremely large and complex design processes can be captured and managed in a collaborative design environment.

The Value of SLM

The simulation-based processes used to design turbomachines are almost as complex as the machines themselves. These processes produce a tremendous volume of data, and engineering organizations can easily be overwhelmed with process management issues. SIMULIA's Simulation Lifecycle Management (SLM) solution has been developed to bring order to large-scale simulation by combining Product Lifecycle Management (PLM) tools with Isight and the SIMULIA Execution Engine to create a powerful collaborative design environment.

SLM also allows companies to collaborate seamlessly across engineering disciplines, organizations, and suppliers to take advantage of all available global resources in manpower, computing power, and manufacturing capacity. It leverages and secures your simulation intellectual property by facilitating the capture, standardization, and reuse of expert-generated workflows and knowledge, and it enables effective management of data, methods, and processes. It connects individual engineers and design teams to each other and to the enterprise, allowing them to share applications, models, data, and results to ensure that they make the best design decisions. It provides an open platform to manage and deploy in-house and third-party applications, and lowers your computer hardware investment by making effective use of all available computing resources, no matter where they might be located. A number of our major turbomachinery customers have already embraced our SLM technology as the platform for their design environment and are working with us to improve its capabilities to meet their future needs.

Customer-Focused Solutions

SIMULIA's strategy for serving the turbomachinery industry is to engage in an open dialogue with our customers and industry consortiums to address both the technology and business needs of the industry. We are already hard at work making a number of important improvements to Abaqus in the areas of rotordynamics, blade stress and vibration analysis, and cavity radiation. We have introduced a new extension to Isight called Eblade 2.0 that integrates many common airfoil design tools in an easy-to-use GUI for the automated multidisciplinary aero/mechanical optimization of axial turbine blades. We are forging new partnerships with key providers of complementary technology, and are developing an extensive library of components that will allow many common software packages used by turbomachinery designers to be easily integrated with Isight. We are committed to working closely with our customers to determine their future needs for enhancements to SIMULIA products to enable them to design the efficient, reliable, and cost-effective turbomachines that their customers demand.

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Jack is responsible for developing and directing SIMULIA strategy for the turbomachinery industry. He has over 35 years of experience in turbomachinery design and optimization achieved through various design and management roles at GE Power Generation, Demag Delaval Turbomachinery, and Engineous Software. He has a B.S. from the University of Virginia, a M.S. from the Massachusetts Institute of Technology, and a M.E. from Northeastern University.

For More Information
www.simulia.com/solutions/turbomachinery