INSIGHTS

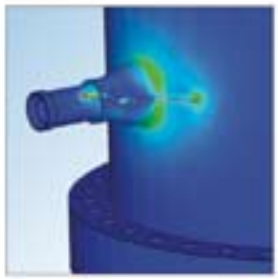
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6 2009
Dassault Systèmes Realistic Simulation Magazine



When Animation Meets Simulation:
Kimberly-Clark Pushes the Technology Envelope



TenCate
Artificial Turf Simulation



Abaqus 6.9
New Capabilities for Realistic Simulation

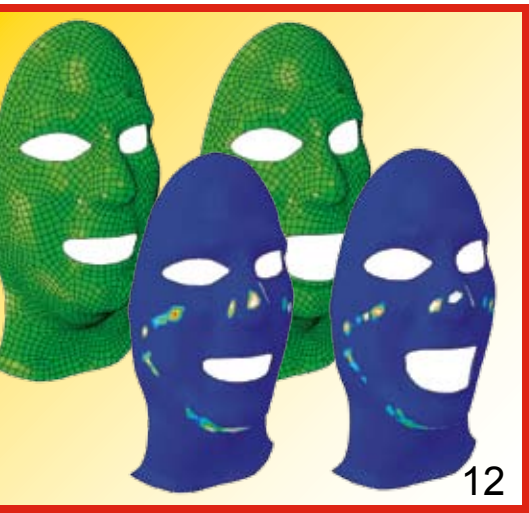


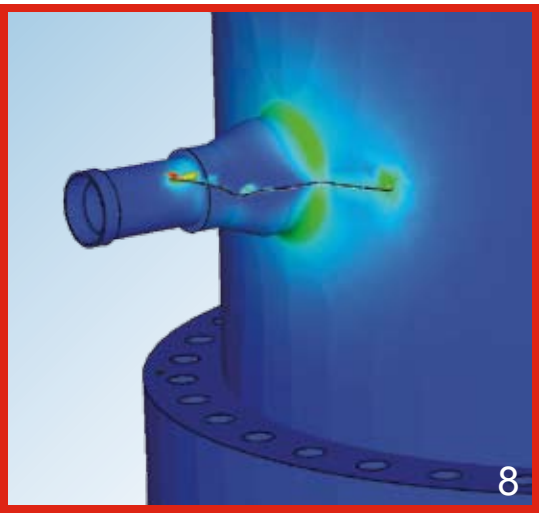
Toyobo
The Analysis of Comfort

SIMULIA

INSIGHTS

May/June 2009







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Increased Market Pressures Require Increased Commitment

In today's challenging global economic climate, we are acutely aware of our customers' needs to reduce costs, be more efficient, and seek strategies that will enable them to emerge from the recession stronger. The pursuit of innovation does not stop during an economic downturn but, in fact, accelerates as individuals and companies seek new solutions to continue their mission to deliver valuable products to the market.

The pursuit of innovation is well-documented by the case studies in this issue of *INSIGHTS*. Toyobo in Japan is improving the performance of textiles for clothing (*INSIGHTS,* p. 16), Kimberly-Clark is using a unique combination of technologies to develop more reliable dust masks (*INSIGHTS,* p. 12), and Silgan Containers is helping its customers get to market faster with products that have the right performance attributes (*INSIGHTS,* p. 11). We appreciate our customers' willingness to share their experiences. At this year's SIMULIA Customer Conference, the record number of customer papers presented included many impressive examples of innovation, efficiency improvements, and cost savings.

One of the best parts of my job is the many meetings and conversations that I have with customers around the world. A consistent theme is that the increased use of realistic simulation technology is one of their key strategies for meeting their engineering challenges and efficiency targets. Frank Popielas of Dana strongly recommends that manufacturers invest now and stay current with software releases so that they gain the most benefit from key software enhancements, especially in the area of high-performance computing (*INSIGHTS,* p. 22).

While investment will ensure that companies emerge from the downturn stronger, there is also an imperative to reduce costs and be more productive. I am often surprised by the large number of different simulation tools that companies use, usually for historical reasons. Consolidating analysis tools has the potential to significantly reduce software and training costs and allow more flexible use of staff. The many new features in Abaqus 6.9 (*INSIGHTS,* p. 8) continue to broaden the range of applications that Abaqus can address, allowing more of your simulations to be performed within the Abaqus unified FEA environment.

Our Isight and SLM products also offer the potential for dramatic productivity gains. Our customers report that simulation processes that have traditionally taken weeks to perform are now taking days—or even just a few hours—due to Isight's powerful process automation and design optimization capabilities.

The recent announcement that Procter & Gamble (*INSIGHTS,* p. 4) is leveraging SIMULIA SLM demonstrates that our simulation lifecycle management strategy is supporting our customers' need to improve and secure their simulation processes. By enabling process and data management, collaboration, and decision-making traceability, SIMULIA SLM is another tool that you can use to ensure that simulation is providing measurable business benefits to your company.

Our goal is to not only provide software, but to partner with you to help your organization and company become more competitive in delivering better products to the market. We are confident that our strategy of developing robust, unified, and scalable simulation technology, as well as our new solutions for process automation, optimization, and simulation management, will help you meet today's economic challenges and achieve competitive advantage well into the future.



Roger Keene
Vice President,
Worldwide Operations,
SIMULIA

Procter & Gamble Selects Dassault Systèmes as Enterprise Simulation Partner

Procter & Gamble Company (P&G) has selected SIMULIA SLM as their simulation lifecycle management solution to support P&G's modeling and simulation strategy. The announcement evolves their long-standing business relationship with SIMULIA in the simulation domain from one of solution provider and customer into a strategic, collaborative partnership.

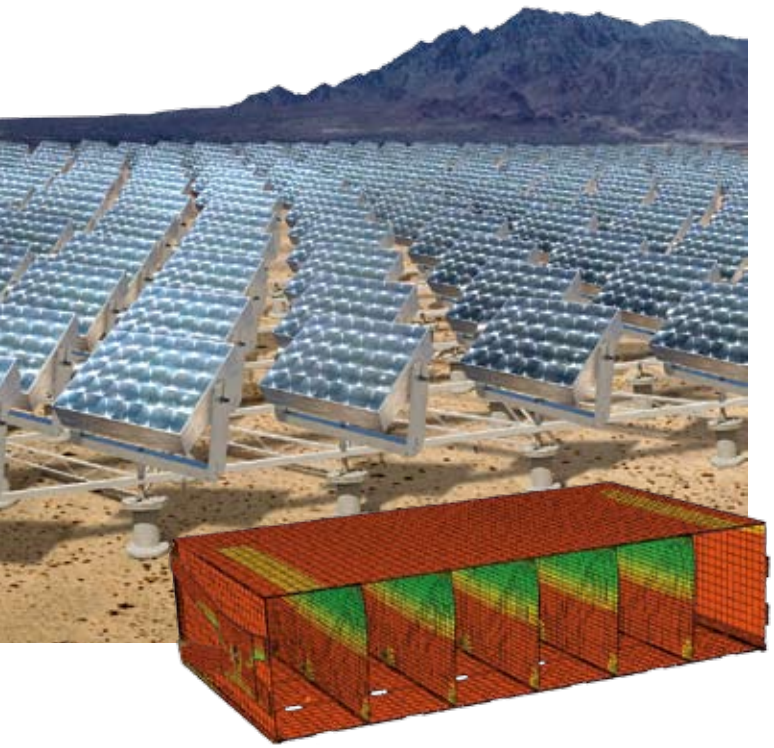
"P&G shares a common vision with SIMULIA regarding the democratization of predictive simulation," said Tom Lange, Director, Corporate R&D Modeling and Simulation, Procter & Gamble. "It is our goal to make the benefits of realistic simulation available to a broader range of users than previously possible. SIMULIA SLM will help our global teams accelerate innovation by providing access to simulation tools, validated processes, and corporate knowledge bases throughout the product lifecycle."

Based on Dassault Systèmes' V6 platform, the online collaborative environment for PLM 2.0, SIMULIA SLM enables engineering organizations to capture, share, and automate the execution of approved simulation methods, improve traceability of simulation data, and accelerate decision-making while securing valuable intellectual property.

"The partnership with SIMULIA will help the company develop better products and test them more efficiently—ultimately lowering costs and accelerating delivery of innovative products to consumers," stated Scott Berkey, CEO, SIMULIA.

>> www.pg.com





Sunflower HCPV energy production simulation is performed using Abaqus to analyze deformation caused by exposure to environmental conditions.

Energy Innovations Drives Down Cost of Solar Energy

Energy Innovations, Inc., a developer of High Concentration Photovoltaic (HCPV) solar products, is making solar energy more affordable with the help of Abaqus FEA software. The Sunflower™, their flagship product line, integrates photovoltaic modules, advanced tracking, unique power optimization, an embedded controller, and wireless communication to produce cost-competitive solar power while reducing installation and maintenance costs.

Energy Innovations has been able to optimize their unique concentrating photovoltaic design product using Abaqus to simulate the effects of nonlinear materials and loads such as gravity, wind, and shipping loads.

"Abaqus FEA provides the usability and robustness we need to evaluate realistic performance during the design phase," stated Mindy Jacobson, Lead Engineer, Energy Innovations. "By leveraging realistic simulation solutions from SIMULIA, we are able to develop the most cost-efficient design, which is helping us drive the price of solar-electricity below the price of fossil-fuel electricity."

>> www.energyinnovations.com



Cambridge University Students Race to Design Solar Car



Photo courtesy of Chellevan

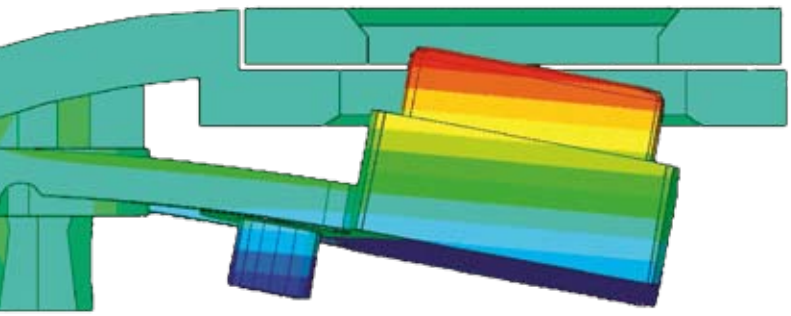
A team of Cambridge University engineering students is using SolidWorks 3D CAD and Abaqus FEA to develop a solar-powered car they will race across Australia in the fall of 2009. More spaceship than road vehicle, the car's flat shape will feature a large solar panel that converts the sun's energy into speeds of 60 miles per hour or faster as the team races against other teams from around the world.

The World Solar Challenge is a biannual event drawing about 40 teams from universities, car manufacturers, and individuals to race across 3,000 kilometers of the Australian outback. This will be the first World Solar Challenge for Cambridge University Eco Racing, and the team is finalizing the car's design and testing in SolidWorks and Abaqus.



"When you think about it, this is just one big optimization problem to solve," said Charlie Watt, a fourth-year graduate student and Eco Racing Team Leader. "The solar panels we use only generate about one kilowatt of power, which is what a hair dryer uses. SolidWorks and Abaqus helped us find the best aerodynamic design to reduce rolling resistance, drag, and overall weight so we could wring the best performance from the battery."

>> www.cuer.co.uk



A simulation for a notebook computer power button is performed using Abaqus to analyze stress.

ASUSTeK Accelerates Electronic Product Innovation

ASUSTeK Computer, Inc. (ASUS) has selected Abaqus FEA software to accelerate innovative product design, performance, and reliability with realistic simulation solutions. ASUS has won numerous awards for innovation and quality in the field of inboard computer components and peripherals. The addition of Abaqus FEA to their product development process will allow ASUS to significantly reduce time and costs while maintaining their focus on excellence.

"Our number one goal is to help our customers be more successful by providing the most reliable and realistic simulation technology as well as the best services and support in the industry," stated Ken Short, VP Strategy and Marketing, SIMULIA.

"The extremely quick pace of innovation, particularly in the electronics industry, makes it critical to diminish time-to-market as much as possible," stated Benson Chan, Manager, Analysis Design Section, Mechanical & Industrial Design Center, ASUS." Abaqus FEA will enable our engineering teams to reduce costly, time-consuming physical tests by using virtual simulations such as mobile phone drop, twisting, bending simulation, hinge-operating simulation, pressure-on-NB cover simulation, and others."

>> www.asus.com

For More Information

simulia.com/news/press_releases

To share your case study, send an e-mail with a brief description of your application to simulia.info@3ds.com.

Artificial Turf **Gains Ground** with Realistic Simulation



The Fédération Internationale de Football Association (FIFA) has deemed artificial turf "an acceptable playing surface for football." The association cites the availability of an evergreen, even-playing surface as advantages of artificial turf over natural grass. But FIFA has also spelled out detailed regulations about the materials, substructure, installation, testing, and certification of artificial turf for playing fields—which means that turf manufacturers have to be on the top of their game when designing their products for performance and safety.

Royal TenCate (pronounced "ten-kah-teh") is the world's leading producer of synthetic grass fibers and other components for playing fields. Whether the game is soccer, American football, rugby, field hockey, or lacrosse, a playing field must be able to take a significant amount of pounding from feet, sports balls, and falling bodies. Add different climates (hot versus cold, wet versus dry) and impact patterns (heavily padded American football teams versus bare-kneed soccer players) and you begin to get an idea of the design variables that TenCate must take into account when designing artificial turf.

Synthetic Turf: More Than Meets the Eye

Artificial turf designers must consider the make-up of the individual blades to mimic the look and playing-feel of natural grass. They must consider what yarn/fiber to use (softer polyethylene for soccer, tougher polyamides for U.S. football), what shape it should be, whether it should be fibrillated or a monofilament, its height above the field surface, its density per square meter, stiffness and dissipative behavior—all of which affect wear, safety, and playing characteristics.

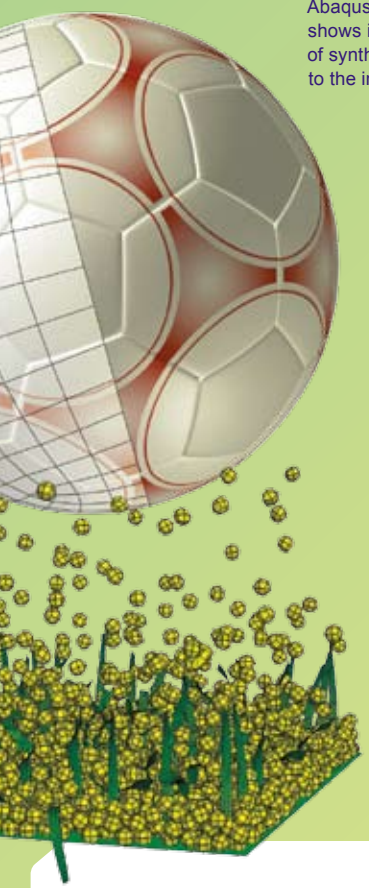


Synthetic turf is actually a complete system of grass fiber, infill and backing, laid over a foundation of earth, sand and/or concrete. Components are fine-tuned to the environmental conditions where a field is being installed.

However, what's below the visible surface of the grass is just as critical: the fiber travels down through infill made of rubber or thermoplastic granulate, which provides shock absorption, controls rebound and prevents skin damage caused by sliding. Beneath that are additional layers of rubber and sand and, finally, the backing in which the grass blade (totaling 6 cm in length) is imbedded.

"For optimum performance you need to fine-tune all the elements that make up a field," says Martin Olde Weghuis, International Manager, R&D, at TenCate. "We make distinct types of polyethylene grass fibers, plus thermoplastic infill material, and polypropylene woven backing fabrics—all of which must work together for optimum results."

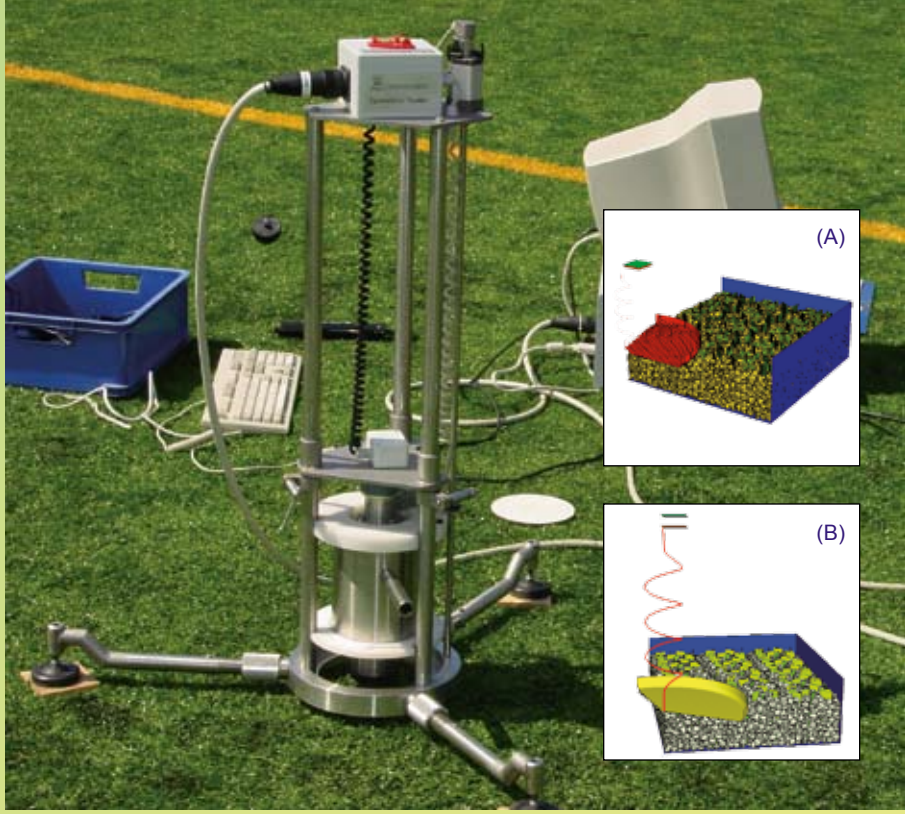
Marco Ezendam, Director of Reden BV (Research Development Nederland), engineering consultants to TenCate, explains,



Abaqus FEA ball-bounce model shows interaction and response of synthetic turf infill and fibers to the impact of a soccer ball.



FEA model of individual granule



The Abaqus FEA data from fiber and infill testing is combined into field properties models with which load (A) and displacement (B) effects can be simulated. Field testing using the "artificial athlete" (photo) verifies the results predicted by the model.

"A playing field is an entire system, not just individual components. If you want better performance from the field, you have to know how the entire system functions and what the interactions are within it. That's the reason we started modeling turf design with Abaqus finite element analysis (FEA)."

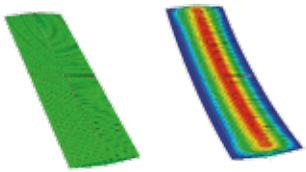
"We initially chose Abaqus because of the breadth of its materials models," Ezendam says. "The capabilities of the software have grown along with our need for increased sophistication in our analyses. With Abaqus FEA you can model the individual characteristics of each component and relate that to the behavior of the total system."

Modeling the Playing Field

When creating artificial turf models, Reden looks at the problem at a number of levels: micro, the properties of an individual fiber; meso, grains of infill interacting with fibers; and macro, a ball or player impacting the field.

"We use FEA to model the properties of a single fiber, translate those into the properties of a group of fibers, and then predict the characteristics of the mass, spring and damping of the field itself interacting with a ball or player," says Ezendam.

A grass-fiber model in Abaqus can be subjected to virtual bending tests, and its mass, shape, height, etc. modified and retested, until the desired characteristics are achieved. Infill models can be adjusted for morphology, size, material, distribution, friction and layer thickness, and then run through triaxial (three-dimensional) compression tests. An entire square of turf, with fibers, infill and backing characteristics built into the model, can be evaluated for compression by a virtual foot or a bouncing ball.



Reden's modelling strategy for TenCate's artificial turf starts on a micro level with Abaqus FEA analysis of an individual synthetic fiber, shown here. Mass, shape, bendability, height and other characteristics can be modified and retested until the desired requirements are met.

By using FEA during product development, Reden can also simulate the effects of the artificial athlete tests on their turf models. The foot simulation mirrors a real-world test, mandated by FIFA. It consists of a circular plate, approximating a player's foot, that is pressed onto the field with a loaded spring to measure field behavior. Reden uses two artificial athletes: the Berlin tests the maximum load on the plate and the Stuttgart measures displacement of the plate. The physical tests are performed on the synthetic turf at TenCate's outdoor testing fields. They then use the simulations to evaluate the performance of different combinations of turf fiber, infill and backing, and make modifications that will optimize the turf's performance in the outdoor tests.

In a similar manner, a ball-bounce analysis is set up using an FEA shell model of a ball full of gas at the correct pressure. For comparison, a real ball is bounced off a surface and the rebound results are then factored into the simulation of the synthetic turf response and used to make product modifications as needed.

FEA Measures Up

With its computer models set up, Reden turns to validation testing against the FIFA-mandated parameters that must be met by every synthetic field. While a single turf-fiber model is fairly simple to build, a full model of a simulated foot impacting a section of turf can have over 250,000 elements with over two million degrees of freedom.

"We are now at the point of validating all our models, and the graphs of our real-world results against what our FEA models predict are coming out very strong," concludes Ezendam.

For More Information

www.tencate.com
www.reden.nl

Abaqus 6.9 Provides New and Enhanced Capabilities for Fracture and Failure, Multiphysics, Noise and Vibration, and More

The Abaqus Unified FEA product suite is focused on helping designers and engineers solve engineering challenges in a broad range of industries, including aerospace, automotive, electronics, energy, consumer packaged goods.

Abaqus 6.9 continues our tradition of providing innovative and robust technology that can be used to solve industry-specific applications within an open and unified modeling and simulation environment.

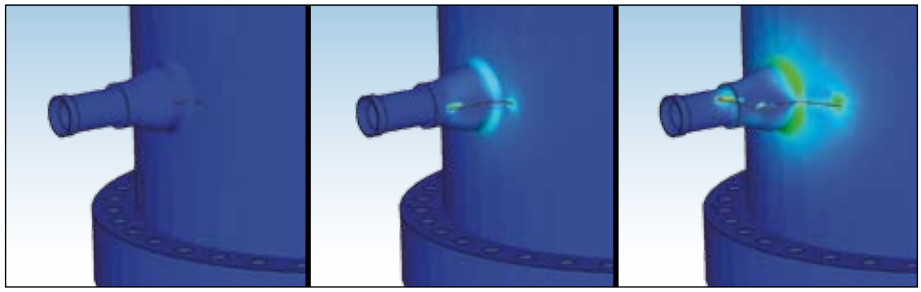
The new capabilities in this release will allow manufacturing companies to consolidate their nonlinear and linear analysis workflows within the Abaqus unified FEA product suite resulting in reduced software costs and significant gains in process efficiency.

"By working closely with our customers on the definition and review of new functionality, we have developed the most robust finite element analysis software available," stated Steve Crowley, director of product management, SIMULIA, Dassault Systèmes. "The unique new features for noise and vibration and fracture and failure analysis enable manufacturing companies to solve real-world design problems while lowering costs and improving product quality."

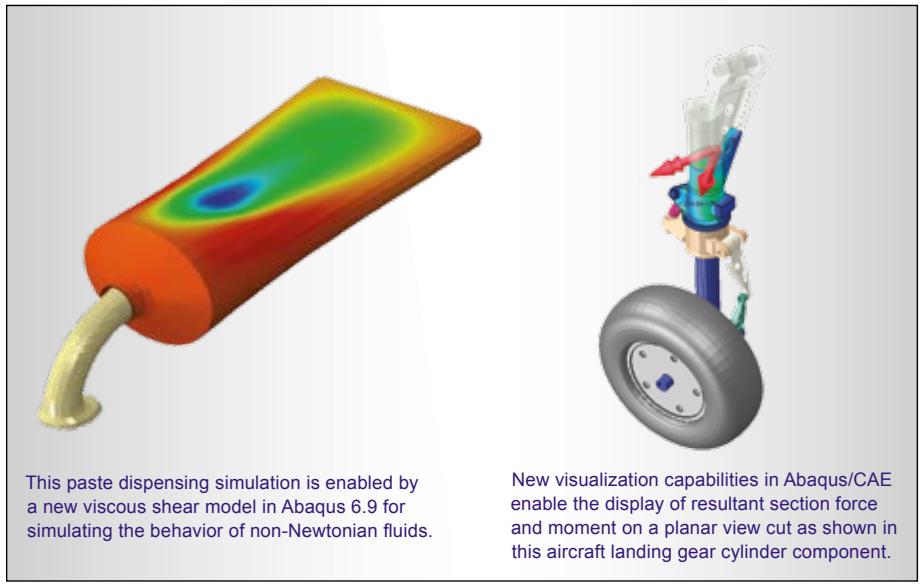
Abaqus 6.9 delivers industry-leading simulation technology including key new capabilities and enhancements for fracture and failure, high-performance computing, and noise and vibration and as well as modeling, meshing, contact, materials, and multiphysics.

Key new features and enhancements include:

- The extended finite element method (XFEM) has been implemented in Abaqus and provides a powerful tool for simulating crack growth along arbitrary paths that do not correspond to element boundaries. In the aerospace industry, XFEM can be used in combination with other Abaqus capabilities to predict the durability and damage tolerance of composite aircraft structures. In the energy industry, it can assist in evaluating the onset and growth of cracks in pressure vessels.
- The new general contact implementation in Abaqus offers a simplified and highly automated method for defining contact interactions in a model. This capability provides substantial efficiency gains in modeling complex assemblies such as gear systems, hydraulic cylinders, or other products that have parts that come into contact.
- A new cosimulation method allows users to combine the Abaqus implicit and explicit solvers into a single simulation—substantially reducing computation time. By using this cosimulation technique, automotive engineers can now combine a substructure representation of a vehicle body with a model of the tires and suspension to evaluate the durability of a vehicle running over a pothole.
- Comprehensive new features in Abaqus/CAE support the modeling of fracture and failure with XFEM, cosimulation, and general contact. Additional enhancements include faster, more robust meshing and powerful results visualization techniques.
- Enhanced performance of the AMS eigensolver significantly improves the efficiency of large-scale linear dynamics workflows such as automotive noise and vibration analyses.
- A new viscous shear model is available for simulating the behavior of non-Newtonian fluids such as blood, paste, molten polymers, or other fluids often used in consumer product or industrial applications.



In this pressure vessel model, XFEM in Abaqus/Standard allows for the prediction of arbitrary, solution-dependent crack growth independent of the finite element mesh.



This paste dispensing simulation is enabled by a new viscous shear model in Abaqus 6.9 for simulating the behavior of non-Newtonian fluids.

New visualization capabilities in Abaqus/CAE enable the display of resultant section force and moment on a planar view cut as shown in this aircraft landing gear cylinder component.

For More Information
www.simulia.com/products/abaqus_fea

Improve Reliability of Welded Joints with Verity® for Abaqus

New Product Leverages Battelle Technology for Nuclear Power, Oil & Gas, and Heavy Machinery Applications

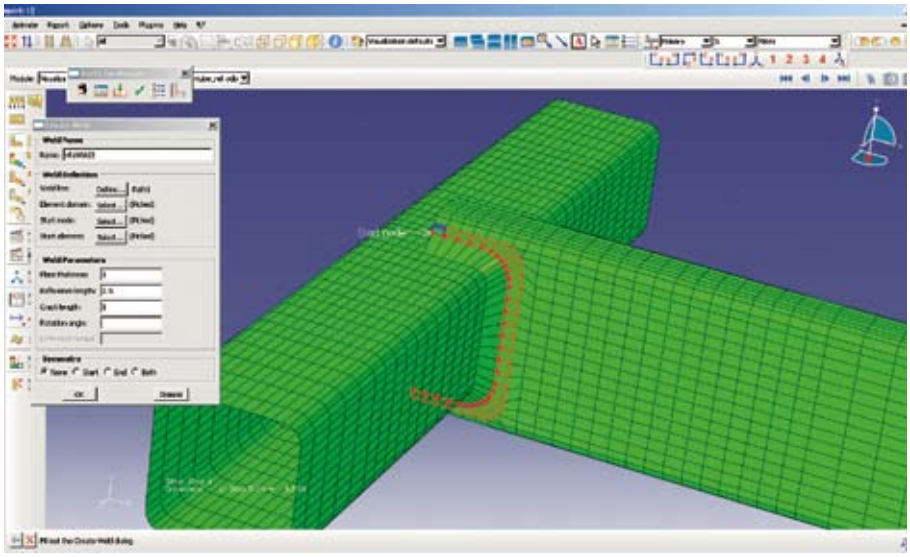
Verity® for Abaqus, a new add-on product for Abaqus FEA software, enables engineers to easily and accurately simulate realistic structural stress in welded joints in industrial applications such as pressure vessels, piping, storage tanks, offshore platforms, and construction equipment. The new product is based on the Verity® mesh-insensitive structural stress method from Battelle, the world's largest non-profit independent research and development organization.

In addition to welded joints, the Verity® structural stress method can also be applied to structures with geometrical notches such as adhesive joints, mechanically fastened joints, electronic packages, and manufacturing notches that exhibit stress concentrations due to loading. The Verity® method has been adopted in the 2007 ASME (American Society of Mechanical Engineers) Boiler and Pressure Vessel Code (Section VIII, Div. 2) and the new joint API (American Petroleum Institute) and ASME Fitness-for-Service (FFS) Standard API 579-1/ASME FFS-1.

"Due to mesh sensitivities in finite element models, it is difficult for engineers to accurately characterize structural stress in welded joints and other discontinuities, and this often results in unreliable fatigue life prediction," stated Steve Crowley, director of product management, SIMULIA, Dassault Systèmes. "By leveraging Battelle's technology, Verity® for Abaqus provides a mesh-insensitive solution and enables engineers to improve reliability and safety of structures that use welds or other joining techniques such as soldering or brazing."

In the nuclear power industry, Verity® for Abaqus helps engineers to more accurately evaluate weld performance of mission-critical components and systems such as pressure vessels to reduce maintenance and in-situ physical inspection. In the oil and gas industry, benefits include improved operational availability of physical systems such as pipelines and offshore structures.

For More Information
www.simulia.com/products/vfa



Verity® for Abaqus provides an interactive user interface to quickly calculate and postprocess structural stress using the Verity® mesh-insensitive structural stress method from Battelle.

"By integrating our Verity® technology with Abaqus, SIMULIA is providing a unique simulation solution that enables companies to analyze accurate weld performance, lower development costs, and accelerate their design and implementation processes."

—Spencer Pugh, Vice President for Battelle's Industrial and International market sector

Abaqus for CATIA V5R19 SP3

New Release Offers Enhanced Realistic Simulation Capabilities for CATIA Users

SIMULIA's Abaqus for CATIA V5R19 SP3 (AFC) release delivers scalable analysis solutions that allow realistic simulation to be used throughout the product lifecycle. With improved usability and robust analysis capabilities, Abaqus for CATIA enables design and engineering teams to improve collaboration, evaluate design performance through the use of common FEA models, technology, and methods. By synchronizing the CATIA V5 design with analysis, CATIA users are able to accelerate the product development process.

New features in Abaqus for CATIA V5 allow users to:

- Analyze an assembly composed of other analysis documents, enabling greater efficiency and better collaboration
- Specify engineering constants to model 3D orthotropic elasticity
- Model bolts as parts using flexible beam elements, including material property assignments, and apply loads across a pre-tension section at any analysis step
- Take advantage of the latest enhancements and performance improvements in Abaqus

For More Information
www.simulia.com/products/afc_v5

Assessing Your Simulation Lifecycle Management Requirements

Shawn Freeman, Senior Consultant, SIMULIA

Historically, simulation work has been performed by specialists using a myriad of tools, data, and processes across many different engineering disciplines. Often, the knowledge of how a simulation is performed has been retained solely in the minds of the analysts. Dissemination of results has been largely through manually-prepared reports, developed outside the mainstream product development process.

For simulation to be a truly effective part of the product development cycle, the processes, authoring tools, data, and resulting intellectual property must be shared, managed, and secured as strategic business assets. SIMULIA SLM has been developed to enable organizations to access the right information through secure storage, search, and retrieval with functionality dedicated specifically to simulation processes and data. It also simplifies the capture, re-use, and deployment of approved simulation methods to provide improved confidence in using simulation results for rapid and collaborative decision-making.

If you are like many of our customers, you may be considering a solution like SIMULIA SLM to manage and secure your simulation processes, applications, and data. In order to determine the right solution for your needs and the best approach for implementation, we encourage our customers to consider all aspects of their simulation practice and implementation—as there are a significant number of requirements and dependencies to evaluate. We believe the successful implementation of a Simulation Lifecycle Management solution depends on the robustness and functionality of the software as well as on the experience and the commitment of your solution provider.

To assist our customers in defining and evaluating their SLM requirements, we have developed a needs assessment process that takes a deep look at your simulation activity. This involves a series of interviews to document what tools are used, how information flows, suppliers of information, recipients of information, current IT infrastructure, existing data systems, etc. The needs assessment rapidly develops a multi-point perspective of your existing simulation processes, and identifies areas of opportunities for overall improvement based on your business objectives. Through this process, we identify, measure, and prioritize improvement opportunities that will deliver the most substantial benefit; define key functionality of the solution to meet the requirements; and develop a project proposal and implement a limited scope pilot project to prove out the solution prior to full deployment.



The time required to perform a needs assessment, provide a project plan, and start the implementation process can range from four to six weeks depending on the customer's project scope, availability, and initiative. The needs assessment not only educates our SIMULIA staff on your processes and requirements, but can also be very informative and eye-opening for your organization.

The fastest and most direct way of conducting a needs assessment is to perform a series of interviews with key stakeholders who participate in your design, engineering, and analysis process. It is our goal to not only uncover the needs of the engineering analysts, but to also gain insight into the requirements of non-analysts. These stakeholders may provide input into design and engineering requirements, support the engineering infrastructure, or need to access data related to engineering decisions. They often include design teams, program leads, application engineers, IT, purchasing, or even sales and marketing. During the interview, we require information about the people and processes related to analysis such as:

- Content that is generated and consumed by analysts
- Analysis tools in use, both commercial and in-house
- Staff responsible for the creation and maintenance of analysis standards
- Consumers of the simulation data, reports, and related decisions
- IT infrastructure and staffing in place to support these activities
- Corporate policy regarding security, data retention, and access permissions

Our professionals also provide a survey of "starter" questions in advance of the actual interview. The primary function of this survey is to spark the thoughts of the interviewee so that the actual interview will be more productive. Upon completion of the interviews, the information is gathered into a formal report describing the "as is" environment, data flows, and processes along with key observations and opportunities for improvement. Due to the "wide and deep" nature of the interview process, many customers find that the report provides additional insight into their operations that they might not otherwise have had. Upon completion of the survey, we review the report with our customers to determine if they are in agreement with our assessment or have other suggestions due to information uncovered during the assessment process.

A thorough needs assessment provides guidance on developing a project proposal, implementation plan, and schedule for various milestones. By taking this critical step, you can ensure that you are tackling the right SLM projects for the right reasons. It also ensures that our services teams are in synch with your requirements and provides the necessary information to track the progress and measure the effectiveness of the implemented solution.

For More Information
www.simulia.com/services

Silgan Containers Uses State-of-the-Art Simulation Software to Increase Speed-to-Market by Predicting Can Performance

Silgan Containers, a subsidiary of Silgan Holdings, is the largest manufacturer of metal food containers in North America, with approximately half of the U.S. unit volume in 2007 and net sales of $1.68 billion. Silgan's partnership approach, supported by quality, service, technology, low-cost producer position, strategically-located geographic locations, and extensive consumer research, is the cornerstone of its strong customer relationships.

Silgan Containers manufactures and sells steel and aluminum containers and ends that are used primarily by processors and packagers for food products such as soup, vegetables, fruit, meat, tomato-based products, coffee, seafood, adult nutritional drinks, pet food, and other miscellaneous food products.

The latest in realistic simulation software is enabling Silgan Containers to increase its speed-to-market and reduce tooling costs for many of its new metal can projects. The software allows Silgan to predict "real-life" performance of its cans with a high degree of accuracy before a single container is manufactured.

"Although modeling and simulation software techniques are not new, what we are seeing now is an evolution. These software packages can model very thin material with a high degree of accuracy, which is key to predicting physical can performance," explains Alvin Widitora, director of new product development, Silgan Containers.

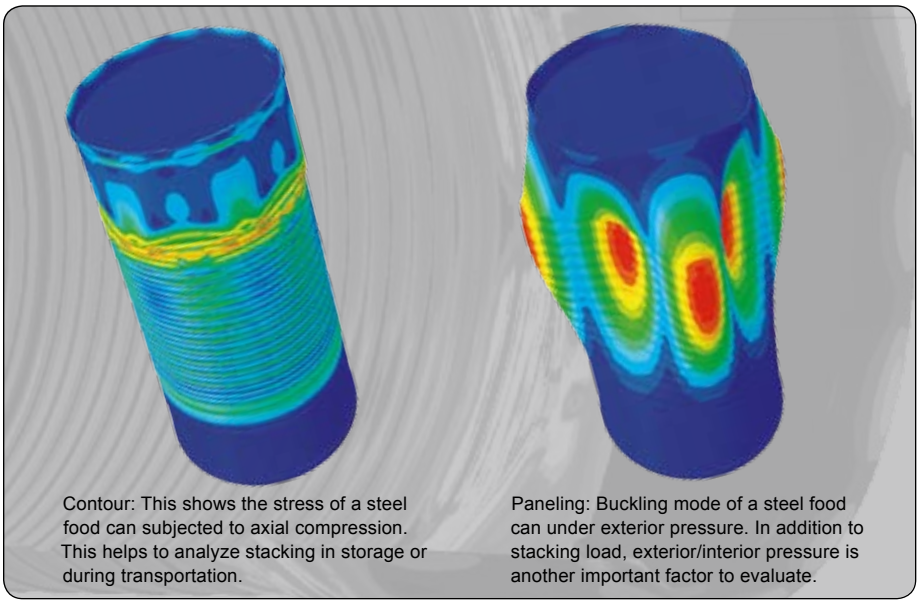
> "We have validated our modeling and simulation process up to a 97% level of accuracy that the actual container will perform as predicted."



Alvin Widitora, Director of New Product Development, Silgan Containers

Silgan is using Abaqus Finite Element Analysis (FEA) software from SIMULIA, the Dassault Systèmes brand for realistic simulation, to evaluate the physical behavior of its design concepts and project how the container will "behave" after it is filled and distributed. As a result, Silgan is able to remove as much as three to six months from the design phase and thousands of dollars in tooling costs.

"We have validated our modeling and simulation process up to a 97% level of accuracy that the actual container will perform as predicted," Widitora says. "That means that we can take a lot of the guesswork out before we get to the tooling stage. This not only saves time, but it also saves money. The end result is that we can help our customers get to market faster, with a container that has the right performance attributes for their product requirements."



Contour: This shows the stress of a steel food can subjected to axial compression. This helps to analyze stacking in storage or during transportation.

Paneling: Buckling mode of a steel food can under exterior pressure. In addition to stacking load, exterior/interior pressure is another important factor to evaluate.



Each design is evaluated from a variety of mechanical performance aspects including axial load (stacking ability) and corresponding panel load (crush strength).

"As part of the process, we also have loaded a significant amount of past learning into our simulation models. As we get new data, we feed that back into the tool so that we are constantly improving the accuracy and predictability," Widitora says.

The software is also used to optimize existing designs. Structures are evaluated for performance and cost improvement potential. Different base weights (metal thickness) and bead patterns are just two examples of what can be reviewed for optimization.

"Our customer feedback has been excellent," Widitora states. "We have been able to save them time and money by steering them away from certain designs that would not have given them the necessary functionality for their product."

For More Information
www.silgancontainers.com

When Animation Meets Simulation

Movie-making tools help drive a virtual product evaluation using Abaqus FEA

As film animators know all too well, the human face is one of the most difficult objects to model realistically. A flexible layer of skin covers a complex array of muscles and bones, producing a seemingly endless number of subtle facial expressions.

These subtleties come alive onscreen due to the blending of live action with special effects that is pushing the animation envelope forward: Animators now use computer-based physics in much the same way that design engineers use realistic simulation.



Figure 2. Kimberly-Clark Professional Duckbill® dust mask (real and simulated).

Modeling Facial Features

Motion capture animation isn't just for making movies. "Representing the positions and movements of the human face is a big challenge in designing some of our products," says Chris Pieper, Associate Research Fellow at Kimberly-Clark Corporation, a leading global health and hygiene company.

Although the company is most known for household brands such as KLEENEX® and HUGGIES®, they also manufacture dust masks, or particle respirators, that are worn by professionals and do-it-yourselfers who are involved in woodworking, machining, and other activities that create by-products that are unhealthy to breathe. The design challenge is to make a mask that's comfortable and at the same time maintains an airtight seal against the changing shape of the face.

For Pieper and his engineering team, the simulation problem was to represent a moving deformable surface—a face—in contact with a flexible object—a dust mask. "It's crucial that the mask conform to the face," says Pieper. "The contact pressure between the mask and the face is very important to the proper function of the product and the comfort of the user." Pieper, who was familiar with motion-capture methodologies, thought that he could adapt techniques from the entertainment industry to the product development process.

From Motion Capture to Simulation

Pieper and his group looked to SIMULIA to explore how high-resolution motion-capture data could be used for virtual product design. "Abaqus FEA is well-suited for studying soft, flexible structures with complex geometry in contact," says Pieper. "The general contact feature makes problem setup easy and solutions stable."

For his analysis, Pieper drew from the computer-generated animation world. He selected Contour™ Reality Capture, a high-fidelity performance capture technology from Mova, LLC. The California-based company recently used its technology to capture the facial movements of actor Edward Norton to animate the face of the green superhero in the 2008 release The Incredible Hulk. The Mova system utilizes an array of cameras—much like

contemporary marker-based systems—but also incorporates a stroboscopic fluorescent lighting set-up. The result is 100,000 3D points at 0.1mm accuracy—high resolution that realistically recreates human facial movements as well as a photographic image of the face at the same time.

The first step in creating a moving facial model for the dust mask study involved extracting surface point positions from a lower-resolution set of facial motion capture data, in an open source format called C3D used by biomechanics, animation, and gait analysis laboratories. The engineering team took the initial positions of the surface points, defined them as nodes, and completed finite element definitions using Geomagic—a surfacing software—to establish nodal connectivity. The team used a Python program to write the nodes and elements to an Abaqus input file so that they could be imported as an orphan mesh part. Using the orphan mesh as the basis for a minimal model definition, they then added a step definition and generated a sparse output database (ODB).

"The Abaqus ODB served as a kind of containment bucket for us," Pieper says. "We added all the displacement data to it to create a global model." They then used the global model to drive a submodel representing a human face undergoing a range of expressions and motions. The global ODB was completed by adding nodal displacements using the Abaqus Python scripting interface. To verify that all data was converted correctly, the team viewed the updated ODB as an animation using Abaqus (Figure 1). "Completing the global facial model was a big step all by itself," Pieper notes.

The engineering team next used the global model to drive the moving surface portion of the submodel, which included both the face and the virtual representation of the dust mask (Figure 2). As a final step in creating the finite element model, they added a submodel boundary condition and additional loads (including a pressure load on the nose piece and an inhaling load on the inner surfaces of the mask). Now the model was ready to run.

Results Get Rave Reviews

Postprocessing revealed several regions that exhibited gapping between the mask and the face—such as the areas of greatest curvature around the nose. This was evidenced by gaps in contact pressure contours (Figure 3), suggesting the need for design changes. "This type of product evaluation is extremely difficult using real human subjects and physical measurements," Pieper points out. "This demonstrates how simulation gives designers the means to rapidly evaluate the benefits of each alternative. We look to these simulations to help us narrow the field of design possibilities, so that when we do testing with human subjects, we are only looking at the design finalists," says Pieper. "That can really shrink the product design cycle."

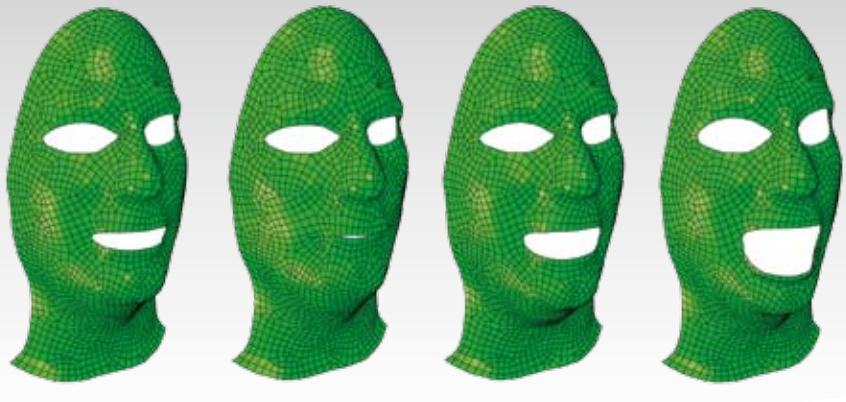


Figure 1. Visualizations of several frames from the updated output database (ODB), showing deformed shapes of the deformable surface (face) at points in time.



Figure 3. Contact pressure contours as an estimate of sealing effectiveness of dust mask on face at various points in time.

While the dust mask simulation was a feasibility study and has not yet been fully validated, Pieper sees the value of marrying motion-capture with simulation to model what he calls "living surfaces"—complex moving surfaces that are not easily described mathematically. "The technique provides a new way of representing a complex moving surface as a boundary condition or constraint in a simulation," he concludes. "This methodology will certainly be useful and feasible for applications that haven't even been considered yet."



Chris Pieper is an Associate Research Fellow for Kimberly-Clark (K-C) corporation in their Corporate Research and Engineering group. Chris joined K-C in 1987 and started using Abaqus in 1995. Since that time he has been devoted to virtual product simulation and is responsible for developing and automating simulation processes. Chris earned his BS and MS in Mechanical Engineering at the University of Wisconsin - Madison.

For More Information

www.kimberly-clark.com
www.simulia.com/cust_ref

Strategy for Sustainable Innovation in Consumer Packaged Goods

Realistic Simulation, Design Optimization, and Simulation Lifecycle Management

David Cadge, Consumer Packaged Goods Industry Lead, SIMULIA Technical Marketing



Consumer Packaged Goods (CPG) is a multi-trillion dollar industry which includes food, beverages, tobacco, cleaning products, and hygiene and beauty products. Companies in this industry are faced with daunting challenges of developing new and innovative products—and then producing them in large volumes, with regional appeal—quickly and at the lowest possible cost.

Today's packaged products must meet many conflicting performance objectives. They need to be unique, lightweight, stackable, and easy-to-open, yet strong enough to resist damage during production and distribution. Often, they must be recyclable, resealable, and reusable, but they must always be affordable for the average consumer. To meet these pressures, the CPG industry is increasing its use of Finite Element Analysis (FEA), Multiphysics, Design Optimization, and Simulation Lifecycle Management solutions from SIMULIA. These solutions are heavily entrenched in the aerospace, automotive, and energy industries where there are many mature, proven, and repeatable simulation processes.

While simulation use is not as prevalent in the CPG industry, there are several companies that are leading the way—and today there are many complex simulations being performed as an integral part of the CPG development process. Abaqus FEA is well-suited to analyzing a wide range of CPG applications due to its capabilities such as advanced material models, general contact, implicit and explicit solvers, flexible multibody dynamics, multiphysics simulation (such as fluid-structure interaction) and its ability to leverage high-performance multi-core hardware. Our software is being used by leading manufacturers such as Glass Service Improve for developing glass bottles, Dupont for researching adhesives, Tetra Pak for the analysis of paperboard cartons, and Silgan Containers for the analysis of metal cans (*INSIGHTS*, p. 11).

Container Lifecycle Analysis

Abaqus FEA enables designers and engineers to evaluate the complete lifecycle of a product and package: from concept, to selecting the right materials, to manufacturing and processing, through to the use cases experienced by the consumer. During the development of a plastic bottle, for example, the blow-molding process can be simulated with Abaqus to ensure manufacturability. The simulation results provide the wall thickness distribution, enabling designers to optimize the bottle design for weight, material usage, and strength. The final shape and wall thickness

distributions are critical to achieving accurate simulation results in subsequent virtual tests, such as:

- Top loading simulations performed to evaluate whether containers can withstand the loads during stacking.
- Heating and cooling analysis to predict how bottles soften or swell during processing.
- Conveying simulation to ensure container stability on conveyor systems.
- Pressurization analysis to help determine if bottles will buckle due to changes in internal pressures during storage and transportation.
- Grip stiffness simulations to confirm that a bottle will have sufficient strength and appropriate deflection under various squeeze loads.
- Finish design simulation of bottle caps to ensure an effective seal is created.
- Opening analyses performed to determine the forces required to open various seals that are often made of films or plastic tabs.
- Drop simulations to help determine whether bottles filled with fluid will break.

Many of these load cases require accurate representation of the actual product inside the container which is often a fluid, such as ketchup, detergent, or water. To gain a higher level of accuracy and realism, we have incorporated the Coupled Eulerian-Lagrangian (CEL) method directly in Abaqus, enabling engineers to include the effect of a fluid interacting with structures. We have also provided the ability to couple third-party CFD products to Abaqus to allow our customers to use the best combination of solutions required to evaluate a product's realistic performance.

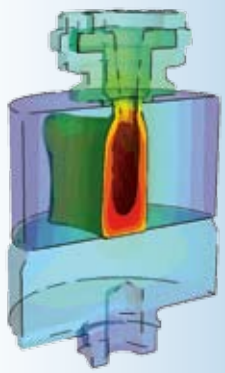
Design Exploration and Optimization

Isight is used by consumer goods companies to connect a variety of applications, automate the execution of multiple simulations, and perform multidisciplinary design exploration and optimization. In the case of bottle manufacturing, the software is used to determine the optimal parison thickness profile for blow-molded plastic bottles. Isight is helping our customers reduce material costs while ensuring that their bottles still satisfy the minimum strength tests. Isight is a key enabler for selecting the best design parameters to meet engineering targets, improve efficiencies, and reduce design cycles.



CEL analysis allows drop testing simulation of containers filled with fluids to study the durability and working life of the container under severe loading conditions directly in Abaqus.

Model courtesy of Bayer MaterialScience, LLC



Automatic meshing improves glass forming analysis.

Model courtesy of Glass Service Improve BV

Many of the simulation process flows described for the virtual testing of a new bottle design—and for the other package types—are robust, mature, and repeatable. This makes it possible to capture the methods, deploy them to non-experts via a template-based interface, automate their execution, and share the results for collaborative decision-making.

The Need for SLM

The new Simulation Lifecycle Management (SLM) solution from SIMULIA enables individuals, workgroups, and large enterprises to manage simulation processes, applications, data, and results. Procter & Gamble recently announced their decision to use SIMULIA SLM to make the benefits of realistic simulation available to a broader range of users than previously possible (*INSIGHTS*, p. 4).

SIMULIA SLM provides unique online collaboration capabilities that allow distributed engineering teams to share simulation methods, models, and results in order to make better-informed design decisions. These capabilities offer significant benefits to the CPG industry, where traceability of simulation results and their impact on design decisions are critical for accelerating product development and achieving regulatory compliance.

Customer-Focused Strategy

As our technology capabilities and product portfolio grow, it is critical that our solutions meet the needs of the CPG industry. We are closely engaged with our customers to understand their processes and simulation requirements in order to deliver specific functionality that answers their needs. Customers in this industry can expect to see focused developments in the areas of advanced material modeling and multiphysics simulation, as well as improvements in ease of use for their challenging analyses. We are also working with industry-leading CPG companies to further define the role of Isight and SLM for their particular simulation process flows. SIMULIA is delivering robust simulation solutions that are enabling designers and engineers to meet the demands of lower cost, more efficient, and more sustainable product development.



David Cadge
Consumer Packaged Goods Industry Lead, SIMULIA

David is responsible for developing and promoting our strategy for simulation within the CPG industry. He has worked at SIMULIA since 1995 (initially at our UK office and then at our Providence, RI, headquarters) in various capacities within our customer service and marketing teams. He has visited our CPG customers around the world to understand their simulation workflows and requirements. Information gathered during these visits will help SIMULIA provide enhancements for advanced technology, usability, and productivity so that simulation can become an integral part of CPG design practices.

Download CPG-related customer papers at: www.simulia.com/cust_ref

Designing **COMFORT** into Clothing

Toyobo develops a pressure simulation system with Abaqus FEA for evaluating realistic garment performance



While fashion design grabs the headlines in the apparel industry, all of us know that comfort, reliability, and performance are equally important considerations in our clothing purchases. Is your underwear too tight? Is your bathing suit too constricting? Do your pants bind when you walk? Traditionally, these questions have been addressed through human perception studies —psychology and physiology—as well as some limited pressure-testing systems. But in an industry which is so large and diverse, it was only a matter of time before someone applied the science of realistic simulation to the study of clothing comfort.

Clothing pressure, or the contact pressure between a garment and the skin, is one of the indicators used for evaluating the comfort of clothing, along with other variables such as thermal characteristics and moisture transfer of fibers and textiles.

Expertise in the clothing field comes naturally to Toyobo Co., Ltd., which was founded as a textile company over 125 years ago and is now a versatile, multi-national company based in Osaka, Japan. In addition to the research and development of textiles, Toyobo works with other high-performance materials and films, such as polymers, industrial materials, and materials for the life sciences.

"In fields such as clothing, healthcare, and sports, a simple and accurate understanding of the clothing pressure and clothing pressure distribution during body movements is essential to the design of clothing and clothing materials," says Chisato Nonomura, Ph.D., manager of the Computational Research Group at Toyobo. As part of the company's research and development into fabrics and textiles, engineers at Toyobo have developed a simulation system that measures the pressure of clothing against the skin. This analysis is useful in the development of fabrics and the design of clothing such as underwear, pantyhose, sportswear, and other tight-fitting apparel to make them as comfortable as possible for the wearer. Nonomura adds, "The adoption of realistic simulation is indispensable to efficiently design garments that create optimal clothing pressure."

This simulation system—as well as subsequent studies on material modeling carried out by Hirohisa Noguchi Prof. Dr. Eng/Masato Tanaka Ph.D at Keio University, and Takaya Kobayashi/Shuya Oi at Mechanical Design & Analysis Corporation—were supported by Japan's Ministry of Economy, Trade and Industry.

To perform their pressure analyses, Toyobo chose Abaqus Finite Element Analysis (FEA) software from SIMULIA, the Dassault Systèmes brand for realistic simulation. The company estimates that by using simulation it reduced the time and cost of their product design process by as much as 80 to 90 percent.

Creating Body and Sewing Pattern Models

To create the virtual human body model for the pressure simulation in Abaqus, engineers at Toyobo used a dummy (WD-20), supplied by Nanasai, Co., Ltd. that corresponded to an average 20-year old Japanese woman. They obtained the surface data from a 3D measurement taken from the dummy and created the virtual body in Abaqus as a rigid model. To create FEA models of the garments themselves, the team selected two types of clothing: a short-sleeved, tight-fitting knitted undershirt made of a blend of polyester and polyolefin; and a pair of pants, commonly worn by women for sports such as golf, made of a blend of nylon and polyurethane. Paper sewing patterns of the shirt and pants were used as the basis for the clothing models.

Having created CAD models for the body and the clothing, the engineering team imported both into I-DEAS for meshing, then created Abaqus input files and added the analysis attributes. They used the rigid element R3D3 for the body and the shell element S4R for the sewing pattern models, using approximately 18,400 elements for the body, 3400 for the pants, and 4300 for the t-shirt. (see Figure 1).

Modeling Fabric is Tricky

Fabrics and textiles do not behave like a homogenous material such as steel, which responds identically to a load applied in any direction. Fabrics are varied and come in many forms—woven or knitted, made from natural or synthetic fibers (such as cotton, wool, polyesters, or acrylics). Because the properties of fabrics are complex, creating a model that accurately represents their behavior without being too detailed is complicated.

Knitted fabric, for example, demonstrates hysteresis in uniaxial extension and unloading (see Figure 2). In addition, its behavior differs depending on the tensile direction, indicating orthotropy. So, in order to simplify the modeling of the fabric, the Toyobo engineering team needed to make some assumptions. For the purposes of the model, they ignored hysteresis, extracted only extension data, and assumed nonlinear elastic behavior. They also ignored the effect of material constriction, a characteristic of uniaxial extension, and to account for anisotropy, they used a Neo-Hookean hyperelastic body as the matrix (see Figure 3). In addition, they assumed the material was of uniform thickness and used non-compression conditions for the model.

Woven fabric behaves differently than knitted. It has fibers that are oriented in two directions—the warp, like longitude on a map, runs vertically, while the weft runs horizontally, like latitude. As the fabric is stretched in either of these directions—north/south or east/west—or on the bias at 45 degrees, it demonstrates different characteristics. To model this behavior, the engineering team used a feature in Abaqus called rebar layers, which functions to reinforce the material in a uniaxial direction—in the same way that metal rebar is used to reinforce concrete.While the rebar feature was developed to model structural concrete, the team developed a subroutine (UHYPEL) so that it could also be used to accurately represent the behavior of fabrics.

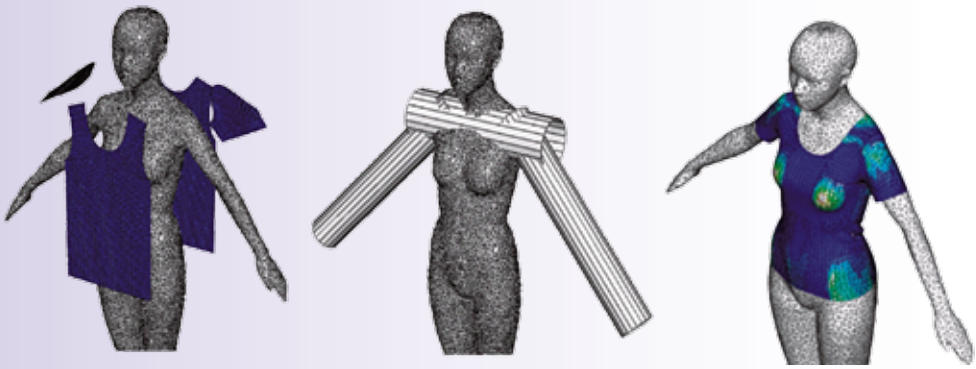


Figure 1. Abaqus finite element analysis of clothing pressure: (left) sewing pattern placement; (middle) intermediate body; (right) contact pressures when wearing garment

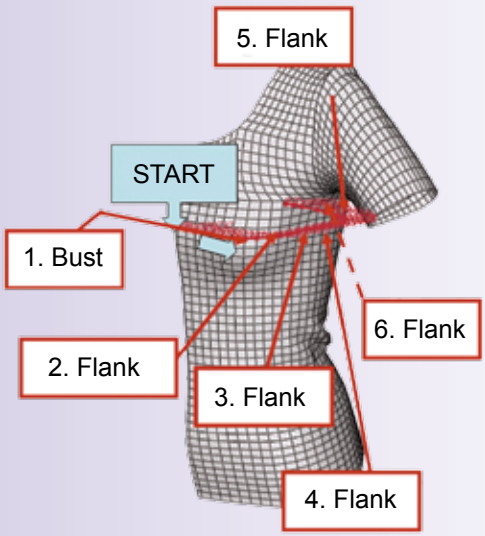


Figure 2. Location of air pressure measurements for a t-shirt, taken during an experiment.

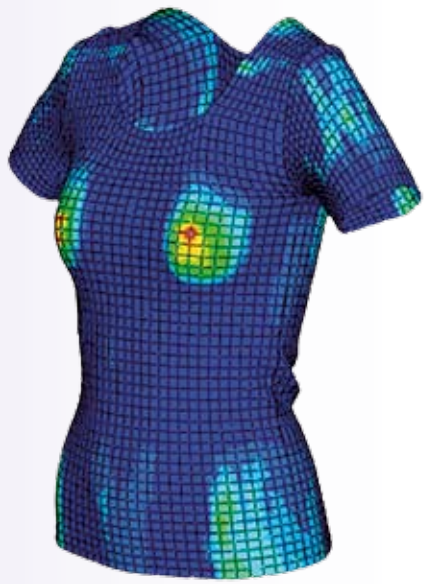


Figure 3. Clothing pressure distribution from Abaqus simulation results for a t-shirt.

Continued on page 18

In the model, the shell is a hyperelastic matrix to which rebar, or reinforcement, is added. Using data that resulted from elongation tests in the warp, weft, and bias directions, the team created a fabric model that allowed for the simple expression of orthotropy and nonlinearity. Following input of specific fiber material properties, engineers determined that the model was representative of both woven and knitted fabrics, although knitted fabrics, with their inherent loops of fibers, demonstrate more complicated behaviors.

Simulating and Validating Clothing Contact

Toyobo chose Abaqus, Nonomura says, because "The FEA software has lots of material options and robust, nonlinear analysis capabilities." For this analysis, the simulation flow was relatively simple. Engineers first imported—from 3D measurement scanning and CAD systems—the human body and sewing pattern data, then placed the patterns on the front and back of the body model, and finally moved the patterns closer to the body, analyzing contact and pressure (see Figure 4). "In Abaqus, it was easy to implement new material models, and also to solve the body-sewing pattern contact problem," says Nonomura. The simulation was done on an HP Xeon workstation (3.6Ghz) and took about six hours for both the t-shirt and the pants.

To validate the simulation results, the Toyobo team used an air-pressure measurement device, a long-standing technique in the industry. This system measures clothing pressure by calculating the difference between atmospheric pressure and the pressure pneumatically transmitted from air packs attached to parts of the body where the clothing contacts the skin (see Figure 5). For the t-shirt analysis, pressure was calculated on the bust, flank (side of chest), and navel regions of the body. For the pants analysis, pressure was calculated for the ankle, shin, knee, thigh, and hip. When comparing the two sets of data, the team found that the simulation results accurately reproduced the actual experimental measurements for both the t-shirt and the pants.

More Comfortable Clothing Through Simulation

"In an industry that is old and quite conservative, it can be difficult to introduce new technologies," says Nonomura. Using the traditional garment development process—from fabric, to sewing pattern, to sewing, to wearing, to measurement—can take a few months, and even more time if there are subsequent changes in the design. Using simulation condenses the entire process: from fabric/sewing pattern, to simulation analysis, to sewing. "Realistic simulation saves on sewing effort and significantly reduces the time and cost of the process," points out Nonomura. "What's more, we can continue to enhance our simulation system—most recently by using anisotropic hyperelastic shells with a polyconvex strain energy function—for even more accurate fabric modeling of the interaction between the warp and the weft."

With new fabrics and fibers being engineered continually and consumers becoming more demanding about the comfort of their clothing, the value of simulation cannot be ignored, Nonomura adds. "A lot of companies in the business of developing fabric, fiber, and garment designs can get tremendous benefit from employing simulation."

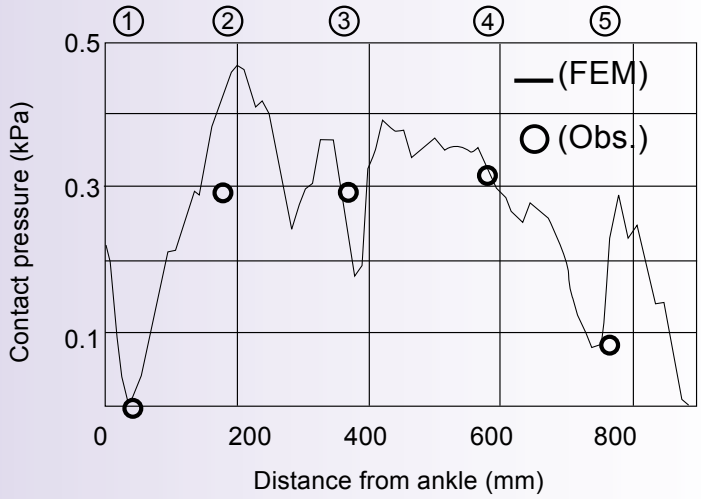


Figure 4. Chart shows validation of pants pressure simulation with experimental data collected from air pressure measurements.

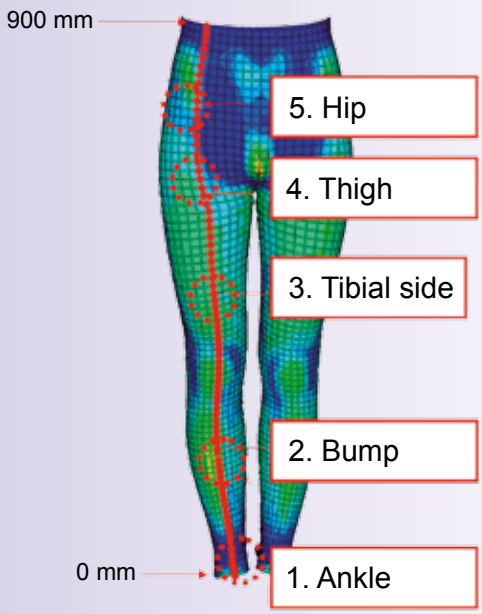


Figure 5. Location of air pressure measurements for pants, taken during experiment.

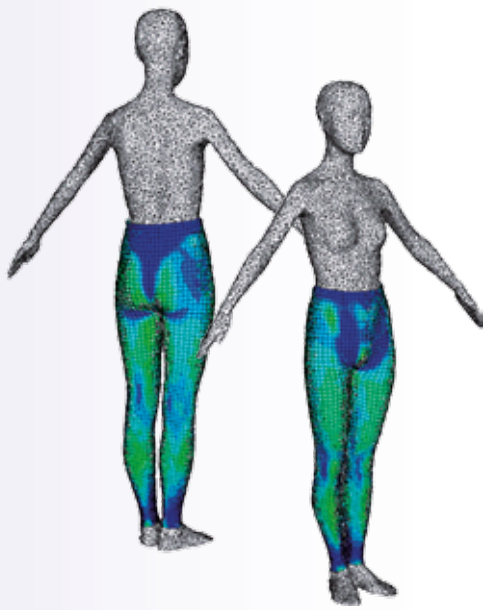


Figure 6. Clothing pressure distribution from simulation results for pants.

For More Information
www.toyobo.com

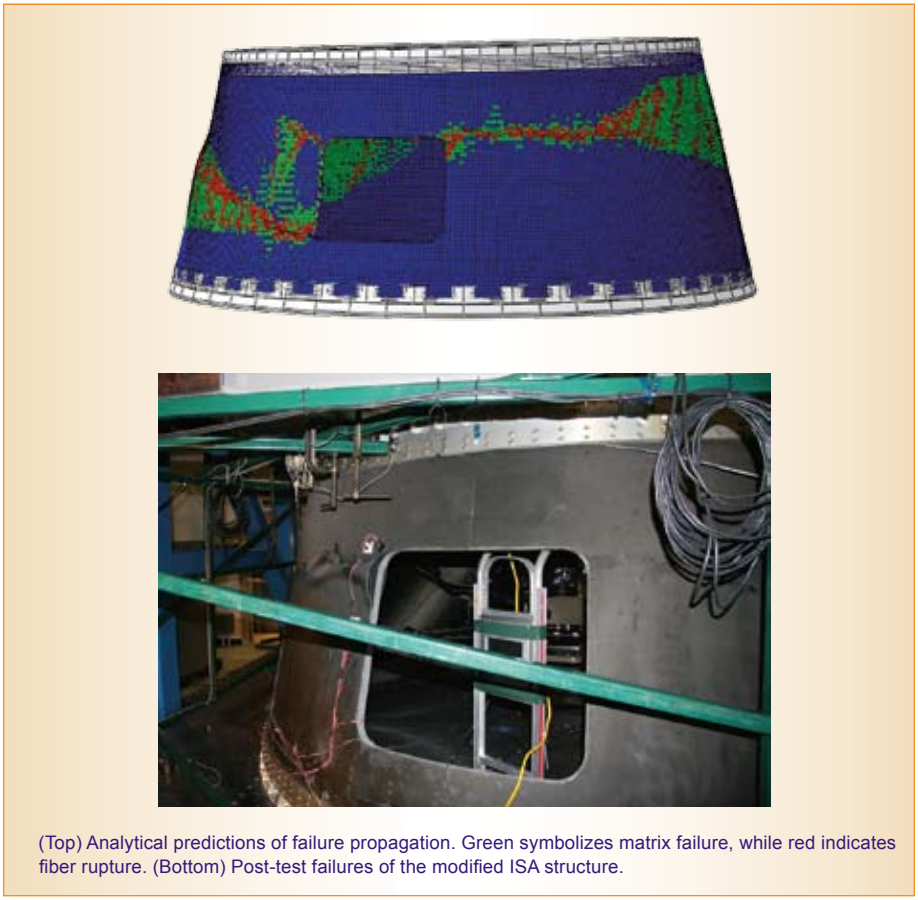
Firehole's Helius: MCT™ for Abaqus/Standard Used for Failure Prediction of Large Composite Space Structures

Firehole Technologies, specialists in the development of software for advanced composite materials modeling and simulation, recently teamed with the Air Force Research Laboratories (AFRL) to investigate the design of composite space structures and determine potential for improvement in efficiency and cost. "The genesis for the large structural failure program at AFRL Space Vehicle's Directorate was really to make a definitive statement regarding the ability of the aerospace community to optimize designs of large composite structures," stated Jeffry Welsh, now the Chief of Research, Development, Technology and Engineering Division at AFRL. To do this, they would seek to correlate accurate simulation with rare physical testing of the Inter-Stage Adapter (ISA) built for the Atlas V booster.

Engineers at Firehole used their software product Helius:MCT™, combined with SIMULIA's Abaqus Unified FEA package, to produce a blind, pre-test analysis of the structure. Helius:MCT is an enhancement to commercial analysis software developed for improving the accuracy of composite structures analysis. It is based on Multicontinuum Technology (MCT), which extracts the unique stress and strain fields for the constituents (fiber and matrix) of a composite material. In doing so, distinct failure criteria and material nonlinearity can be applied separately, permitting Helius:MCT to correctly identify failure of individual material constituents and degrade the composite material accordingly. The MCT multiscale approach provides an unsurpassed combination of accuracy and efficiency for predicting damage failure in composite structures.

Requiring only industry-standard material data, Helius:MCT is easily employed via a graphical user interface (GUI) within Abaqus/CAE. Functionalities such as layered solid elements within the Abaqus FEA suite perform effectively with Helius:MCT to produce a detailed progressive failure analysis of the structure.

The two products combined to provide exceptional failure prediction for the space structure. The model completed a full progressive failure analysis of the structure in less than 40 hours on an 8 CPU desktop PC. The ISA was successfully tested to failure at the AFRL/VSSB Large Aerospace Structures Simulation (LASS) Laboratory, Kirtland AFB, N.M. The Helius:MCT analysis predicted catastrophic failure of the modified ISA to occur at 187% of required flight load. The test of the ISA produced a catastrophic failure of the structure at 183% of required flight load.



(Top) Analytical predictions of failure propagation. Green symbolizes matrix failure, while red indicates fiber rupture. (Bottom) Post-test failures of the modified ISA structure.

In addition to predicting the ultimate failure load within 2.5%, Helius:MCT also accurately predicted the location and progression of failure. Moreover, the results demonstrated a notable improvement over traditional "smeared" composite failure approaches such as Hashin or Tsai-Wu, which over-predicted the failure load by 47% and 89% respectively.

The analysis proved that the structure was overdesigned—by as much as 47% of design requirements. The success of the analysis also demonstrated the viability of Helius:MCT as an accurate tool for analysis of composite structures during the design and analysis process. Welsh noted that, "With innovative analysis technologies such as Helius:MCT, I am convinced that these composite structures could remove as much as 40% mass, which translates into tremendous savings for many space applications." Such a mass reduction could translate into cost savings of $500,000 per launch or a significant increase in payload.

Helius:MCT for Abaqus/Standard provides a valuable tool set for design engineers to accurately simulate the mechanical response of composite structures. With the added capability and reliability of composite progressive failure analysis, these advanced materials can be used more effectively and efficiently to fully realize their unique benefits.

Project Funded by the Air Force Research Labs Space Vehicles Directorate under the direction of Dr. Tom Murphey.

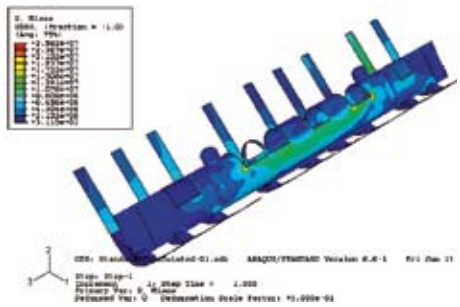
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www.fireholetech.com

Clemson University Research Groups Using Abaqus for Realistic Simulation of Civil War Submarine and Lunar Rover Wheel

H.L. Hunley Civil War Submarine Preservation

The H.L. Hunley is an American Civil War-era submarine that sank off the coast of Charleston, South Carolina in 1864. The submarine was discovered in 1995, recovered from the ocean in 2000, and is now under treatment for long-term preservation at the Clemson University Conservation Center. Extensive corrosion has weakened the wrought- and cast-iron riveted structure, making the handling of the submarine a very delicate procedure with a constant risk of crack initiation and propagation that could compromise its structural integrity. In collaboration with conservators and archaeologists, Dr. Vincent Blouin, Assistant Professor in Materials Science and Engineering at Clemson University, and his students are using Abaqus to simulate the structural behavior of the submarine under various critical scenarios such as the rotation from its current 45-degree tilt to its natural upright position. The modeling issues being addressed in this project are due to large size, complex geometry, lack of symmetry, a non-uniform corrosion layer of unknown thickness, and—most importantly—a complex friction-based supporting sling system comprised of polyurethane cushions and synthetic belts. The accuracy of the model relies extensively on the ability to properly model the surface-to-surface contact interactions between the submarine and the support system. In addition, the lack of accurate information on the mechanical properties of this archaeological artifact leads to uncertainties that must be addressed using intensive parametric studies. The modelers developed a bi-level coordination strategy between a low-fidelity global model of the submarine and a high-fidelity local model of a riveted connection. This strategy allows them to deal efficiently with the complexity of the structure and study the effect of various levels of corrosion and the presence of cracks around rivets.



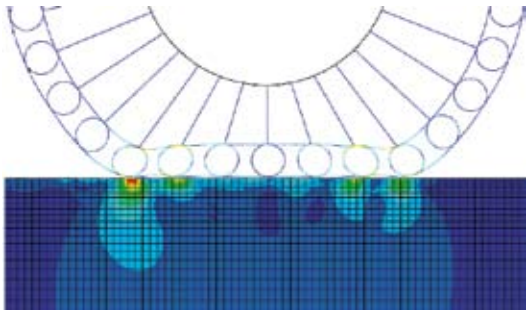


For More Information
www.hunley.org

Tweel Lunar Rover Wheel Traction

NASA's renewed initiative to return to the Moon for long-term exploration requires a new generation of non-pneumatic wheels—such as the Michelin Tweel™—capable of withstanding harsh lunar conditions that include large temperature range, UV and cosmic radiation, and high abrasion. A group of researchers led by Dr. Joshua Summers, Associate Professor in the Department of Mechanical Engineering at Clemson University, is using Abaqus to model the interaction between the Tweel and soil to study the behavior and traction of the lunar rover wheel.

In a numerical model developed by Post-doctoral Fellow Dr. Jeff Ma, the Tweel is treated as an elastic deformable body and modeled with 1-D beam elements. The soil is treated as an elasto-plastic solid and is modeled by the Drucker-Prager/Cap plasticity constitutive law with hardening and discretized with linear plane strain quadrilateral elements.





The carrying load is initially applied to the Tweel by prescribing a vertical displacement vector to the center of the rigid hub. The motion is then generated by a horizontal displacement vector and the Tweel rotates clockwise due to its interaction with the soil as it moves from left to right.

The useful output energy used to propel the rover is the input energy provided by the motors to the wheels minus the energy losses due to the deformation of the wheels, the slip at the interface or within the sand, and soil compaction. The ongoing research consists of developing appropriate sand behavior numerical models and designing, through simulation, the various components of the wheel to minimize the interrelated energy losses.

For More Information
aid.ces.clemson.edu

Techniques for Analyzing the Effect of Fire on Building Structures Using Abaqus FEA

Gaining a thorough understanding of the vulnerability of steel structures under fire conditions poses significant challenges to the structural engineering community. Conducting a large-scale fire test in a controlled environment is extremely complex, expensive, and involves significant risk. However, with advancements in computational technology, tools such as Abaqus FEA can be very effective in simulating and predicting the behavior of complex systems such as steel structures under fire loading.

Professor Amit H. Varma and his students in the School of Civil Engineering at Purdue University have been using Abaqus to analyze complete building structures as well as various structural components under fire conditions. Their research includes heat transfer analysis for predicting the temperatures of the individual members and structural analysis for predicting structural system responses.

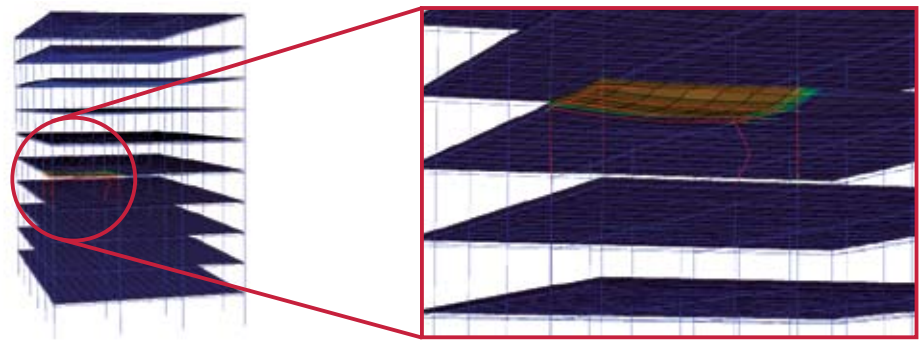
Heat transfer analysis uses fire temperature as input and generates temperatures across the cross-section of the members as output. The structural analyses are usually aimed at finding the response beyond the stability limit of the structure.

Heat transfer from the gas to the steel sections involves conduction, radiation, and convection. FEA is not traditionally known for solving highly turbulent heat and mass transfer equations associated with convection. However, for this application, an exact formulation was used to model conduction and radiation heat transfer. Convection was treated in an approximate manner based on previous research, and a user subroutine was created to account for convection and radiation along with conduction heat flux.

For the structural analyses, the Purdue students had three objectives:

- Simulating the effect of fire on structural components
- Parametric evaluation of structural components
- Analyzing overall behavior and collapse of complete buildings with different structural systems

In a real fire scenario, gravity loads on the structure are maintained at a constant level while the fire deteriorates the structural strength and stiffness properties—inducing additional internal forces into the system, and leading to structural failure. However, in the case of a RIKS analysis, the mechanical loads must vary. Therefore, in order to conduct a RIKS analysis, one has to heat the unloaded and partially loaded structure to a desired temperature and then load it to failure and beyond. This is reasonable, but not accurate for parametric studies of steel members.



Building simulation for fire in a corner compartment of fifth floor. The structure eventually stabilizes after the failure of an interior column.



L-R: Amit H. Varma, Anil Agarwal, and Guillermo Cedeno of Purdue University School of Civil Engineering.

Most structural members, such as composite beams and floors, are more sensitive to the order of events. Therefore, nonlinear implicit or explicit dynamic analysis procedures are more appropriate methods for analyses.

The cooling phase of the fire is also crucial—particularly for structural connections—due to the internal forces developed in the cooling or contraction process. Modified RIKS analysis cannot be used to capture these effects on connection behavior and fracture. Dynamic analysis methods are more appropriate and preferred for these analyses, though they take time to run and occupy more disk space. Time scaling has proven useful in saving CPU time in the case of dynamic analysis.

It is evident from this ongoing research that Abaqus FEA provides the robust capabilities required to study temperature effects on the structural integrity of steel building structures. Through this research, the building industry will be able to learn how to use FEA analysis to improve their building designs for enhanced structural safety.

Article contributed by Amit H. Varma, Associate Professor; Anil Agarwal, Ph.D. Candidate; and Guillermo Cedeno, Ph.D. Candidate, Purdue University School of Civil Engineering

For More Information
engineering.purdue.edu/ce

Investing in CAE During an Economic Downturn

Frank Popielas, Manager Advanced Engineering, Dana Holding Corporation

Engineering companies affected by the economy are looking to control expenses. But whatever you do, don't cut your CAE resources—especially your CAE engineers, who are the key to your business survival, and your best insurance for emerging stronger when the climate improves.

"Analysis-led design" will keep you focused on cost-effectively producing quality products. A well-developed computer-aided engineering (CAE) system lets you design your product properly up front and test it virtually before you start prototyping, which helps manage your expenses without jeopardizing your business.

Find Your "Sweet Spot"

It is essential to identify the "sweet spot" for your HPC (high-performance computing) system as it runs today's large, complex models. HPC, used with the right software, will give you the proper scaling and performance. The "sweet spot" is the right combination of hardware, software, and engineering costs that gives you the lowest expense-per-unit for your process.

A critical way to maximize your existing HPC investment is to upgrade your software whenever new releases come out. Only the newest software best utilizes hardware performance, minimizing the cost-per-unit of both hardware and software. Recent developments in software are boosting performance even further, to a point where hardware is a minor factor in simulation costs.

Software Boosts Performance

In 2007, Dana performed a benchmark using Abaqus FEA on a basic powertrain model. At that time, we identified a sweet spot around 64 cores. In 2009, we tested the latest software release, Abaqus 6.9, and found that—on essentially the same model and analysis—we only needed about 32 cores to hit the sweet spot. The hardware provided some degree of better handling, but the main reason for the reduction was software improvements.

However, it's not enough just to have the resources: you also need to be well-organized to use them efficiently. At Dana, we make sure that when there is a new software release, our entire CAE team upgrades—globally. We are now at the point where our hardware and software work in tandem and everyone on the team is able to communicate more easily.



CAE Team at the Lisle Technical Center discussing simulation results. (from the left: Amit Deshpande, Marsha Minkov, Rohit Ramkumar, Frank Popielas, and Jason Tyrus.)

"Only the newest software best utilizes hardware performance, minimizing the cost-per-unit of both hardware and software."

—Frank Popielas, Dana Corporation

How CAE Saved a Business

The success of a large customer of ours is an example of how a focused CAE development strategy pays off. In the past, they wasted time and money getting a product to market that was no longer profitable or competitive. To survive, they had to rethink the way they did business. They could have slashed costs by just cutting staff—which, to some extent, they did. But they also reexamined how they allocated existing resources, changing their mindset from a costly process of build/test/error–build/test/error to a new focus on upfront design. They invested in CAE technology and began using Analysis-led Design to optimize their product on the computer before they began cutting prototypes. This helped control costs while building a new technology foundation. The end result: after several years, the company doubled its market share.

Investing in CAE Promotes Faster Recovery

How can you invest in CAE during an economic downturn? First, step back and look at the big picture. Even if you have a small CAE team in place, you should strongly support them—they are the foundation for your future success. Make sure you establish basic simulation techniques and standards, and only then should you look for an HPC system that will support those needs. While you may not see immediate results, any delay will put your company at further risk.

What is your company's sweet spot? What will be your return on investment? An exact ROI figure will depend on how well you employ your CAE capabilities. Given the lower costs of hardware and software, ROI within two years seems very likely. So, hang on to your CAE team, support them at the best level you can, and stay up-to-date with current software releases—then, you'll be ahead of the game when the economy picks up again.

The results of the HPC study, "Accelerated Simulation Performance through High Performance Computing for Advanced Sealing Applications," by Dana, R-Systems, and SIMULIA was presented at the 2009 SIMULIA Customer Conference.

Download the paper at: www.simulia.com/cust_ref



2009 RUM Schedule

Attend the upcoming Regional Users' Meeting in your area. Learn about the latest enhancements to our products and the ongoing strategy of SIMULIA. For additional information, visit www.simulia.com/events/rums.

Americas

Date	Location
September 2–3	São Paulo, Brazil
September 15	Beechwood, OH
September 22–23	Bloomington, MN
October 21	Houston, TX
October 27	Seattle, WA
October 28	Bay Area, CA
October 29	Los Angeles, CA
November 10	Plymouth, MI

Europe/Middle East/South Africa

Date	Location
September 17–18	Göteborg, Sweden
September 21–22	Würzburg, Germany
October 13	Prague, Czech Republic
October 22	Athens, Greece
October 23	Volos, Greece
November 6	Barcelona, Spain
November 9–10	Graz, Austria
November 10	Paris, France
November 12–13	Netherlands
November 12–13	Istanbul, Turkey
November 19–20	Poznań, Poland
November 25	Israel

Asia Pacific

Date	Location
September 3	Bangalore, India
September 8–9	China
September 17	Daejeon, Korea
October 22–23	Penang, Malaysia
October 27	Tokyo, Japan
October 30	Osaka, Japan
November 3–4	Taipei City, Taiwan



Germany



Korea



Scandinavia



Americas

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