DESIGN THROUGH ANALYSIS: ANALYSTS NEED MORE ROBUST, EFFICIENT, FLEXIBLE TOOLS TO SUPPORT SIMULATION-DRIVEN PRODUCT DEVELOPMENT

White Paper

OVERVIEW

The transition to a smart, automated approach to product development and manufacturing—to develop higher quality, more innovative products faster and more cost-effectively in response to competitive pressures—affects everyone in product development, but may have the biggest impact on the role of analysts. As manufacturers pursue strategies that emphasize increased innovation, automation, and throughput across their product development and manufacturing organizations, analysts are being asked to take on additional roles beyond final design validation and evaluation of product performance issues, and become more directly involved in simulation-driven product development.

In today's changing product development environment, analysts need to be able to perform a greater number of complex simulations earlier in the product development process and collaborate more frequently and effectively with design, engineering, and manufacturing personnel. What analysts need to fulfill these added functions and execute their work more effectively are more powerful, efficient, and flexible simulation tools. This paper explores the changing role of design analysts, the new challenges that they face, and how **3D**EXPERIENCE WORKS Simulation from Dassault Systèmes can help analysts succeed in meeting these emerging responsibilities.

THE CHANGING ROLE OF THE ANALYST

As manufacturing organizations move toward greater automation and data sharing among product development and manufacturing technologies—a trend often referred to as the "Smart Factory" or "Industry 4.0"—the role of the design analyst is changing. Traditionally, analysts have been experts in the finite element analysis (FEA) method for simulating and predicting the physical behavior of product designs. The historical role of an analyst has primarily been to validate design performance prior to manufacturing and investigate field failures. However, increased automation boosts the demand for simulation, compelling more and more engineers to do the work of analysts and more and more analysts to get involved in earlier stages of product development.

Manufacturers are pushing automation because it provides many competitive advantages, such as faster time to market, reduced development costs, fewer manufacturing issues, higher quality, safer designs, and more innovative products. In this new product development and manufacturing paradigm, everyone associated with product design and production, including analysts, is expected to do more by working smarter.

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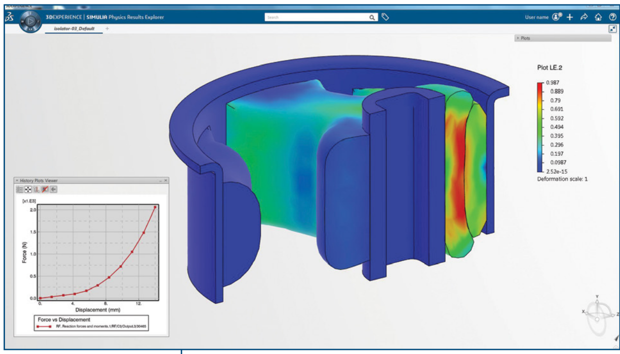
Instead of waiting on a figurative island for product designs to analyze for final validation—or field failure/warranty issues to resolve—analysts increasingly need to wear additional hats and integrate their work into the product development process at an earlier stage. An analyst's expertise is extremely valuable for resolving design performance and manufacturing problems before they negatively impact schedules, budgets, and time to market. That's because greater involvement of analysts earlier in the process helps to minimize rework/retrofits in production, reduce the number of required prototypes, eliminate field failures, reduce warranty claims, and avoid ancillary costs involving product performance and/or manufacturability issues. More and more, analysts have a role to play in ensuring greater design fidelity and quality earlier in the process through simulation-driven product design.

With a greater emphasis on design performance, innovation, safety, cost, and time to market, manufacturers are taking greater advantage of an analyst's expertise earlier in the development cycle, which creates a host of challenges for an analyst beyond the specific simulation problem at hand. In addition to needing a way to increase analysis throughput by conducting a higher volume of more complex simulations earlier in the product development process—seemingly increasing an analyst's workload—analysts face new workflow, data sharing, and communication requirements that create challenges beyond the capabilities of traditional, single-point finite element analysis (FEA) solutions.

In short, analysts need access to more robust, efficient, and flexible simulation tools that allow them to work smarter and more collaboratively—instead of harder—to overcome these unfolding challenges. A powerful, cloud-based simulation solution like **3D**EXPERIENCE WORKS Simulation—developed by Dassault Systèmes for use with the SOLIDWORKS mechanical design system—can help analysts confront and overcome growing demands for increased analysis throughput, more effective communication, and greater collaboration.



Large deformation with complex contact interactions of a rubber bushing.

WHY ANALYSTS NEED TO INCREASE SIMULATION THROUGHPUT OF MORE COMPLEX ANALYSES EARLIER IN DEVELOPMENT

There are several reasons why analysts need to increase simulation throughput of more complex analyses earlier in the cycle, ranging from handling growing product complexity to supporting concurrent, automated approaches to product development. As part of emerging smart workflows, simulation-driven product development places a range of demands on analysts that result in the need to conduct a higher volume of sophisticated analyses in less time.

Need to Validate More Complex Concepts Faster

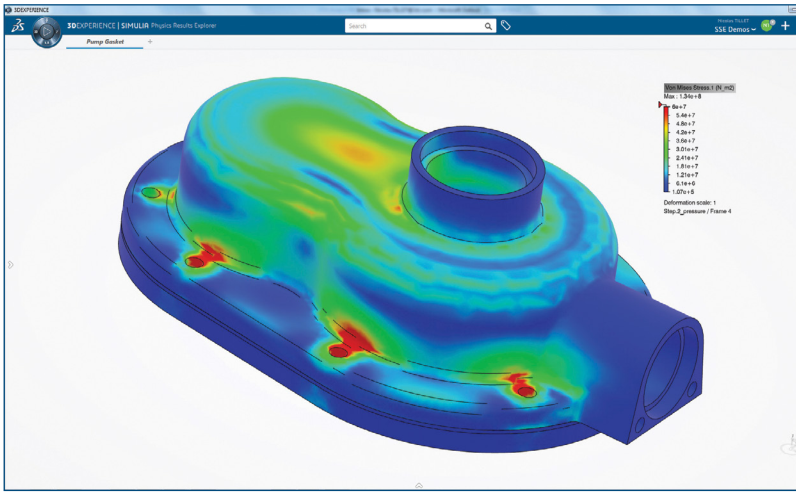
As products become more innovative and complex, the need to understand design behavior and performance becomes more challenging. Physical prototyping is costly, and some products are so complex that it's virtually impossible to physically test them. Others require advanced nonlinear analysis tools and greater computing resources for conducting accurate simulations. Growing product complexity—combined with a compressed, automated product development cycle—results in the need to validate sophisticated design behavior more frequently and in less time.

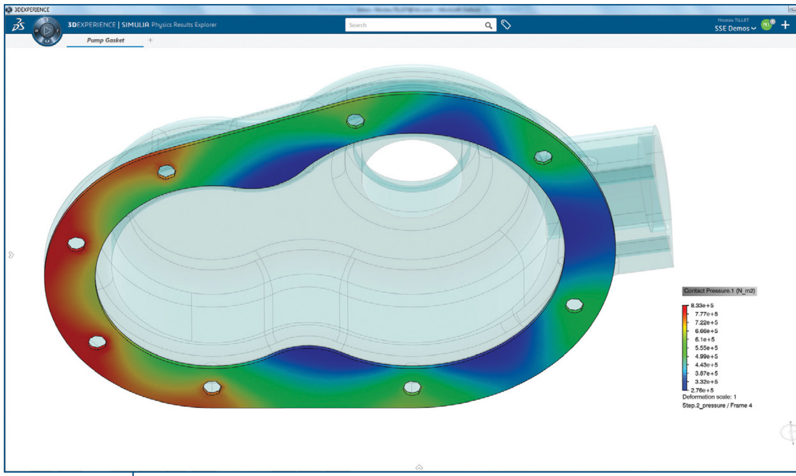
Need to Simulate Newly Engineered Materials

In addition to innovating new products, manufacturers are engineering new types of materials, including those used in additive manufacturing. Hyperelastic materials, such as the rubber used in a gasket, are becoming more frequent, as are materials exhibiting plasticity, permanent deformation under load. These types of materials require nonlinear simulation tools because understanding how they will affect design performance in the real world is becoming both more common and critical to product success. Thus, analysts will need to evaluate the use of a growing range of materials and their properties in addition to handling more complex geometric and structural nonlinearities, increasing the number of simulations required.

Need to Ensure Safety

While most analysts are familiar with conducting simulations focused on validating the appropriate factor of safety to ensure safe usage of a product by customers, the number and complexity of these types of analyses will steadily grow as part of simulation-driven product development. As products become more and more innovative and complex, factor of safety analysis will become more frequent and challenging, requiring access to advanced simulation capabilities and greater computing resources to ensure safety without incurring the cost of over-design.





Stress and contact pressure results of a pump housing under high pressure to analyze the number of bolts and amount of pre-load to avoid gasket leaking.

Need to Reduce Costs

The need to reduce costs applies both to reducing the number of prototypes required and increasing the volume, accuracy, and realism of complex simulations. This presents analysts with a real dilemma because minimizing prototyping requirements generally requires running more simulations and having confidence in the results and reliability in the tool and method used. However, how can an analyst run a greater number of complex simulations in less time without working longer hours or investing in additional analysis and/or computing resources? To reduce costs in a meaningful way, analysts need to run more simulations, which heretofore required spending more money. The return on investment associated with using simulation tools is significant because of reduced physical testing and validation costs.

Need to Increase Collaboration with Designers, Engineers

Interactions between analysts, designers, and engineers can be confrontational at times in an iterative, sequential, prototype-heavy design through manufacturing process. This often results when analysis is done at the end of the process for validation, which can substantially alter the work of design and engineering colleagues without giving them a sense of buy-in. Sharing simulation models and reports by email can also result in errors and/or delays. In an integrated, simulation-driven product design through manufacturing process, analysts engage in greater collaboration with designers and engineers—and have the tools to facilitate these discussions—early in the cycle, so that they can contribute valuable expertise and important insights into how to improve design performance.

Need to Validate Greater Design Fidelity Earlier

Instead of just identifying design problems at the end of the process during validation, analysts are increasingly being asked to solve design problems at the beginning of the product development cycle through collaboration with designers and engineers as part of a project team. Ensuring greater design fidelity early in the process is not just the responsibility of designers and engineers but increasingly involves analysts, who can make more valuable contributions running multiple simulations early in the cycle than running just one at the end or when a failure occurs.

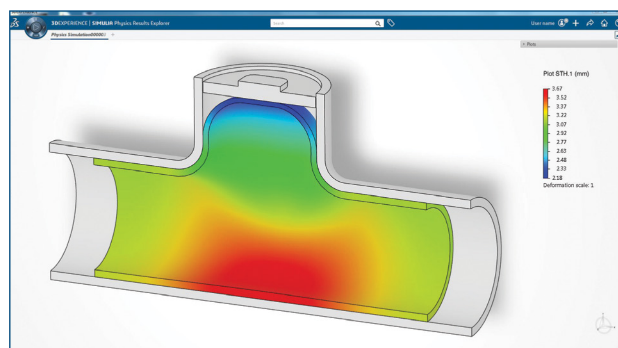
Need to Verify Design for Manufacturability

How a product will be manufactured (e.g., machining, casting, injection molding, 3D printing, etc.) can have a significant influence on time to market, especially when manufacturability issues are discovered late in the product development process. Analysts are increasingly adding manufacturability to the growing number of complex simulations that they need to conduct, especially with the availability of new production technologies such as additive manufacturing. In the emerging smart factory, analysts need to validate manufacturability as well as design performance.

Need to Support an Integrated, Concurrent Approach

In the concurrent, automated workflows of the "Smart Factory" or "Industry 4.0," every function connected to design and manufacturing—including visualization, prototyping, validation, cost estimating, manufacturing planning, data management, quality control, documentation, packaging development, and marketing—is able to work with the master product model earlier in the process. Analysts need simulation tools that are integrated with the CAD environment not only to access the master CAD model, save time, iterate quickly, and validate design performance and manufacturability early on, but also to share recommended changes to the master product model to support other functions and further shorten time to market.

The need to reduce costs applies both to reducing the number of prototpyes required and increasing the volume of complex simulations.



Thickness plot results to predict design of material thickness resulting from manufacturing of hydro-formed tube.

HOW ROBUST, INTEGRATED, CLOUD-BASED SIMULATION TOOLS HELP ANALYSTS RESPOND TO GROWING ANALYSIS NEEDS

Analysts can efficiently respond to the challenges associated with performing a greater number of more complex simulations earlier in the product development cycle—and make more significant contributions to product development—by utilizing integrated, cloud-based simulation tools, like **3D**EXPERIENCE WORKS Simulation, which was developed by Dassault Systèmes for SOLIDWORKS users.

Validate Complex Concepts Earlier without Additional Hardware

With robust, cloud-based, simulation capabilites, analysts can efficiently respond to the need to perform a higher volume of complex analyses earlier in the process without working longer, cloning themselves, or acquiring additional computing hardware. They can simply set up a number of simulation studies and let them run overnight sequentially in a batch approach, utilizing cloud computing resources to solve the analysis instead of having to purchase additional expensive computing hardware. By working smarter with a cloud-based simulation application, analysts can efficiently solve the challenging design behavior and performance simulations related to more innovative, complex products earlier in the development process. Executing large simulations on cloud also keeps your local hardware from getting bogged down, freeing it up for other work.

Simulate Performance of Newly Engineered Materials

Adding simulations of newly engineered materials to an analyst's growing list of simulation responsibilities can be more easily handled with robust, cloud-based simulation tools. As product designs become more innovative and complex, the need for engineering new materials to make them will also increase, creating the need to evaluate the advantages or disadvantages of using them in a particular design. The operative term here is "robust," because assessing the behavior and performance impact of using newly engineered materials typically requires advanced nonlinear analysis tools.

Ensure Safety Earlier in Development

The number and complexity of factor of safety simulations that ensure safe usage of a product by customers will also increase in parallel with product sophistication. Analysts can most effectively handle the onslaught of simulations that they need to perform with a robust, cloud-based system that allows them to set up problems during working hours, which run overnight or over the weekend. With this type of batch capability, analysts can validate product safety early on in the product development process while eliminating the costs associated with over-designing a product. With more accurate, realistic simulations, there are fewer assumptions and idealizations that can result in an overabundance of caution and over-design.

"With **3D**EXPERIENCE **WORKS** Simulation, we were able to evaluate a range of geometric and material options, a process that helped us quickly optimize the tapered, barrel-shaped design of the bearings and also decide the best high-strength steel for the design.... This allowed us to optimize critical internal components for cyclic fatigue-loading (bending stress), a common cause of twist-offs down-hole, and confirm a higher torque rating and increased durability for our product."

Peter Kjellbotn
Mechanical Engineer/Simulation Specialist
InFocus Energy Services, Inc.

Reduce Costs, Minimize Prototyping, Boost Analysis Productivity

Running simulations in the cloud instead of consuming internal computing resources, or purchasing additional hardware, will certainly lower hardware acquisition costs. By running more analyses earlier in the development process, analysts can also help minimize prototyping requirements and their attendant costs. And because analysts can batch process the solving of simulations at off-times and no longer have to wait for simulations to solve, analysis productivity will increase, saving additional money while maximizing utilization of analysis resources.

Increase Collaboration, Input through Integration with Design

The ability to work with product design data to run analyses, and subsequently share simulation results with design, engineering, and manufacturing colleagues early on, will encourage productive interactions and collaboration between analysts, designers, and engineers. Analysts have valuable expertise and insights to contribute to design and engineering, and the ability to work with the same data and results information will increase the number of simulations performed, facilitate discussions based on results, increase an analyst's contributions to product design, and improve design performance overall.

Contribute to Greater Design Fidelity Earlier in Development

By providing the capacity to run more simulations of a more complex nature in less time, robust, cloud-based simulation capabilities can transform analysts from problem identifiers into problem solvers. Instead of just validating a design or pinpointing performance issues at the end of product development, these types of simulation tools will generate the knowledge and foster the collaboration that results in greater design fidelity at an early stage of product development.

Verify Design for Manufacturability

Instead of dealing with manufacturability issues at the end of the product development process, analysts can leverage robust, cloud-based simulation capabilities to confirm design for manufacturability early or even suggest a better way to produce a component. Analyzing the best way to manufacture a design can lead to beneficial discoveries that can resolve manufacturability issues, improve product quality, or shorten time to market. By adding manufacturability verification to design analysis, analysts can help their organizations select the best manufacturing approach for a particular product, which is critically important for success during a time of emerging manufacturing technologies.

Support Smarter, Concurrent Approach to Development

Robust, cloud-based simulation tools serve to integrate analysts into the concurrent, automated workflows of the "Smart Factory" or "Industry 4.0." The premise of smart product development and manufacturing is to validate a master product model as early as possible in the product development cycle, so that all functions connected to design and manufacturing—including visualization, prototyping, validation, cost estimating, manufacturing planning, data management, quality control, documentation, packaging development, and marketing—can work concurrently with it instead of sequentially. Using integrated, cloud-based tools, analysts can run the greater number of simulations required to support this approach and shorten time to market.

… A CASE IN POINT

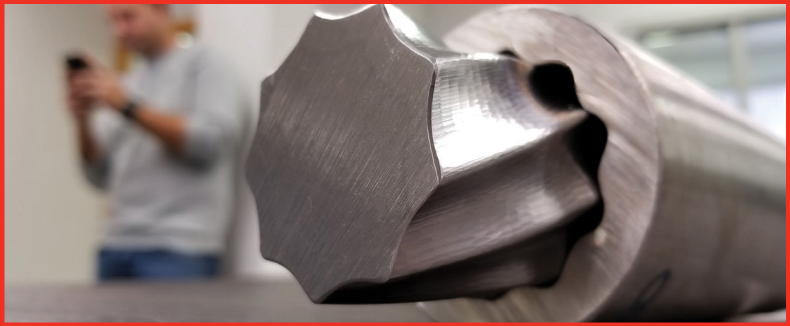
InFocus Energy Services, Inc. is an innovative Canadian company specializing in the development of solution-driven downhole products for the oil and gas industry. Staying on the cutting edge of the oil and gas industry requires robust design and engineering tools, which is why the company utilizes the integrated SOLIDWORKS® 3D product development suite.

"We needed more simulation power, as well as a solution that worked smoothly with SOLIDWORKS," explains Mechanical Engineer/Simulation Specialist Peter Kjellbotn. "When we heard that SOLIDWORKS was launching a new **3D**EXPERIENCE® simulation solution that incorporated the SIMULIA® Abaqus solver, we signed up for the Lighthouse Program so we could start using the new solutions immediately. As soon as we got our hands on it, we started testing it and benchmarking it against known test results."

InFocus first utilized **3D**EXPERIENCE WORKS Simulation on the bearing section of the company's RE|FLEX Premium HP/HT Drilling Motor. The motor's bearing section is a proprietary design that was developed to convert extreme loading parameters, including torque of over 30,000 foot-pounds, into efficient drilling action. The company's initial concept design of the drive system, which utilized traditional ball bearings, resulted in failure during testing when the load crushed the bearings and the faces that load the bearings. **3D**EXPERIENCE WORKS Simulation predicted the failure—with accurate correlation to actual test results—and helped the company develop a better, more innovative design.

"With **3D**EXPERIENCE WORKS Simulation, we were able to evaluate a range of geometric and material options, a process that helped us quickly optimize the tapered, barrel-shaped design of the bearings and also decide the best high-strength steel for the design," Kjellbotn says. "Because we analyzed our options in software, we didn't need to physically test all of the possibilities and ran just a few verification tests on the design validated in **3D**EXPERIENCE WORKS Simulation, which confirmed that our simulation results were accurate. This allowed us to optimize critical internal components for cyclic fatigue-loading (bending stress), a common cause of twist-offs down-hole, and confirm a higher torque rating and increased durability for our product."

READ THE FULL INFOCUS ENERGY SERVICES CASE STUDY



ANALYSTS NEED ROBUST, CLOUD-BASED STRUCTURAL SIMULATION TOOLS TO SUPPORT SMART PRODUCT DEVELOPMENT

The structural simulation tools that analysts need for overcoming the challenges of smart product development are very different from the capabilities of traditional, single-point FEA analysis solutions. Expanding simulation throughput, while solving increasingly difficult, complex analyses, requires simulation flexibility, scalability, and power—flexibility to utilize simulation tools for just three months or over an entire year, scalability to access the specific types of physics simulation required, and power to access additional computing resources on the cloud when necessary. Smart product development requires cloud-based access to a more extensive set of FEA analysis capabilities, ranging from linear analysis and topology optimization to nonlinear analysis and advanced dynamics/vibration simulation.

LINEAR ANALYSIS

At the bare minimum, analysts need access to linear analysis tools that enable them to simulate design behavior and performance whenever there are no nonlinearities involved. Linear analysis is suitable for first-pass, which is sufficient for most designs in the early stages of product development. Not all problems are nonlinear in nature, and the ability to run linear analyses gives analysts the option to run the most efficient simulation based on the nature of the problem. For more information, contact your local reseller.

At the bare minimum, analysts need access to linear tools that enable them to simulate design behavior and performance whenever there are no nonlinearities involved.

Will It Break, Buckle, or Deform?

Using linear analysis tools, analysts can determine whether a design will break, buckle, or deform (bend) in response to the loads and boundary conditions of its operating environment. These types of studies can be used to confirm the appropriate factor of safety for a specific design, as well as predict the effects of weight-reduction efforts. For more information, contact your local reseller.

Is It Stiff Enough?

Understanding the relative stiffness of a particular design to determine if it meets the requirements of its intended use requires deflection/displacement simulation and natural frequency study capabilities. Some designs need to be very stiff so they don't deflect very much while others can't be too stiff because they require some level of controlled deflection. Mechanical systems are designed such that the resonant frequencies of structures do not match frequencies of vibrations to which they are subjected. These simulations can help analysts work with designers and engineers to achieve the appropriate level of stiffness for a particular design.

When Will It Wear Out?

Predicting how long a period of time it will take—or after how many cycles—before a product or component will wear out or fail requires robust fatigue analysis capabilities. Analysts need fatigue analysis tools so they can use the results to work with designers and engineers on improving quality, increasing durability, or extending a product's lifespan to ensure that a product will continue to perform way past its warranty period. For more information, contact your local reseller.

Motion/Kinematics

While linear static stress analysis tools are sufficient for simulating the behavior of products and components that don't move, many assemblies, such as mechanisms, and the individual parts within an assembly, move a great deal. Analysts need to be able to conduct kinematics and motion simulation studies not only to observe how an assembly or system will move but also to generate accurate dynamic loading information for every part within the assembly to support additional structural analyses. For more information, contact your local reseller.

Thermal Simulation Tools

In addition to simulating the impact of structural loads on a design, analysts need thermal simulation capabilities to understand how temperature and heat transfer effects influence structural performance. Such analyses provide the insights necessary for determining whether a heat sink or cooling system is indicated. Then, analysts can use the same thermal analysis tools to validate that the heat sink or cooling system transfers away enough heat to ensure optimal performance. For more information, contact your local reseller.

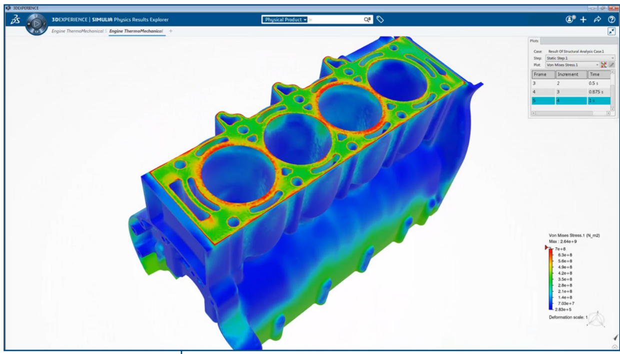
Pressure Vessel Studies

Many types of products require the use of pressure vessels, which are designed to contain a variety of liquids, gases, or liquified gases at high pressure. Analysts need to be able to conduct pressure vessel studies so that they can work with designers and engineers to optimize pressure vessel designs in terms of wall thickness and material, while simultaneously validating that a pressure-vessel design can handle the loads associated with its pressure rating. For more information, contact your local reseller.

Analysts need thermal simulation capabilities to understand how temperature and heat transfer effects influence structural performance.

NONLINEAR ANALYSIS

Although linear analysis tools can help solve some types of structural problems, the vast majority of simulations—especially with complex products—tend to be nonlinear in nature. The physical world where products operate is not a flat, linear domain where structural responses are always proportional to the applied loads. The real world is 3D, nonlinear, and dynamic, requiring the use of nonlinear analysis tools for obtaining accurate FEA solutions. Nonlinear structural analysis problems generally fall within three categories: nonlinear materials, nonlinear geometries, and nonlinear interactions between parts or structural nonlinearities. Some nonlinear problems can even involve all three types, as well as nonlinear loads/boundary conditions and nonlinear dynamics/vibration. For more information, contact your local reseller.



Thermal-stress results of an engine block.

Nonlinear Materials

Many modern materials, such as plastics, synthetics, metal alloys, and composites, have unique properties—or properties that change with changes in temperature—that require nonlinear materials analysis to capture their complex load response behavior. Because an increasing number of products (e.g., medical stents, plastic clips, etc.) are designed to deform in shape and stretch without failing, analysts need nonlinear analysis tools to understand nonlinear material behavior, such as plasticity in metals, the deformation of material undergoing non-reversible changes of shape in response to applied forces; hyperelasticity in rubber/plastics, the deformation of material in response to applied forces that returns to its original shape after forces are removed; and creep, the tendency for material to stretch slowly or deform permanently over time under the influence of mechanical stresses that are below the material's yield strength. For more information, contact your local reseller.

Geometric Nonlinearities

Just as the load response of certain types of materials is not proportional or linear, some complex geometric shapes also respond to applied loads in a nonlinear fashion. The most common type of geometric nonlinearity is when displacements alter a structure's stiffness in ways that are not proportional. Linear analysis assumes stiffness is constant regardless of deflection, while nonlinear analysis determines stress based on the deformed shape. Analysts need robust nonlinear analysis tools so they can evaluate geometric nonlinearities alone, as well as situations where material nonlinearities, structural nonlinearites, nonlinear loads/boundary conditions and nonlinear/dynamics/vibration are all present. For more information, contact your local reseller.

Structural Nonlinearities

Because product designs are increasingly sophisticated, they can present a growing number of more complex analysis problems that go beyond material and geometric nonlinearities and involve a nonlinear load response related to the interaction of different parts within an assembly. Structural nonlinearities occur in situations where the interactions between parts are nonlinear in nature, such as contact. Analysts need robust, cloud-based simulation tools that can handle any type of nonlinearity, or all three types together, such as a product made from a hyperelastic material in a shape that presents geometric nonlinearities and contact in its operating environment. For more information, contact your local reseller.

Nonlinear Loads and Boundary Conditions

While the term "nonlinear" primarily refers to the disproportional nature of a design's physical response under load, the loads and boundary conditions that elicit nonlinear responses can also be nonlinear, or dynamic, in nature. When the applied load is a function of time, and the material response is a function of displacement or temperature, designs can respond in ways that are difficult to predict. However, analysts can use sequential loading events—also called multi-step analysis—and sequential thermal/structural analysis to simulate this type of behavior. For more information, contact your local reseller.

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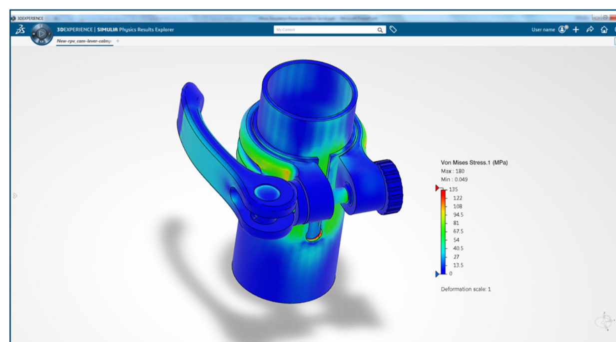
Complex Contact Analysis

Many modern products involve parts that contact each other in ways that create a nonlinear response. Whenever parts are joined together—such as with bolts, welds, and glue—the contact is simple and generally does not require nonlinear contact analysis. However, when moving parts contact each other—as is the case with gears, cams, levers, and other assemblies in motion—and the contact area between components changes throughout the continuing load, robust, nonlinear contact analysis is necessary for simulating this often unpredictable behavior. General contact simulation from ABAQUS, which is included in **3D**EXPERIENCE WORKS Simulation, is the most realistic and reliable contact analysis in the industry. For more information, contact your local reseller.



Von Mises stress plot result of a bike seat post simulating accurate complex contact.

ADVANCED DYNAMICS/VIBRATION ANALYSIS

Structures not only can deform, buckle, yield, and fatigue under applied loads but also can vibrate in ways that can be fairly obvious or distinctly unpredictable. Vibration can be magnified as a result of load-inertia coupling or amplified by periodic forces as a result of resonance. With advanced dynamics simulation capabilities, analysts can solve perplexing problems related to vibration, whether it's through modal, modal time history (time response), harmonic (frequency response), random vibration, or drop test analysis. For more information, contact your local reseller.

Modes of Vibration

In vibrational analysis, modes of vibration are the different ways in which the system tries to oscillate naturally without any excitation force. The frequency of oscillation is the system's modal or natural frequency, and the shape made by the system is called mode shape. While a system can vibrate in various ways, it has a tendency to follow certain shapes with each related frequency when oscillating, depending upon material properties and governing mechanics. With any mechanism or machine with moving parts, it's critically important to determine the natural frequencies, and the modes of vibration associated with those frequencies, for a given part or assembly, in order to control vibration and produce a design that runs smoothly. For more information, contact your local reseller.

Time-Dependent Loads

While understanding natural frequencies and their modes of vibration is important, it's equally important to study the forced vibration characteristics of designs in which a time-varying load excites a response in one or more components. Analysts need advanced dynamics analysis capabilities to predict the impact of time-varying loads and other load-related effects, such as damping and inertia, which can occur with alternating forces, sudden applied forces, or intermittent loads. For more information, contact your local reseller.

Frequency-Related Loads

There are times when a dynamics problem involves a load that is not a function of time but is a function of frequency. A shaker table, an oscillating platform that can be used to test structures by simulating earthquakes or to demonstrate resonance, is an obvious example. Analysts need to be able to conduct frequency-varying simulations known as harmonic analyses for many different types of designs and mechanisms, especially those with rotating components. For more information, contact your local reseller.

Random Vibration

On designs for which the load is not deterministic and subject to random variations, analysts need to be able to conduct a random vibration analysis, which takes a probabilistic approach to load definition. Random vibration is motion which involves a load that is neither a function of time or frequency, meaning that future load behavior cannot be precisely predicted. The randomness is a characteristic of the excitation or input, not the mode shapes or natural frequencies. Simulating vibration effects related to the loads generated by an earthquake on a building is an example of random vibration analysis. For more information, contact your local reseller.

While understanding natural frequencies and their modes of vibration is important, it's equally important to study the forced vibration characteristics of designs in which a time-varying load excites a response in one or more components.

Drop Tests

In an age of hand-held electronics and smart gadgets, analysts need to be able to conduct drop test simulations. These types of analyses can help shorten time-to-market because they allow analysts to predict what will happen to a product if it is subjected to varying forces related to being dropped from different heights, without having to drop prototypes over and over. Drop test simulations don't solely apply to hand-held electronic products, however, because many manufacturers of replacement parts also want to know what happens to the part if someone drops it before having a chance to install it. For more information, contact your local reseller.

TOPOLOGY OPTIMIZATION

Another type of simulation application that is particularly useful in helping analysts work more closely with designers and engineers is topology optimization. A topology study explores design iterations of component geometry to satisfy a given optimization goal—such as balancing the weight-to-stiffness ratio, minimizing mass, or minimizing maximum displacement—based on specific loads and geometric constraints, including those imposed by the manufacturing process used. Topology optimization is a valuable tool for generating innovative design concepts, establishing starting points for the design team, or generating ideas for refining an existing design. For more information, contact your local reseller.

HARDWARE INDEPENDENT, CLOUD-BASED SIMULATION

The primary difference between a cloud-based simulation solution and a traditional, single-point FEA analysis tool is that analyses performed in the cloud are completely hardware independent. While analysts may still be able to batch-process simulations on their own hardware, they'll need to continually invest in newer, faster, and increasingly expensive computers to handle the growing number of computationally intensive complex simulations. Analysts can achieve the same level of computing and solving performance using a cloud-based analysis system as they can with their own hardware, with the added benefit of not having to continually spend money on bigger, faster computing resources. For more information, contact your local reseller.

Topology optimization is a valuable tool for generating innovative design concepts, establishing starting points for the design team, or generating ideas for refining an existing design.

SUPPORT SIMULATION-DRIVEN PRODUCT DEVELOPMENT WITH 3DEXPERIENCE WORKS SIMULATION

Analysts can effectively respond to the workflow, data sharing, and throughput challenges of smart product development and fully support a simulation-driven product development approach. For more information, contact your local reseller.

ABAQUS Nonlinear Solver on the 3DEXPERIENCE Platform

Powered by the industry-leading ABAQUS Realistic Simulation nonlinear analysis solver on the **3D**EXPERIENCE® platform, **3D**EXPERIENCE WORKS Simulation software provides an extensive environment for conducting structural static (linear and nonlinear analysis), frequency, buckling, harmonic response, modal dynamic response, and thermal-structural simulations of assemblies and individual parts. These cloud-based capabilities can help analysts increase simulation throughput, collaborate more effectively with design and engineering colleagues, and contribute to increased innovations in product development.

Linear and Advanced Nonlinear Capabilities

3DEXPERIENCE WORKS Simulation includes both linear and advanced nonlinear static structural analysis tools and can produce the accurate simulation results that product development teams need to succeed in today's fast-paced manufacturing environment. Analysis capabilties include:

Material Nonlinearities

- Plasticity
- Hyperelasticity
- Creep

Geometric Nonlinearities

Nonlinear Loads and Boundary Conditions

- Sequential Loading Events (Multi-Step Analysis)
- Sequential Thermal/Structural Analysis

Thermal Analysis

Complex Contact Analysis

- Deformable, Intermittent Contact between Parts and Assemblies
- Surface Pairs
- Automatic Detection
- General Contact
- Initialization

Numerous Connection and Connector Options for Simulating Fasteners and Mechanisms

Dynamic Response Analysis

- Frequency Analysis
- Modal Transient Analysis
- Modal Harmonic Analysis

Analysts can effectively respond to the workflow, data sharing, and throughput challenges of smart product development and fully support a simulation-driven product development approach.

Robust Meshing Tools

Analysts will have complete mesh flexibility and control with **3D**EXPERIENCE WORKS Simulation's robust meshing tools. These capabilities include automated meshing using rules-based meshing and 1D, 2D, or 3D elements. Analysts will also have access to a wider range of element types (e.g., quad, brick, continuum shells, etc.)

Runs in the Cloud

3DEXPERIENCE WORKS Simulation can be run either locally, utilizing internal computing resources, or in the cloud, gaining additional computing power. This degree of flexibility enables analysts to free up local computing resources during a solution run or tap more CPUs to solve large, difficult simulations faster.

Supports Sequential Batch Processing

Analysts will be able to easily boost simulation throughput by taking advantage of sequential processing capabilities. The ability to solve simulations sequentially in the cloud—overnight or over a weekend—will allow analysts to increase productivity without working longer.

Results Sharing via Lightweight Web Apps

3DEXPERIENCE WORKS Simulation provides high-performance results visualization—especially for very large models—as well as related web apps for the sharing of lightweight simulation results via table, smartphone, etc. Analysts can also choose to post-process large-scale simulation data by using remote machines for the rendering and visualization computation.

CAD/CAE Integration

Tight associativity with both SOLIDWORKS® and CATIA® 3D design systems allow analysts to use **3D**EXPERIENCE WORKS Simulation to work directly on the product design geometry. This means that simulation results and CAD design data remain tightly linked and synchronized, even after design changes are made.

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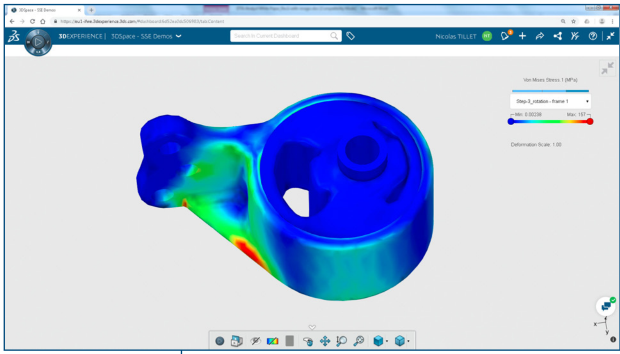
3DEXPERIENCE **WORKS** Simulation can be run either locally, utilizing internal computing resources, or in the cloud, gaining additional computing power.



Visualization in a web browser of a rubber bushing Von Mises stress light results under large deformation, complex contact interactions and sequential loading.

VALIDATE INNOVATIVE PRODUCTS EARLIER WITH 3DEXPERIENCE WORKS SIMULATION

Competing successfully in today's global market requires manufacturers to increase innovation, automation, and throughput as part of the transition to the "Smart Factory" or "Industry 4.0." Smart product development and manufacturing require greater automation and data sharing among design, engineering, and manufacturing personnel and technologies—a trend that is changing the roles and responsibilities of analysts. Everyone associated with product design and production, including analysts, is expected to do more by working smarter. Analysts, in particular, are being asked to do more by boosting simulation throughput, running more complex simulations, and collaborating with design and engineering colleagues more effectively through direct involvement in simulation-driven product development.

Increasing simulation throughput substantially, communicating analysis results more effectively, and collaborating with colleagues more directly creates a slew of new challenges for analysts—challenges that demand more robust, efficient, and flexible simulation solutions. With a powerful, cloud-based simulation solution like **3D**EXPERIENCE WORKS Simulation from Dassault Systèmes, analysts can overcome growing demands for increased simulation throughput by using advanced, nonlinear analysis tools—like hyperelasticity and complex contact—to run more realistic simulations faster, without investing in expensive hardware or increasing IT costs to set up and maintain CPU clusters. With **3D**EXPERIENCE WORKS Simulation, analysts can embrace their changing role and make more significant contributions to product development.

To learn more about how **3D**EXPERIENCE WORKS Simulation can improve your design, engineering, and manufacturing processes through simulation-driven product development, visit www.solidworks.com/simuliaworks or call 1 800 693 9000 or 1 781 810 5011.

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