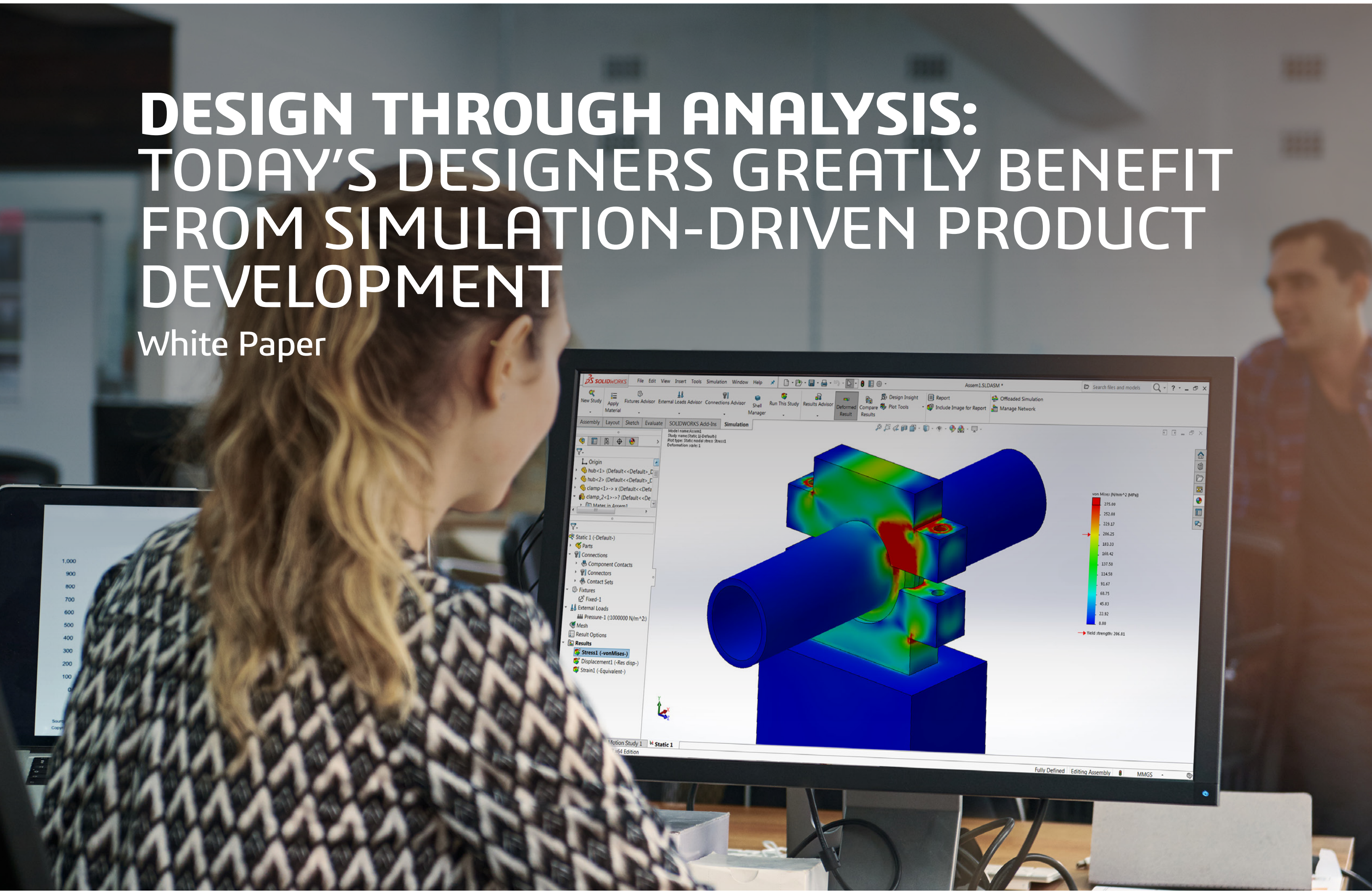
DESIGN THROUGH ANALYSIS: TODAY'S DESIGNERS GREATLY BENEFIT FROM SIMULATION-DRIVEN PRODUCT DEVELOPMENT

White Paper



OVERVIEW

In today's increasingly competitive global market, product designers face mounting pressures to not only create more innovative products but to also deliver designs of higher precision and fidelity—in terms of manufacturability and performance—more quickly and cost-effectively than ever before. Demands for increased innovation, automation, and throughput across manufacturing organizations are already affecting the work of designers who now face greater expectations for more complete designs earlier, with fewer, if any, design changes or manufacturability surprises encountered late in the product development process. What product designers need to respond to this growing demand are integrated, easy-to-use, and automated design simulation and analysis tools, such as those included with SOLIDWORKS® Simulation software. This paper examines the increasing demands that designers face to deliver more robust designs early in the process and how integrated simulation capabilities can help them drive the design creation process to achieve that goal.

DESIGN TOOLS: IT'S NOT JUST ABOUT MODELING OR DRAWING ANYMORE

Product design is presently undergoing evolutionary changes similar to the previous transitions from mechanical drawing on drafting boards to 2D computer-aided design (CAD) drawing packages, and then from 2D drawing tools to 3D CAD parametric solid modeling systems. Product designers moved away from drafting tables and began using 2D CAD because it was faster and easier, and shortened time to market. The move from 2D to 3D emanated from the productivity gains and improved visualization of working in 3D. Unlike these previous transitions, the solution to the mounting pressures of today's greater global competition requires product designers to augment, expand, and automate the set of design tools that they use to develop products, not just replace them with something else. Designers are now adding new solutions to their 3D toolbox with an eye towards leveraging more accessible simulation technology; greater automation; and new manufacturing processes to design safer, better-performing, more innovative products.

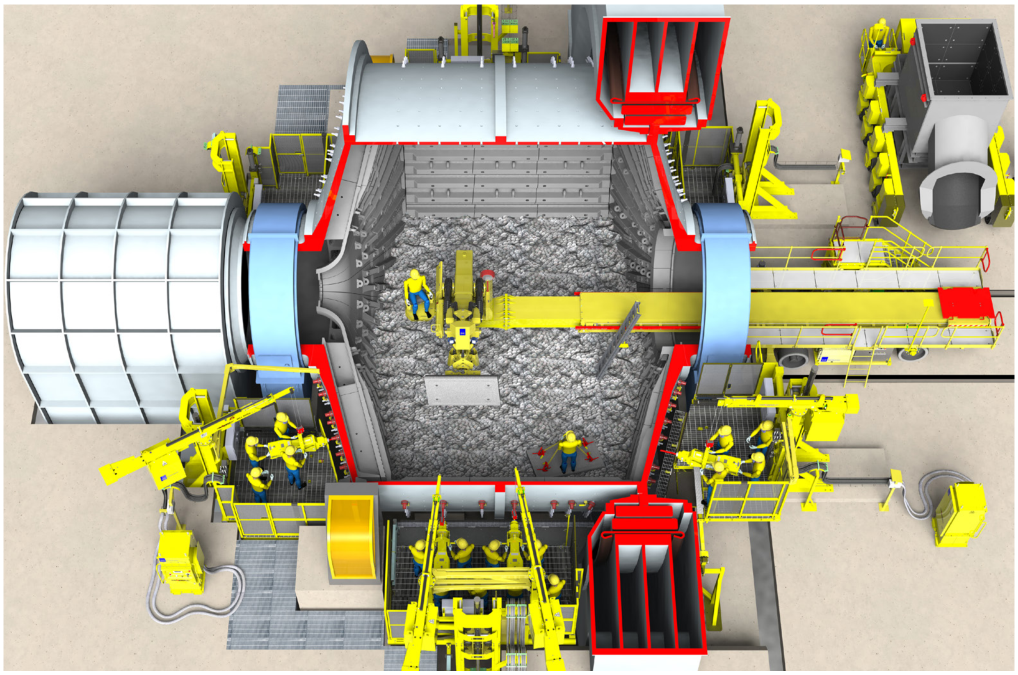
Developing more innovative, better-performing products requires everyone associated with product development to do more by working smarter to support more exacting product development requirements. For example, while designers were previously tasked with creating geometric models and drawings of components that fit a specific function, the validation of the design, through physical and virtual prototyping, was typically completed later and possibly by another group. Now, designers are being tasked with integrating simulation within initial designs to deliver greater fidelity earlier in the process, so manufacturers can start production planning earlier and avoid costly late-cycle change iterations. With higher-fidelity designs, manufacturers will spend less time resolving product performance or manufacturability issues late in the process, minimizing the frequency of rework and retrofits, and reducing costly field failures, returns, and warranty claims.

With the greater emphasis on design performance, innovation, safety, cost, and aesthetics, CAD-integrated simulation tools that were once thought of as a nice-to-have luxury have become a must-have capability in the designer's toolbox. That's because the greater design fidelity and quality enabled by design simulation during initial design eliminates or drastically reduces late-process performance and manufacturability issues.

Yet, the simulation and analysis needs of a designer are very different from those of traditional finite element analysis (FEA) engineers or analysts. Selecting the simulation tools that are best-suited for use by designers requires an understanding of why designers need to know more about design behavior and manufacturability during initial design, and how simulation-driven design can help.

WHY MUST DESIGNERS BETTER UNDERSTAND REAL-WORLD DESIGN BEHAVIOR?

Designers need to better understand real-world design behavior because they face a long and growing list of demands related to delivering higher-fidelity designs. By more fully simulating, analyzing, interrogating, and refining product designs during upfront iterations, designers can directly help their organizations avoid the late-cycle pitfalls that mar a manufacturer's competitiveness; effectively respond to growing job demands; and deliver better quality, more innovative designs.



Demands for Innovation

Nearly all manufacturers value innovation in product design to help turn a market on its head or establish a new market or product category. In many ways, innovation is the opposite of complacency—doing things the way they've always been done. Innovation requires new ways of thinking and a deeper understanding of design constraints, product operating environments, and design behavior under those conditions. In short, without an understanding of real-world design behavior, designers may pursue unworkable ideas merely because they are innovative, or reject innovative ideas as unworkable without really knowing if that's the case. Simulation tools help designers judge the potential of innovative ideas early in the process.

Demands for Safety

Making a product safer for customers to use requires a deep understanding of design behavior under load. Some designers work toward specific factors of safety on their designs to ensure that their products are safe for customers to use. Others often over-design a part just to be on the safe side. But, it's more efficient and cost-effective, to achieve the regulatory or desirable factor of safety, and avoid the high cost of safety-related recalls, when designers use simulation to verify how a design will perform in its operating environment at the start the product development process.

Demands for Cost Reductions

Designers are increasingly being asked to trim costs out of designs for new products or models as part of the initial design requirements/specifications that they receive. While there are some fairly obvious approaches for doing this—such as reducing weight/volume to cut material usage, using a less costly material, or employing a more affordable production technique—designers won't really know if any of the various cost-reducing options that they might try will work without resorting to physical prototyping, which increases costs. With simulation tools, designers can explore the various options for reducing costs and verify if any of them meet their design criteria.

Demands for Aesthetics

Demands for improved design aesthetics—the look, feel, and general appearance of a product—remain a constant challenge, especially when designers don't fully appreciate how modifications made to enhance design aesthetics can impinge upon product performance. If you improve the overall appearance of a product but it fails in its intended function, or requires rework later in the process, cosmetic improvements will not be worth the effort. However, if a designer can validate design performance after aesthetic improvements are made, the likelihood of late-cycle iterations or field failures diminishes.

Demands for Improved Performance

When a manufacturer introduces a new product model, the company doesn't merely want to make changes to the previous model just for change's sake. Product development isn't about window dressing or putting on a fresh coat of paint. Manufacturers want to make product changes that increase customer satisfaction by improving how the product functions or performs. With access to simulation tools, designers can gain a better understanding of what design modifications will help them improve design performance. In short, if you can measure it, you can optimize it.

Demands for Design for Manufacturability

The most elegant, beautiful product design is of no real commercial value if it cannot be manufactured at volume and sold at a profit. Increasingly, designers need to consider how a product or part will be made as part of initial design. Machining a part because "we've always machined parts" is no longer good enough, especially with the advent of additive manufacturing technologies, which provide the means for making parts that were previously impossible to produce. By using simulation tools, designers can assess the manufacturability of their designs while they design, leading to better production choices and outcomes.

Demands for Concurrent Design

One of the reasons that designers are being asked to create designs of higher fidelity early in the process is the power and efficiency of concurrent design workflows. With concurrent design, 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. When the design is more complete early in the process, other functions can work with it sooner, compressing the entire design-through-manufacturing process dramatically.

Integrated Simulation Tools Can Help

While designers clearly need a greater understanding of design behavior, performance, and manufacturability—to respond to increasing job demands and improve their companies' competitiveness—you certainly don't need or want all of the simulation capabilities utilized by high-end analysts. The critical success factor for designers' use of simulation tools is that the solutions are directly integrated inside their modeling environment, so they can apply simulation results directly as refinements made to the design. By extending a designer's toolbox, integrated simulation capabilities can help designers do more to improve design fidelity by working smarter.

Idea Generation

Design ideas come from many places. Some designers work with the previous design for a product and work to improve it. Others may begin with a classic engineering shape or form. Still others may begin with a shape that they've visualized in their mind's eye. Innovation stems from unconstrained design freedom and the ability to generate ideas that may not occur to you. With integrated simulation applications that include topology optimization tools, designers can generate fresh ideas based solely on the operating and manufacturing requirements for a product or part.

Design Refinement

Refining a design is an iterative process that is most efficient and less costly when performed during initial design. With integrated simulation software, designers can apply the knowledge gained from simulating design performance directly onto their design model and then run the simulation again. You can then learn from that analysis, further modify the design, and run the analysis again. Through this fast, iterative process, you can refine your designs while you create them, ensure that later analyses confirm your findings, and eliminate design refinements later in the process, when they take longer and are more costly.

Considering Other Design Options

Some designers work with a single design concept and then strive to improve it. By having access to integrated simulation tools, you will have the time and space to consider other design approaches, potentially discovering a better-performing design than your initial effort. The more design options that you can quickly evaluate against performance criteria using simulation tools, the greater the likelihood that you will identify an optimal or improved concept, leading to a design that may not have been contemplated without the use of simulation tools.

Going Beyond Factor of Safety

While designers can certainly use integrated simulation capabilties to validate the required factor of safety of a design, you can also leverage simulation to make additional design improvements beyond what is required to ensure safety. Adding material to beef up areas of high stress is a common design tactic for reaching the intended factor of safety. However, the same simulation tools can be used to confirm that the trimming of material from another area, or adding cosmetic flourishes to the area in question, doesn't affect the required factor of safety.

> "In today's fast-paced world, we simply don't have the time to do something a second time. With SOLIDWORKS Simulation, we have an integrated tool that helps us get it right the first time and improve the quality of our products."
>
> — Yong Peng Leow, Co-Founder, Managing Director, and Engineering Director, Akribis Systems Pte. Ltd.

Comparing Alternate Materials

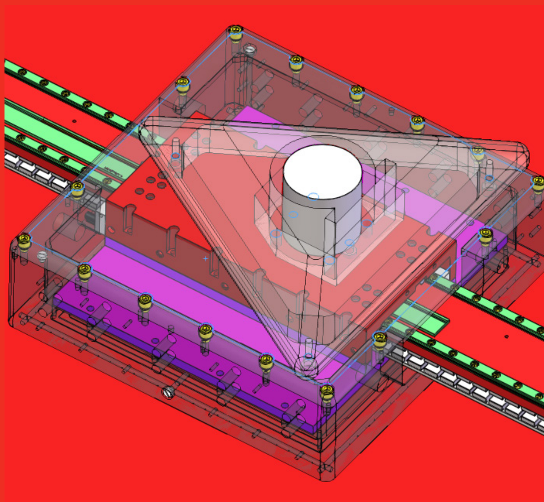
Unless you can use material properties to calculate engineering equations longhand or in your head, there's really no other way to compare the use of different materials for the same design than by using simulation tools. The trend in manufacturing is to replace metal parts with more affordable plastic parts without negatively affecting performance. With integrated simulation software, you can evaluate different metals, alloys, plastics, and even 3D-printed materials to better understand your material options, so that you make the right choices.

Evaluating Production Methods

Just as you can use simulation tools to assess the use of alternate materials for your designs, you can use the same integrated analysis tools to evaluate the manufacturability of your designs and help you select the best production method. Does the part have enough draft for injection molding? Can it be machined or will you need to use metal additive manufacturing to produce the part? Is there a better way to make it? Assessing the manufacturability of a design is just as important as validating design performance when trying to avoid late-cycle iterations.

Delivering Greater Design Fidelity

Although simulation capabilities can certainly aid designers in delivering designs of greater fidelity early in the process, having the simulation tools directly embedded inside the CAD modeling environment is critically important for doing so efficiently. If you have to leave your CAD system and export your model into another application to run an analysis, it will take longer and you won't have the benefit of referencing the simulation results while working directly on your model. Furthermore, it will take longer to improve the fidelity of your design—time when other functional departments that could use the design concurrently have to wait. In short, delivering greater design fidelity early in the process requires integrated simulation tools.



a case in point

GROWING A PRECISION MOTION-CONTROL TECHNOLOGY COMPANY WITH SOLIDWORKS

Akribis Systems Pte. Ltd. is a leading manufacturer of direct-drive precision position and linear motion control systems for industrial and electronics manufacturing, inspection, and testing—serving customers with semiconductor, mobile phone, flat panel, data storage, photonics, biomedical, and machine tool applications. The Singapore-headquartered company standardized on SOLIDWORKS design and SOLIDWORKS Simulation analysis software because the solutions are easy to use, have the best price/performance ratio, and provide Akribis with the integrated capabilities that it needs to succeed and grow. Akribis maintains high-quality standards by leveraging SOLIDWORKS Simulation finite element analysis (FEA) tools to validate system designs while avoiding costly, time-consuming rounds of prototyping.

The company's designers conduct kinematics, linear static stress/strain, and frequency analyses of parts and assemblies to confirm that they will perform as intended in the customer's specific application. "The FEA studies that we conduct with SOLIDWORKS Simulation software are vitally important for ensuring top system performance without spending time and money on prototypes," says Co-Founder, Managing Director, and Engineering Director Yong Peng Leow.

"Our systems involve high-speed motion, so we need to verify the vibration characteristics of our designs and optimize the stiffness to mass ratio as much as possible," Leow continues. "In today's fast-paced world, we simply don't have the time to do something a second time. With SOLIDWORKS Simulation, we have an integrated tool that helps us get it right the first time and improve the quality of our products."

Using integrated SOLIDWORKS design and analyis solutions, Akribis has reduced its design cycles by 30 to 50 percent, shortened time-to-market by 15 to 20 percent, cut development costs by 15 to 20 percent, and supported expansion into new markets and countries.

To read the full Akribis Systems Case study, click here.

WHAT TYPES OF SIMULATION TOOLS DO DESIGNERS NEED?

Although adding simulation tools to the designer toolbox provides a range of benefits associated with creating high-fidelity designs during initial design, the types of analyses that designers need to perform and the capabilities of the simulation tools that each designer needs substantially differ from the traditional FEA systems used by engineers and analysts. As stated previously, the primary requirement for designer simulation tools is that they are integrated directly inside the designer's modeling environment. Other factors to consider involve whether a designer is engaged in part or assembly design.

Component Design

When designing individual parts, designers need to know how the part will behave under the loads and boundary conditions of its operating environment. While motion analysis is typically not indicated for individual parts, motion studies can generate accurate dynamic loading information for separate components when conducted on the assembly in which a part is included. Yet, when creating individual parts, designers generally need answers to three primary questions: Will it break? Is it stiff enough? When will it wear out?

Linear Static Stress – Will It Break?

To identify areas of high stress that could result in component failure, you need at minimum the ability to conduct linear static stress analyses of part designs within your CAD modeling environment. By simulating a design's response to the loads and boundary conditions of its operating environment, you can pinpoint areas of high stress and use simulation tools to rework the design to bring stresses within allowable levels, verify the appropriate factor of safety, or reduce weight/material usage, while maintaining performance.

Deflection/Displacement – Is It Stiff Enough?

Understanding the natural frequencies of a component design is another valuable simulation capability for designers because such studies show whether a design will deflect, or be displaced, too much or too little. On some designs, controlled deflection is a design requirement so the part cannot be too stiff. On other designs, you may not want the component to deflect much at all, so increasing stiffness is a design goal. In either case, the ability to quickly simulate deflection/displacement becomes a valuable capability.

> "We use SOLIDWORKS Simulation to quickly evaluate concepts and ideas in terms of strength and stiffness. We also use SOLIDWORKS to simulate movement and resolve challenges."
>
> — Bas van Deursen, Mechanical Design Engineer, Ultimaker B.V.

Fatigue – When Will It Fail?

Improving the quality of a product by extending its lifespan—or ensuring that the product will continue to perform past its warranty period—requires an understanding of when the part will wear out. With integrated fatigue analysis tools, designers can project the number of cycles, or use over time, before a specific component will wear out and fail. With this valuable information in hand, they can make design modifications to either maintain or extend the life of a part.

Assembly Design

While some designers only work on parts, others exclusively design assemblies or a combination of components and assemblies. Simulating assembly performance is just as beneficial to designers as conducting analyses on individual parts. However, the simulation capabilities required for assembly analysis are a bit different, as are the questions to which designers want answers. When dealing with assemblies, you'll want to know the following: How will it move? What are the dynamic loads? Will parts break or deflect?

Motion/Kinematics – How Will It Move?

Although not all mechanical assemblies move, many assemblies, such as mechanisms, move a great deal. Using kinematics and motion simulation tools, designers can actually see how their assemblies will move, as well as generate important dynamic loading information for the design, which improves the accuracy of both assembly and individual component structural simulations. By simulating assembly movement, you will gain a better appreciation for the dynamics of the entire assembly and quickly pinpoint areas that need improvement.

Stress Analysis – What Are the Dynamic Loads?

Obtaining accurate structural simulation results for both assemblies and components is wholly dependent on the accuracy of the operating loads and constraints used to run the analysis. Motion studies accurately generate the dynamic loads for an assembly, which designers can use to run stress and deflection analyses on the entire assembly. These capabilities will tell you the part or collection of parts that may break or deflect too much. With those results, you can then drill down on the component or group of parts that require additional work.

Topology Optimization – Finding the Optimal Shape

Another type of simulation application that is particularly useful in helping designers improve design fidelity early in the process is topology optimization. A topology study uses the maximum allowed design space for a part in combination with applied loads and manufacturing constraints to automatically generate the minimum-mass, optimal shape or geometry for a part. Topology optimization capablities provide designers with a valuable tool for generating new design concepts, establishing a starting point for your design, or create ideas for refining an existing design.

a case in point

TAKING 3D PRINTER DEVELOPMENT TO THE NEXT LEVEL WITH SOLIDWORKS

Ultimaker B.V. is a Dutch 3D printer manufacturer that has held a prominent position within the 3D printing and Maker market since the company shipped its first printer in 2011. Although the company utilized 2D vector drawings to produce laser-cut parts for the Ultimaker Original printer, ramping up development and expanding its product offering required a more efficient development platform.

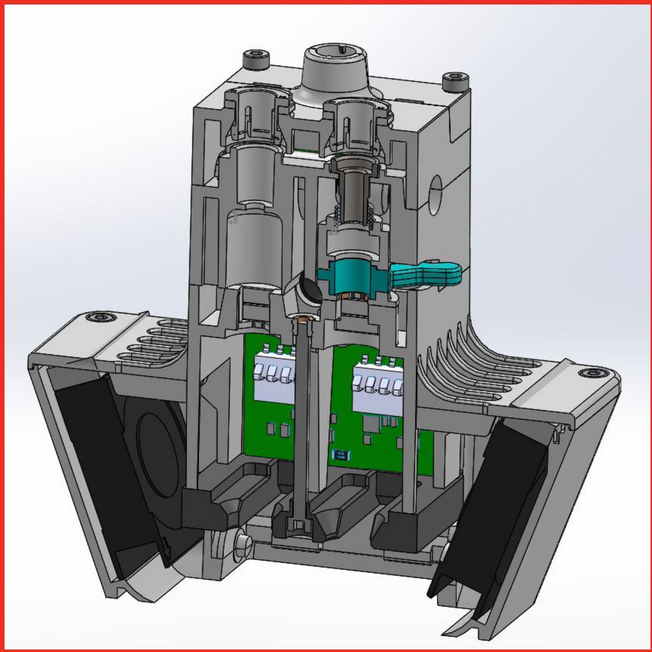
After evaluating several CAD systems, Ultimaker implemented SOLIDWORKS design and SOLIDWORKS Simulation analysis software, because the solutions provide the required capabilities, are easy to use, and are widely known.

Ultimaker utilizes SOLIDWORKS Simulation software to analyze and validate the performance of critical components—during both early conceptual design and for validation—minimizing the number of prototypes required. "We use SOLIDWORKS Simulation to quickly evaluate concepts and ideas in terms of strength and stiffness," notes Mechanical Design Engineer Bas van Deursen.

"We also use SOLIDWORKS to simulate movement and resolve challenges," van Deursen adds. "For example, we had a challenging issue involving the mechanical positioning of the print core, in which the heat break sometimes moved slightly relative to the print head base plate. To find the cause of the issue, we used the moving parts, physical dynamics, and collision detection capabilities of SOLIDWORKS to analyze this movement. We then combined these insights with testing with 3D printed parts to better understand and solve the issue we had with the positioning mechanism."

Using integrated SOLIDWORKS design and analyis solutions, Ultimaker has expanded its product offering from one to six printers in three years, minimized prototyping with simulation, improved printer ease of use, and enhanced product aesthetics.

To read the full Ultimaker Case Study, click here.



EASILY INCORPORATE SIMULATION-DRIVEN DESIGN WITH SOLIDWORKS SIMULATION

Designers can reap the benefits of simulation-driven design, and ease the implementation of powerful simulation capabilities, by adding integrated SOLIDWORKS Simulation software to your SOLIDWORKS CAD system. Switching to SOLIDWORKS as your 3D development system and incorporating SOLIDWORKS Simulation software will give users access to the analysis tools that designers use most from inside their modeling environment.

Opening a Window on Design Behavior

SOLIDWORKS Simulation software opens a window into design behavior by providing designers with an intuitive, virtual testing environment for linear static, time-based motion, and high-cycle fatigue simulation inside the SOLIDWORKS CAD system. Designers can tackle common structural engineering challenges with these tools, enabling them to calculate component stresses, strains, factors of safety, and displacements. The fatigue study estimates the high-cycle fatigue life of

a case in point

AUTOMATING MILL RELINING SYSTEM DEVELOPMENT WITH SOLIDWORKS

Russell Mineral Equipment (RME) is the world's leading manufacturer and supplier of specialized equipment and services for the hard rock mining industry. RME Mill Relining System products and services make the maintenance of grinding mills faster and safer, and have boosted the productivity of mine sites in more than 45 countries.

Since RME first standardized on SOLIDWORKS design software in 1997, the company has expanded its implementation to include SOLIDWORKS Simulation to speed up turnaround on proposal development, design, production, and assembly, while maintaining quality.

Using the finite element analysis (FEA) capabilities of SOLIDWORKS Simulation software, RME has improved the quality of its products and has greatly reduced the number of assembly errors. "We run a complete FEA structural analysis across critical assemblies on every project before cutting steel," notes Engineering Manager Andrew Limpus. "We're able to do this more efficiently because we can run a SOLIDWORKS Simulation study in just an hour or two."

"By incorporating SOLIDWORKS Simulation FEA into our process, assembly markups are negligible and have become rare," adds SOLIDWORKS Coordinator Daniel Haines. "The ability to predict the stresses in every part of a RUSSELL Mill Relining Machine and put the assembly through a range of motion studies not only gives us more confidence in the design, it results in better quality products."

Using integrated SOLIDWORKS design and analyis solutions, RME has shortened mill relining machine design time from three months to seven days, reduced proposal/quoting preparation time from a week to a day, cut proposal and quote drawing generation time from six hours to 15 minutes, and increased production volume fourfold.

To read the full Russell Mineral Equipment Case Study, click here.

components subjected to multiple varying loads where the peak stress is below the material yield stress. Cumulative damage theory is used to predict locations and cycles of failure.

Get Answers Faster, More Affordably with Virtual Testing

With the virtual test bench provided by SOLIDWORKS Simulation software, you can get fast, accurate answers to important questions about the behavior, performance, and manufacturability of your designs without the expense of physical testing. Instead of wondering how a design will perform or working off a hunch, you will have the ability to learn so much more about your design concepts that you'll be hard-pressed not to improve the fidelity of your designs.

With SOLIDWORKS simulation solutions, you can get reliable answers to the following performance questions while you design:

- **Will it break? If so, where?**
- **Should I add or remove material?**
- **Does the design have the required factor of safety?**
- **Can I use a less expensive material or production technique?**
- **Is my design stiff enough? Is it too stiff?**
- **Where should I add material to increase or decrease deflection/displacement?**
- **When will my design wear out?**
- **How will my assembly move?**
- **Will dynamic loads cause components to fail? If so, which ones?**
- **Is there a better form to fit my function?**
- **Does my design behave as intended?**

DEVELOP BETTER, MORE INNOVATIVE PRODUCTS FASTER AND MORE EFFECTIVELY WITH SOLIDWORKS SIMULATION-DRIVEN DESIGN.

Competing successfully in today's global market requires manufacturers to increase innovation, automation, and throughput. These objectives trickle down to product designers in the form of greater demands to deliver more complete designs. By generating higher-fidelity designs that minimize or eliminate design behavior and/or manufacturability issues late in the product development process, designers can help manufacturers achieve these goals and improve a product development organization's effectiveness.

Developing more innovative, better-performing products requires everyone associated with product development to do more—especially designers—by working smarter to support changing product development requirements. Designers can meet the challenge of creating higher-fidelity designs by adding SOLIDWORKS Simulation software to their SOLIDWORKS 3D design installation. Using the powerful combination of intuitive SOLIDWORKS modeling capabilities and integrated, easy-to-use SOLIDWORKS Simulation design analysis tools, users can consistently create higher-fidelity designs, which will help companies spend less time resolving product performance or manufacturability issues late in the process; minimize the frequency of rework and retrofits to address problems; and eliminate costly field failures, returns, and warranty claims.

> "By incorporating SOLIDWORKS Simulation FEA into our process, assembly markups are negligible and have become rare. The ability to predict the stresses in every part of a RUSSELL Mill Relining Machine and put the assembly through a range of motion studies not only gives us more confidence in the design, it results in better quality products."
>
> – Daniel Haines, SOLIDWORKS Coordinator, Russell Mineral Equipment

To learn more about how SOLIDWORKS Simulation solutions can improve the fidelity of your designs, visit **www.solidworks.com** or call 1 800 693 9000 or 1 781 810 5011.

SIMTEK
Real Time. Real Results

SIM Technologies Pvt. Ltd.

3rd Floor, "Mamanjee Centre" ,
S7-A, Thiru-Vi-Ka Industrial Estate,
Guindy, Chennai – 600 032

+91-8754447021 **marketing@simtek.in**