White Paper

# The Competitive Edge: Robust Design Innovation with Simulation Driven Product Development

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Innovate or evaporate. That's the new business imperative. Until recently, getting a product to market faster, cheaper and better than the competition usually was good enough. Not anymore. Now in addition to time to market, cost and quality, manufacturers must focus on innovation: designs that take the market by storm along with leading-edge development processes that transform conceptual ideas into saleable, reliable and cost-effective products

Products must stand apart from others, breaking new ground in performance, size/capacity, or other attributes — which all work together to drive consumers to pick a particular item from among many or OEMs to do business with one supplier over others. In many cases, companies improve existing products with imaginative functions and enhancements. Other times, organizations create whole new classes of products that totally dominate a market segment as competitors scramble to catch up. In a world economy of radical change and fast-moving trends, innovation has emerged as the big market differentiator across nearly all manufacturing industries and market sectors.

*"Advanced analysis technology helps to develop innovative products that differentiate manufacturers and bring more revenue to the bottom line."*

"Past initiatives aimed solely at product cost, quality or time to market are no longer sufficient to gain market advantage in today's highly competitive manufacturing markets. The focus today is on innovation: products that clearly differentiate themselves from others while also being affordable, reliable and delivered to market at the optimal time," explained Ed Miller, president of consulting and research firm CIMdata, Inc., headquartered in the United States. "To sustain sales growth and market position, manufacturers absolutely must have strategies for developing products to meet customer needs innovatively without driving up costs, sacrificing quality or delaying product delivery."

In this competitive climate, forward-thinking manufacturers must aim continually for innovation. These companies listen to the voice of the customer, anticipate swiftly changing trends, identify buyer expectations and make appropriate changes. Their solutions are innovative because they stand out from the crowd. Their development processes are innovative; as a result, these manufacturers can quickly crank out successful designs one after another, year after year.


Numerous business studies confirm that engineering simulation adoption is leading to pervasive simulation — a world in which no new product design will be introduced without extensive virtual, numerical modeling to optimize and test it. Leading companies adopt pervasive simulation as a way to bridge the gap from brilliant ideas to successful business initiatives. The combination of engineering cost management, product integrity and sustainability together with smart innovation can dramatically affect time to market and long-term competitive advantage.

U.S.-based Cummins, Inc. manufactures commercial engines and related systems, including turbochargers. The organization is developing and testing radical improvements in engine design, including the use of alternative materials and smaller engine footprints that reduce weight, improve fuel economy and reduce emissions — while also boosting performance. “The ease of using simulation tools has helped to transform our organization from a test-centric culture to an analysis-centric culture,” said Bob Tickel, Cummins’ director of structural and dynamic analysis.

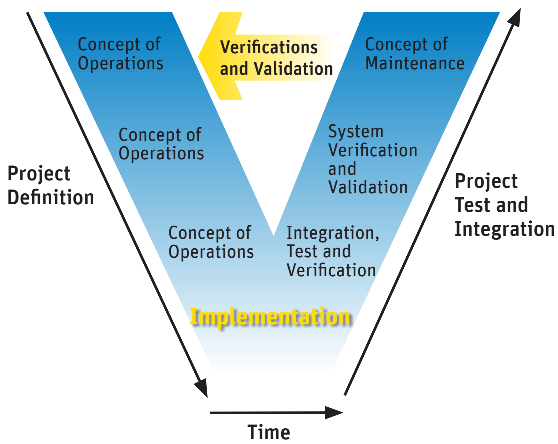
**Adopting Simulation**

Engineering simulation is a 40-year-old technology widely used to predict the behavior of products and processes by modeling the reaction of fluids, solids, acoustics and electromagnetic fields under internal and external perturbations. Not surprisingly, this technology is at the foundation of numerous efforts in achieving repeatable and efficient design innovation. The ability to quickly perform what-if studies and readily evaluate alternative designs gives engineers valuable insight into product behavior, lets them make intelligent tradeoff decisions, and provides the freedom not only to imagine way-out ideas but to easily test feasibility — especially important as organizations try to incorporate customer demands. Design optimization and sensitivity studies augment engineering creativity and serve as guides to creative solutions that are not always intuitively obvious. And all this can be done well before the first hardware prototype is tested.

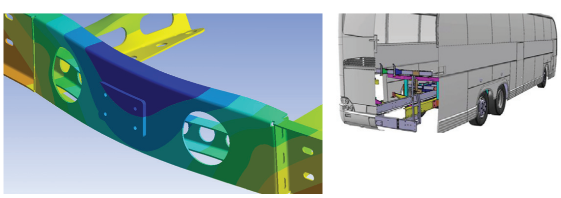
This process of systematically testing ideas — early on — in new product development is referred to as enlightened experimentation by Stefan Thomke, professor of technology and operations management at Harvard Business School in the United States and author of books on product innovation. According to Thomke, technologies such as simulation increase the number of breakthroughs by trying out a greater number of diverse ideas. “Computer simulation doesn’t simply replace physical prototypes as a cost-saving measure; it introduces an entirely different way of experimenting that invites innovation,” he explained. “The rapid feedback and the ability to see and manipulate high-quality computer images spur greater innovation. Many design possibilities can be explored in real time yet virtually, in rapid iterations.”

Using wide-ranging capabilities, virtual prototyping can simulate an entire system or subsystem in its operating environments to study and refine real-world product performance, thus enabling engineers to develop workable innovative designs or products that otherwise might turn out to be market flops because of performance, warranty or reliability issues. In this manner, simulation can leverage the creativity of engineers and the intellectual capital of the enterprise. This elevates the approach to a strategic role as an innovation enabler, allowing manufacturers that make smart use of the technology to establish their brand value, strengthen their market position and boost top-line revenue growth by developing steady streams of winning products.

According to statistics from Daratech, a market research and technology assessment firm in the United States, companies are investing in engineering simulation at unprecedented levels. But gaining market advantage now takes more than simply utilizing analysis tools. The competitive edge is determined by how an organization uniquely applies the technology and integrates it into its product development processes. To fully leverage a solution, many successful firms have initiatives for performing more upfront simulation to refine designs early instead of trying to hurriedly fix problems near the end of development. Here, modeling and simulation drive new solutions rather than just verify existing ones. And the information gleaned




The V-model, as applied to product development, describes the two-way cascade of information workflow that occurs during the process. Specifications are progressively detailed, from consumer requests to parts, before being assembled into the final virtual product. Engineering simulation is playing a central role to coordinate the efficient flow of designs and information.



TEMSA, a leading bus and coach manufacturer in Turkey, uses simulation from the very beginning of product development. In evaluating and verifying the strength of structural designs for a trailer vehicle, TEMSA engineers were required to meet European regulations concerning strength of a frame, load-bearing parts of the bodywork and the chassis structure. They employed software from ANSYS to apply vertical and horizontal static loads to a finite element analysis (FEA) model. Initial investigations were made, then preliminary decisions were given to designers according to the analyses results. The bottom line for TEMSA was shorter turn-around, higher customer satisfaction and improved quality for a product that met safety standards without being over-designed. Using engineering simulation at the outset allowing the company to foresee failures and take preventive action as needed.

from analyses can be captured and managed, resulting in a wide range of initiatives including enterprise standards, best practices, improved quality and error reduction.  ANSYS, Inc., a leading developer of innovative simulation technologies, calls this process Simulation Driven Product Development™.

**Integrating Analysis into the Design Process**

At a number of companies, simulation is performed as a separate function from design, with engineers throwing designs over the wall to an analysis group — typically in the final phases of product development when design changes require considerable time and money to perform. Moving simulation up front in the conceptual stages of product development can shorten time to market and lower product development costs.

A major next step at a growing number of companies involves solutions that allow simulation to be done more seamlessly and continually within the product development process to guide the design. Systematic simulation performed as an integral part of this process — rather than done separately off to the side — continuously verifies the design and guides the configuration of the product. In this way, Simulation Driven Product Development elevates the role of analysis from a stand-alone troubleshooting tool for individual problems to that of an integrated design approach for creating and refining innovative designs.

“Until now, analysis has been done almost as an afterthought at many companies, performed apart from design and out of the product development loop,” noted James Crosheck, a retired structural engineer with Deere and Company and now head of the consulting firm Effective Engineering Solutions in the United States. “Advances in technology and processes notwithstanding, the single most important factor in bringing simulation into the mainstream of product development is a radical shift in attitude. In engineering departments, simulation tools are now more commonly being regarded as an integral part of design instead of an outside service used only on a limited basis. And at the executive level, simulation today is being taken into account as part of corporate strategy in bringing more innovative products to market and more revenue to the company’s bottom line.”

Engineering simulation technology is critical in implementing Simulation Driven Product Development, especially in facilitating upfront simulation, efficient evaluation of alternative designs, iterative modification of designs based on simulation and collaboration between different groups throughout the process. In such an approach, simulation guides the direction of the design to optimally satisfy requirements such as performance, reliability, sustainability and cost. Hundreds of concept alternatives can be evaluated with simulation before detailed design is begun.

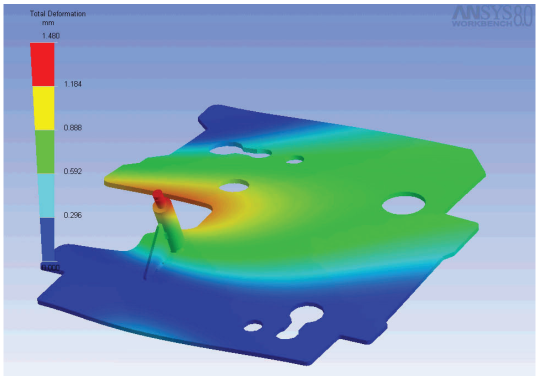
**In many cases, the process involves setting overall product performance targets based on customer preference studies and usage profiles, anticipation of market trends and testing competitive products. These overall performance targets then are cascaded from system to subsystems and assemblies to individual components. In automotive design, for example, ride and vibration targets are translated into vehicle suspension forces and displacements, which in turn establish design targets for shock absorbers and other individual parts in terms of stress and deformation determined from structural analysis. The product then can be designed from the component level up to satisfy these various requirements.**

“For the Murray Power 2 Steer snow thrower, ANSYS® software was essential in the simulation-driven design approach used to analyze and develop components and assemblies,” noted ITI product development manager Brian Lewis. “Parametric capabilities allowed us to quickly change models to study alternatives. The software worked extremely well with other packages in providing a convenient way to integrate structural analysis into a virtually seamless product development process, from concept through release to manufacturing.”

Engineering consulting firm International TechneGroup Inc. (ITI) in the United States has helped hundreds of clients around the world implement Simulation Driven Product Development, which ITI more specifically calls Systems Engineering/Analysis Led Design (SE/ALD™). Using this process and simulation tools, ITI has helped numerous companies achieve significant benefits in developing a wide range of products in industries including automotive, aerospace, electronic equipment, consumer products and more. An aircraft engine manufacturer, for example, took its product to market a full year before their closest competitor by evaluating more than 1,000 concept alternatives using simulation driven design.

For another project, ITI consultants used virtual prototyping in a collaborative program with lawn and garden equipment manufacturer Murray Inc. in the United States. Their charge was to design a tractor mower with all-wheel steering capability. A primary goal was to minimize steering forces so the mower could be turned easily without hydraulic power-assist systems, which add complexity and cost to the design. The manufacturer also wanted the mower to have a tight turning radius, and high reliability was mandatory. Staying on schedule was paramount for the mower to be introduced before the peak selling season.

Early in conceptual design, structural analysis software studied 12 critical components identified as contributing most to mower performance and reliability. The software determined stress distributions over a range of operating conditions for these components; this was used as an input for fatigue life predictions based on a typical customer duty cycle. Performing simulation upfront in mower development allowed engineers to study several alternative configurations and optimize the final design. As a result, the new Murray mower was introduced on time and the product maintained good reliability. Turning force was minimized so that costly, complex hydraulic power-assist systems were not required. Moreover, a tight turning radius of only 14.25 inches was achieved, well below the original goal of 18.5 inches.




In analysis of a support pin for the Xerox iGen3 printer, simulation software imported geometry directly from a CAD system to automatically build the simulation model and quickly predict baseplate displacement and weld stresses. The digital printing system was regarded, at that time, as one of Xerox's premier flagship products; it won numerous industry awards.

"Engineering simulation is an ideal tool in early product development for conceptual simulation-based design and was instrumental in the success of the iGen3. We used technology from ANSYS as one of our primary analysis tools for advanced simulation, particularly in multiphysics applications," explained Korhan Sevenler, director of product lifecycle management at Xerox. "In typical product development programs at Xerox, simulation-based methods using these types of predictive tools have definitely helped reduce the number of prototype testing iterations, each costing tens of thousands of dollars and weeks of time. In the end, development time and costs are reduced. But more significantly, our high quality standards are met and time to market is shortened in developing innovative, winning new products, enabling Xerox to grow top-line revenue and increase market share."

**The Value of Virtual Prototypes**

At the foundation of Simulation Driven Product Development is the concept of virtual prototyping, in which real-world product performance is predicted and studied with simulation models instead of hardware prototypes.

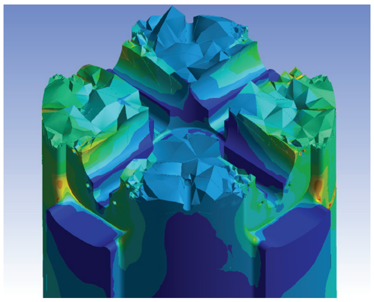
By shortening or even eliminating the cycle needed for physical testing near the end of design, virtual prototyping gives engineers added time earlier in development to explore and investigate innovative concepts. Moreover, identifying and correcting problems through virtual prototyping before designs are committed to hardware ensures that design innovations are carried through in the final product configuration. Otherwise, companies would stick with familiar approaches rather than risk encountering unforeseen problems with new and untried product configurations and manufacturing processes.

Virtual prototyping overcomes the historic build–test–redesign problem by evaluating designs through computer simulation and analysis earlier in the product development process and reducing reliance on validation testing late in the cycle. Often, performance problems encountered late in the product development cycle necessitate repetitive redesign cycles until satisfactory performance is achieved, with several testing iterations usually required. This adds considerable time and cost to the development cycle. For example, automobile mock-ups can cost $300,000 to $500,000 each and require months to build.

Studies have shown that the cost of change increases exponentially with each stage of development. Also, original designs are often less than optimal, requiring quick-fix changes to meet scheduling demands solving isolated problems that usually detract from the overall design. Components may be grossly overdesigned with needless weight and bulk, for example, to strengthen failed assemblies. Once changes are incorporated and the product is launched, the window of market opportunity may have closed, or performance may not satisfy customer demands and expectations.

With Simulation Driven Product Development, using virtual prototyping in the early stages of development, when concepts are just starting to take shape, avoids such difficulties later in the cycle by exploring a variety of product configurations, evaluating different part geometries and materials, and examining all the many tradeoffs inherent to product development.

The aim in virtual prototyping is not to entirely eliminate physical testing but, rather, to reduce the dependency on physical testing for troubleshooting problems late in development. This simulation-based approach leads to fewer, but better, hardware prototypes that serve to verify a refined design at greater levels of sophistication. The bottom line can be significant time reductions, cost savings, quality improvement and product design innovation.



The original design for a steerable conductor for offshore drilling used custom hydraulic cylinders that cost about $160,000 each and required four months for delivery. Using engineering simulation, Cognity engineers demonstrated that the custom cylinders could be replaced with the internal parts from off-the-shelf hydraulics that cost only $7,000 each and could be delivered within one month.

One of the biggest challenges in offshore drilling is accurate placement of the conductor casing. the pipe that is driven into the ground prior to drilling to prevent soft mud collapsing around a designated hole. The biggest concern is that conductors must be positioned securely and accurately to maximize oil production.

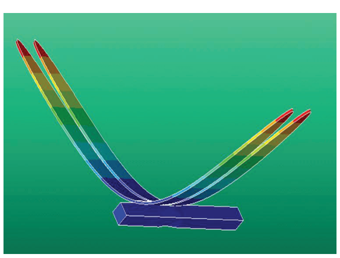
Engineering consulting firm Cognity Limited addressed this problem by developing a steerable conductor that provides real-time accurate positioning. This device must withstand compressive forces of up to 600 tons as the conductor is pounded into the ground; it also must provide an unobstructed bore once it is driven to depth. Soils increase in strength with depth, which increases the moment and loads on the conductor as it is driven into the seabed. By using engineering simulation, Cognity engineers doubled the load-carrying capacity of the steering mechanism, allowing the conductor to be maneuvered in very deep soils. In addition, the team finalized the design in five months, a time frame months or possibly years less than would have been required using traditional design methods.

## Multiple Physics Solutions

In the past, engineering simulation was aimed at predicting the effects of a single physical phenomenon, such as structural deformation or heat transfer. In the development of many of today's innovative designs, however, engineers must account for the effects of two or more coupled physics such as fluid, structure, electromagnetics and acoustics. In fluid–structure interaction (FSI), for example, fluid flow exerts pressure on a solid structure, causing it to deform such that it perturbs the initial fluid flow. With thermal–mechanical coupling, structures change shape along with their material properties according to temperature. In electric–thermal interaction, current flowing in conductors generates resistive/Joule heating.

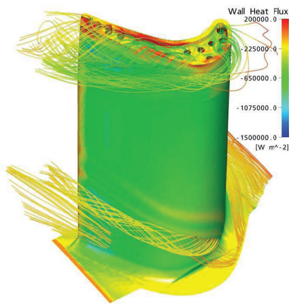
Some of the most sophisticated multiphysics and multiscale applications can be found in micro-electro-mechanical system (MEMS) devices with micron-size parts that can be prohibitively expensive to prototype. At DaimlerChrysler in the United States, for example, coupled electrostatic–structural–fluid analysis was used to accurately predict the critical response time of a MEMS RF switch consisting of an electrostatically actuated double-supported beam. Engineering simulation analysis allowed the design team to optimize device performance by changing the diameter and number of several fluid damping holes in the beam.

Integrated models use multiphysics solutions that automatically combine the effects of two or more interrelated physics within one unified environment. Modern solutions and software seamlessly manage data exchange between the different physics to perform coupled analysis. As a result, coupled analyses can be performed in a fraction of the time previously required, providing for greater solution accuracy and allowing users to explore a much broader range of engineering parameters in a given time to facilitate innovation in multiphysics designs.

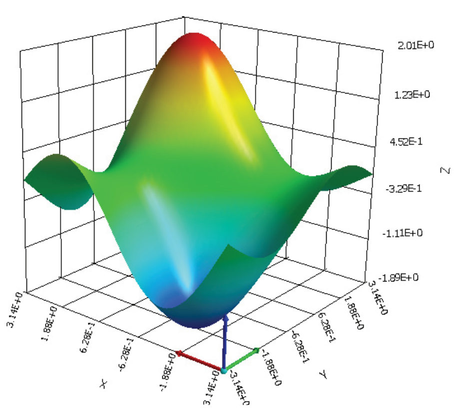


Silmach in France used ANSYS® Multiphysics™ software in developing an electromagnetic actuator with a power output of 100 Watt/gram compared to 1 W/g for standard devices — a 100-fold performance enhancement.

An integrated platform brings together tools that significantly reduce the time needed to obtain solutions to complex multiphysics phenomena. Nowadays, a user can set up, solve and post-process an intricate electromagnetic–fluid–structure interaction (EMFSI) simulation completely in a single environment. This approach is fully integrated with many analysis tools, such as parametric modeling capabilities to readily change the way problems are set up, design optimization and probabilistic design functionality to account for uncertainties and variabilities, and CAD import features for easy transfer of design data from mechanical computer-aided design (MCAD) and electronic computer-aided design (ECAD) environments.




Advanced multiphysics solutions have built-in computational fluid dynamics (CFD) and bidirectional FSI capabilities that allows fluid pressures and temperatures computed by CFD software to be readily incorporated into a structural analysis. This capability is useful in applications such as gas turbines. At Wood Group Heavy Industrial Turbines AG in Switzerland, a numerical simulation coupled CFD for fluid flow with FEA analysis for the structural response of a turbine blade to assess operating performance. Together, the resulting thermal and mechanical stress distributions in the blade were used to determine component life. Applying these loads, life-limiting elements of the blade design could be determined and new design alternatives evaluated.




To allow users to readily visualize results, design exploration software such as ANSYS® DesignXplorer™ uses response surfaces to establish a mathematical relationship between input and output parameters and as a basis for performing subsequent optimization or probabilistic studies. This solution can work with many types of input parameters, such as those from CAD, customized parametric design language and design simulation. The software handles a range of output parameters such as deflection, stress, mass, frequency or fatigue life. Results allow users to clearly visualize the complex relationship between multiple parameters and often point to solutions that may not be intuitively obvious.

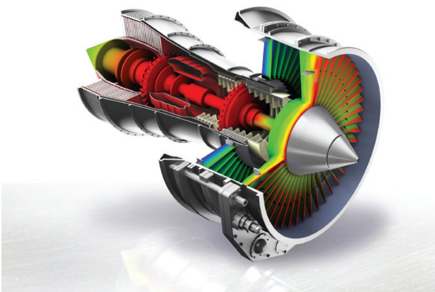
## Optimizing Complex Designs

A major challenge in developing innovative designs is the number and complexity of competing engineering requirements. For example, automotive components must be lightweight for the highest possible fuel economy yet strong enough for maximum crashworthiness. And engine assemblies must be compact while maintaining adequate airflow for proper cooling. Many of today's products involve a dozen or more such competing requirements. All are important, and neglecting just one can result in a missed opportunity in the market.

However, most simulation tools generally are intended to handle only a limited number of variables simultaneously. So users face the tedious and time-consuming task of running multiple simulations to iteratively zero in on an often-elusive good solution satisfying most of the requirements. More often than not, engineers develop a design based on only the most critical variables and neglect the rest, hoping any conflicts can be corrected later in the cycle. The result usually is not an overall optimal nor innovative design but rather one that simply works and barely meets performance and market requirements.

A variety of technologies are coming together in providing a new class of simulation tool that automatically optimizes designs based on operating conditions and ranges of variables entered by the user. Design of experiments (DOE) technology performs numerous iterative simulations using various sampling and statistical methods, including probabilistic design and Monte Carlo simulation. Instead of performing multiple simulations, another approach called variational technology (VT) uses series expansion to make all necessary calculations much more efficiently using a single solution. Depending on the problem, VT can arrive at solutions 10 to several thousand times faster than conventional DOE approaches.

Some of the more advanced design optimization tools combine these technologies with CAE simulation methods and parametric CAD into an integrated solution. Such tools define the optimal dimensions of a part so that stress or weight is minimized, for example, or that a resonant frequency is below a specified level. By clearly showing the relationship of multiple parameters and their effect on performance, design optimization guides the process of arriving at a configuration that might not otherwise have been considered with pure-point solution simulation, and results often point to solutions that may not be intuitively obvious. In this way, optimization technology augments engineering creativity and helps facilitate design innovation.



This wide availability of HPC systems is enabling important trends in engineering simulation. Simulation models are getting larger — using more computer memory and requiring more computational time — as engineers include greater geometric detail and more-realistic treatment of physical phenomena. These higher-fidelity models are critical for simulation to reduce the need for expensive physical testing.

As an advanced solution of this type, design exploration software allows users to interact dynamically with the model for each key variable, changing parameters and seeing how this affects the overall design. Feedback is immediate, so engineers can run through multiple what-if scenarios that otherwise would be too time consuming to perform with conventional tools. Moreover, because the underlying mathematics of the solution does not limit the number of variables to be considered, factors such as manufacturability and other issues can be taken into account, which otherwise would wait until after the design was completed.

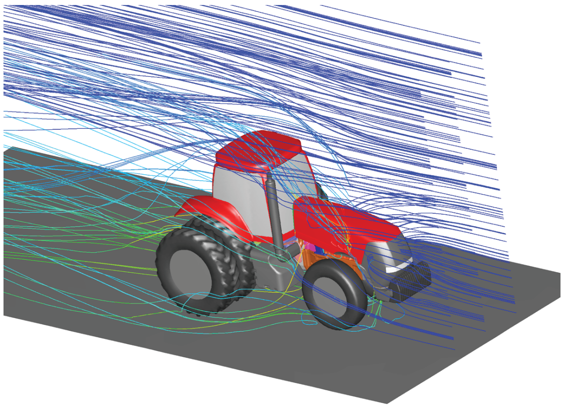
Response surfaces are a key element in the three types of parametric complex studies of product behavior.

→ Goal-driven optimization seeks optimal designs that satisfy one or several criteria, such as minimizing weight and deflection.
→ Six sigma analysis accounts for scatter in input variables, such as material properties or operating conditions, and results are expressed as probabilities.
→ Robust design optimization combines both of these aspects by determining how to change certain input variables to control the uncertainty in the results for more predictable, reliable designs.

Response surfaces generated with design exploration technology allow users to readily see the influence of input variables on design performance: the way stress or deflection is impacted as design geometry or material properties vary, for example. The technology provides insight into product behavior by arriving quickly at a range of results that otherwise would be impractical to generate using individual single analysis runs.

Solving such complex problems requires a great deal of computational power. High-performance computing (HPC) is becoming increasingly accessible, scalable and affordable to companies of all sizes, budgets and needs. HPC solutions are becoming simple to deploy, operate, and integrate with existing infrastructure and tools. Multicore processors, standards-based high-speed interconnects and 64-bit architecture are enabling engineering organizations to supplement (or even replace) live, physical experiments with computer-simulated modeling, tests and analysis.

The technology holds great potential for expanding engineering opportunities. With more computing horsepower for design simulations, engineers have an opportunity to imagine out-of-the-box ideas and be more inventive while avoiding the endless repetition of building trial-and-error prototypes.



Engineers at CNH Case New Holland in the United States used CFD software to reduce prototyping in developing a tractor cooling package in which engine coolant, fuel, air intake, transmission oil and air conditioning modules all must work individually as well as integrated to avoid overheating, minimize the amount of engine power devoted to cooling and right underhood packaging constraints. In the past, the company had to build several prototypes to meet these requirements. By modeling airflow through the cooling system, however, engineers were able to evaluate the performance of any proposed design without the expense of multiple prototypes.

"In our recent product launch, these methods made it possible to evaluate enough potential designs to optimize one design to the point that fan power is reduced significantly while reducing the costs of building and testing prototypes," said Panos Tamamidis of CNH, who noted that they used ANSYS software because it demonstrated the ability to accurately simulate extremely complex cooling packages while keeping computational requirements at reasonable levels.

**Simulation as a Collaborative Tool**

When groups and departments must work together on projects, differences in processes, procedures, terminology and convention can cause significant problems that hamper effective collaboration, productivity and accuracy. Moreover, complexities in simulation and product development are compounded when operations are dispersed around the world. Facilities in China, Europe and the United States, for example, may have operated independently for years, and in many cases might have been separate companies until a merger or acquisition brought them together. Ways of modeling parts, performing simulation, displaying data and evaluating results can vary widely among these diverse groups and generally are deeply engrained in their structure and culture. For example, MANN+HUMMEL's Martin Lehmann, head of Simulation Filter Elements, said, "We have engineers in Europe and in India who frequently needs to share models, CAE data and simulation results. They also need to collaborate in real time while performing CAE analysis."

By implementing Simulation Driven Product Development on a global scale, companies are gaining a competitive edge with innovative products and processes by tapping into their global intellectual capital — the collective knowledge, expertise and insight of workers in multiple disciplines around the world. Through the ability to quickly perform what-if studies and evaluate alternative configurations, simulation provides insight into product behavior and gives free reign to the imagination of product team members. They all can see the way a proposed product would function if it existed in hardware and have the freedom to investigate alternative ideas.

In these implementations, internet communications become the conduit for rapidly exchanging critical data, while simulation guides the design process and serves as the knowledge driver that channels everyone's ideas and insights into the problem. In this sense, simulation is a tremendous collaborative tool, allowing engineering to demonstrate to others — no matter where they are located or in what discipline they work — how various designs perform, enabling cross-functional team members at dispersed facilities to provide valuable input into product design.

In the early stages of development, when changes are most easily made, a marketing manager in Chicago could suggest a slimmer case for a consumer product, for example, or a manufacturing planner in Tokyo might see ways to reduce the parts count with a single injection-molded assembly. Analysis results can quickly show the entire team the impact of such ideas on stress, deformation, vibration and other aspects of product behavior.

Researchers at Sports Engineering @ CES, Sheffield Hallam University in the U.K. used CFD simulation to conduct aerodynamic studies on hang gliders for Avian Gliders. The team defined a detailed computer-aided design (CAD) geometry of a hang glider, which included details of the pilot and harness bag. Simulation captured the aerodynamic flow field around the glider. Engineers validated the computer model using lift and drag data from flight tests and found excellent agreement. This gave them confidence to examine the fine details in the flow patterns, inparticular over the pilot and wings. "Avian hopes that some patentable innovations come out of the analysis work, especially when coupled with other research into modern high-performance materials," noted Sheffield Hallam University researchers. "CFD has been able to show aerodynamic results in fine detail, especially for a small change to a glider's design. The flow vectors, surface pressure data and detailed flow separations would be difficult and costly to observe by any other method."

Through these capabilities, Simulation Driven Product Development enables multiple disciplines to work together in product development, and it facilitates the creativity that comes from such synergy. In that respect, the approach leverages valuable global intellectual capital at progressive companies that will likely be among the world's superstars in the coming years.

Simulation Driven Product Development does not disappear at the end of product design. Managing simulation processes and the wealth of engineering data is a specialized subset of the larger product lifecycle management (PLM) vision. But it is often overlooked or poorly addressed, since managing simulation processes and data is more demanding than the file/document-centric approach of PLM and related product data management (PDM) systems. Simulation data is both richer and typically many orders of magnitude larger than other types of product data: It can be several terabytes in size, requiring sophisticated data reduction techniques. In addition, to extract the true value and knowledge represented by simulation data, a user must capture both the content and context associated with the product being simulated using a process known as engineering knowledge management (EKM).

The complexity of the task notwithstanding, the need to manage simulation data and processes is now more important than ever. Robust data management systems have the potential to provide significant benefits to companies by enabling users to access and reuse historical design information and expertise for speeding creation of new designs, providing ways to capture and leverage existing engineering knowledge, and addressing the problems of loss of engineering expertise and protection of intellectual property.

Process management in the context of product engineering essentially means optimizing the design workflow through more effective use of engineering simulation tools. This can result in a wide range of improvements including enterprise standards for work procedures, consolidation and automation of best practices, and increased quality and reduction in errors. The work that ANSYS is doing in this area is aimed at meeting the challenges associated with backup and archival, traceability and audit trail, process automation, collaboration, and capture of engineering expertise and IP protection. Tools for capturing and harnessing the knowledge present in an engineering organization will enable greater value to be extracted from the lessons of experience.

A major U.S.-based multi-national agricultural equipment manufacturer is meeting collaboration challenges by standardizing its unique simulation-based processes through the use of templates in the software environment. Process automation capabilities are provided by the software through wizards and templates that automate repetitive operations to handle simulation problems faster and make the development process consistent from project to project and group to group across the company.

The firm's project manager for computer-aided engineering explained that this template approach enables the company to capture the core competencies and invaluable specialized expertise of particular skilled individuals in these different groups, while at the same time providing a consistent methodology for performing these tasks and collaborating across multiple groups on projects. Templates provide a way to ensure that company processes follow industry-standard best practices. Automatic report generation capabilities provide valuable documentation for project histories and accountability for compliance with relevant standards.

"In the past, engineers here could perform simulations however they wanted, so long as they obtained accurate results," noted the manager. "Now the process is standardized company-wide, allowing engineers to collaborate more effectively." Capturing and standardizing the process enables the company to better assess and evaluate its overall product development process for shifting operations from time-intensive and costly multiple prototype testing cycles to higher levels of upfront analysis early in design. "Old habits are difficult to break," the manager continued. "The template approach gives us the tools we need to effectively institute these changes, provide consistent ways of working, and enable us to move to simulation-based product development that companies must adopt to compete on a global scale."

**Implementing Simulation-Based Approaches**

Because of differences in product strategies and corporate priorities, the simulation technologies best suited for a company's applications and the way these tools are utilized in the enterprise's product development process are unique for each organization.

Companies seeking to implement simulation — or to more closely integrate simulation into design processes — almost always undergo a self-assessment of how products currently are developed, where improvements are possible and what role simulation should play in new ways of operating. In some cases, companies already have experience in simulation and find it necessary to expand the use of these tools or shift the manner in which they are utilized. Other firms not currently using simulation initiate programs to investigate the ways they might benefit from the technology.

**The Competitive Edge: Robust Design Innovation with Simulation Driven Product Development**

The cost of implementing simulation software is justified based on return on investment from savings in expense reduction and operational efficiency. Such time and cost benefits are quite easily quantified and extremely important for a company to determine. From a broader perspective, however, the greatest value of simulation for manufacturing companies is in facilitating innovation. Senior executives know that innovation in product development as well as manufacturing processes is key to a company's long-term potential in the market. In this respect, engineering simulation has been elevated from that of an obscure technology understood only by dedicated analysts to a critical component of a company's corporate market strategy.

These and other necessary organizational changes require a significant investment in time and effort, of course, but the level of commitment defines how companies uniquely leverage simulation; it also determines which firms will most likely lag behind while others reap the greatest business value from Simulation Driven Product Development.

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