When Engineering Intuition is Not Enough

A new technology helps design engineers quickly create dramatically lighter structures — and better understand the effects of material placement in whatever they're developing.

By Beverly A. Beckert

Structural engineers depend on their intuition, experience and knowledge every time they design something new. When the problem they are addressing is straightforward, they can often sketch the solution faster than they could open a laptop computer. If the package space becomes complex and multiple loads are applied in three dimensions, for most, their engineering intuition is not enough anymore. It is too early in the design process to apply conventional simulation tools, and creating an initial geometry based on an existing part is often ineffective.

Structural optimization has helped many manufacturers create better products by generating the ideal material layout for a component. Altair brought topology optimization to the computer-aided engineering (CAE) community in the early 1990s. Since then, Altair OptiStruct® has become established as a key technology in the development of highly engineered products such as airliners and passenger cars. Until recently in these organizations, topology optimization could only be applied after computer-aided design (CAD) geometry had been created and required an expert understanding of finite-element analysis (FEA) to use.

solidThinking Inspire®, developed by solidThinking, a wholly owned subsidiary of Altair, is a new tool for designers and structural engineers. It generates structurally efficient concepts that can be evolved into a finished product with easy export to all major CAD packages. New users need, at most, just a few hours of training, and many require none at all.

Inspire has been quickly adopted by many organizations for use in their design departments. Customers have embraced the opportunity to bring the advantages of topology optimization forward in product design without introducing a radical change in their development process. After Inspire generates an ideal material layout, the concept is exported to the preferred CAD tool for geometry creation prior to undergoing the standard corporate validation procedures, virtual and physical, for new parts.

Reducing Weight – and Design Iterations

Polaris, Roseau, MN, is a renowned manufacturer of snowmobiles, and its Snowmobile Chassis Structures Group is engaged in design and testing initiatives that support three different platform teams with chassis solutions for each set of requirements. Snow Group Staff

Engineer Rick Kerner is a key member of the team responsible for optimizing snowmobile designs. He relies on two basic FEA tools to mesh computer models of the designs and analyze them using linear static modeling.

Typically, it takes between 10 to 12 iterations to achieve acceptable results. Kerner explains that he wanted to meet his optimization goals yet reduce the time and effort to do so.

In 2012, Kerner came across an online article on Inspire and followed up with Altair. "When I found out solidThinking was included in HyperWorks®," he says, "I realized I had the tool available to me as soon as I upgraded to the latest version of HyperWorks."

Kerner reports that he used Inspire to develop a new chassis incorporating some tough weight-reduction goals that needed to be met without sacrificing structural integrity. He used Inspire for load-path "ideation," applying appropriate load cases and allowing the software to generate a design that fit the requirements for the chassis.

He then coupled the design-generation capabilities of Inspire with Altair's OptiStruct optimization tool. He used OptiStruct to conduct topology analysis on a previous chassis to determine if the tool could come up with a more efficient solution for the weight and strength of a subassembly of welded tubes and brackets.

"Inspire gave us the basic shape and engineering," he says, "then we moved to OptiStruct to refine the shape for manufacturability and stress requirements." The engineers also teamed Inspire and OptiStruct to evaluate the weight reduction potential of substituting aluminum for steel in subassembly structures.

The team removed all the steel except for anchor points and then let Inspire generate a shape that supported using aluminum. Engineers assessed the shape, determining where they wanted to retain steel tubes and where it looked like aluminum was feasible.

The team was able to remove 15% to 20% weight of the previous chassis structure in its new model. Where the team could use aluminum instead of steel, the weight reduction reached 35% to 40% per unit volume.

Kerner notes, "Now, whenever Polaris needs a new structure, it's fairly easy to use the boundary condition and put a design space in there for the load case. I'll use the geometry from Inspire and run a linear static analysis or put the same design space into OptiStruct and see how it works with the same constraints with added stress limits. The results turn out to be very similar, which adds to my confidence level in what I'm seeing from the output."

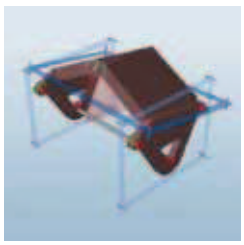
He adds that Inspire cuts a lot of time out of the front-end thinking part of the process. He simply creates a design space and lets the tool come up with the load path solution. "Instead of the average 10-to-12 CAD and FEA iterations we previously required," he says, "now we need only five to six iterations with Inspire and OptiStruct."

In addition, the HyperWorks units-based licensing structure eases the design process for Kerner. "It's a one-for-one swap with other HyperWorks tools," he says, "and since we use the same HyperWorks units for Inspire as for the rest of the suite, investigating more designs costs only our time."

Existing design of a snowmobile chassis component

Two images above: New component design concepts are explored in Inspire

For a new suspension arm assembly, designers at Polaris started from the existing welded-tube design



Design space definition

Optimized shapes in solidThinking Inspire®

Developing Better Products

Key Safety Systems (KSS), Sterling Heights, MI, designs and manufactures automotive safety-critical components and systems including airbags, seatbelts and steering wheels. Products are featured in more than 300 vehicle models produced by more than 60 manufacturers around the world.

Stefan Terebesi, KSS senior CAE engineer, explains, "Our safety systems are complex and must be highly customized to meet our clients' unique vehicle packaging constraints, corporate requirements and government regulations." Terebesi is a member of a centralized simulation services group for both KSS core and application engineering departments focused on quantifying critical design characteristics and how they impact the overall safety system performance. "Quick turnaround of assessments and what-if scenarios," he says, "are imperative in our business to meet customer deadlines and avoid unnecessary downstream engineering and testing costs. It is our goal to eliminate changes during the development cycle, and simulation helps tremendously with that."

Continuous innovation throughout the product development process has helped the company become the fastest growing safety restraint company globally and consistently deliver products that meet or exceed customer and industry standards within shorter and shorter design cycles.

This pursuit led KSS to investigate Inspire and its applicability to the company and its development process. As a long-time HyperWorks customer, KSS was able to try Inspire through Altair's patented on-demand software licensing system at no

additional cost. Immediately impressed with the technology, KSS quickly adopted Inspire within its existing design process.

One of the first projects in which KSS applied Inspire was the redesign of a seat belt retractor lever. The retractor lever is a critical safety component as it initiates the locking mechanism that stops the movement of the seat belt during a crash event. This component is subjected to a complex set of load cases and constraints with a goal to use a minimum amount of material – a design objective ideally suited for applying Inspire within KSS's established development process.

Terebesi quickly modeled the lever for the shearing load case with Inspire's shape control features. The results pointed to an arch design with thicker ribs for the given package space. Designers were able to easily incorporate the new arch and rib design attributes into their CAD models and determined that it was possible to machine the existing injection molding dies to produce the new design. Subsequent validation runs on the new design confirmed the required stiffness and similar injection-molding shrinkage values to the original design.

Inspire helped KSS quickly address three key requirements on this program. First, the peak displacement of the retractor lever was successfully reduced from 2 mm to 1 mm. Second, the shrinkage from the injection-molding analysis was similar to the existing production design. Third, the component supplier confirmed that the result from Inspire could be injection-molded with only minor changes, saving significant costs in new tooling and production downtime.

According to Terebesi, "We were interested in generating design concepts based on optimized performance requirements that would help design better performing parts in less time. solidThinking Inspire® provides a tool that can quickly suggest ideal part geometries, giving an opportunity to reduce development cycle time and enhancing the knowledge of the engineer regarding structural requirements of the component."

Improving Communication

Headquartered in Miamisburg, OH, Evenflo Inc. is a manufacturer of infant and juvenile products including car seats, baby travel systems, high chairs, play yards and activity products, among others. Key considerations in its design process include safety, ease of use and cost control.

Through a combination of engineering and industrial design (ID), Andy Davis, senior design engineer, Evenflo CAE, was interested in making child safety simple with innovative and easy-to-use products. After learning about Inspire, he and Brian Pleiman, senior project engineer in the Child Restraint team, decided to try it out on the redesign of a car seat release handle. This important part secures the seat shell to a seat base or a stroller. The intent of the redesign was to improve the styling and maintain the ease of use while remaining cost neutral.

Images courtesy of Evenflo, Inc.

To use Inspire, the team needed two things – a package space and a set of static loads for the release handle. Since this was a replacement part, the package space was easy to create with a simplified version of the current part in the CAD system. The team used previous data to generate approximate loads. A high degree of accuracy was not essential for idea generation because the design would still be developed in the company's CAD system and validated using the standard corporate procedures.

The initial Inspire results showed potential for a 30% mass and material reduction. The engineering team was also able to see load paths for the design in Inspire before exporting the file to the CAD system. Engineers were seeking to improve on the boxy appearance of the part, and the Inspire results provided a place to start the conversation with ID to ensure the delivery of style and function.

Once the design direction was finalized, the part was matured in the CAD system. Next, a rapid prototype was built for stroller and sled testing.

Pleiman notes, "This was a successful project for us. After styling the part, we were able to achieve a 25% improvement. The quick results we were able to get from Inspire assisted the co-development of the new part between ID and engineering."

Davis says, "Inspire is quick to learn and has given us a different way to look at parts."

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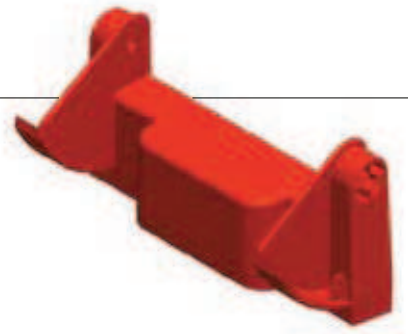
— Brian Pleiman, senior project engineer, Child Restraint team, Evenflo Inc.



Previous production design

New production part

Technology Democratization

According to Dr. Keith Meintjes, practice manager for Simulation and Analysis, CIMdata Inc., Ann Arbor, MI, "Inspire demonstrates solidThinking's innovation and profound understanding of how companies develop products. It provides an early indication of the effects of material placement on product performance, up front in the development process. It is a great example of how simulation can be democratized and made usable without the requirement to understand the details of the underlying technology."

solidThinking Inspire® enables design engineers, product designers and architects to create and investigate structurally efficient concepts quickly and easily without detailed CAD or advanced FEA knowledge. The software is easy to learn and works with all major CAD packages to assist in the design of structural parts that are right the first time, lower cost and quicker to develop as well as parts that use less material and are lighter weight. C2R

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For more information on solidThinking Inspire®, visit www.C2Rmagazine.com/2013.