

Topology optimization and new manufacturing methods enable lightweight design in agricultural engineering



AMAZONE

Key Highlights

Industry

Agricultural machinery, general machinery

Challenge

Re-design of an originally welded suspension component as a casting part, while improving weight and durability properties.

Altair Solution

Topology optimization with solidThinking Inspire

Benefits

- increased durability by a factor 2.5
- 8% weight reduction
- lower production costs
- higher flexibility for customers in add-on modules

Amazone develops and produces innovative agricultural technology with a high standard of quality, enabling and supporting modern and economical arable farming methods. With these standards in mind, Amazone leverages advanced development tools, processes, and manufacturing methods to contribute to its customers' success.

Agricultural machinery is used under very harsh and extremely varying conditions. In addition to service quality and the availability of spare parts, product longevity is a key purchase criterion for farmers. When developing a new product, manufacturers not only have to be competitive regarding price, they also have to consider the durability of the product, since this aspect impacts the manufacturer's reputation in the marketplace.

New manufacturing methods for higher longevity and economic viability

Agricultural machinery and related equipment have seen an enormous increase in efficiency during the last decade. By increasing the ground coverage with, for example, higher throughput rates, expanded cutting units, and higher tank capacities, overall productivity has been significantly enhanced. However, the equipment must still be robust enough for harsh operating conditions, and design improvements must not lead to higher prices for the final product.

Amazone Success Story

"To optimize the structure, we used solidThinking Inspire. Thanks to the load-specific structure of the casting part, durability increased by a factor of 2.5 while the weight was reduced by 8 percent. The new version of the suspension component is already in operation and has reduced Amazone's manufacturing costs by one-third."

Sebastian Kluge
Amazone

This is where new development and manufacturing processes come into play. In addition to the material resources saved in the production process by using a load-specific structural design, product durability and weight can be improved at no additional cost to the end user with a targeted, manufacturing-oriented, optimized development process.

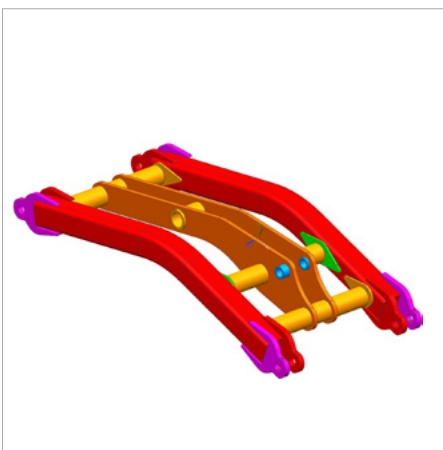
Amazone recently conducted a project in which a suspension component for a soil tillage unit was subjected to optimization to evaluate the part's material usage and durability. The unit was the trailed compact disc harrow, Catros-2TS, which

is pulled by a tractor and can be used in different configurations. The compact disc harrow is used for intensive mixing and shallow cultivation (working depth up to 15 cm).

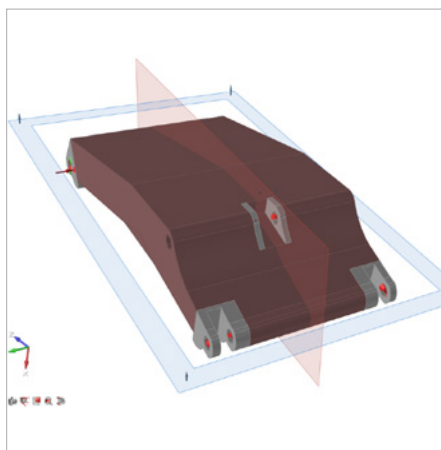
Light-weighting this component offers another benefit to farmers. With a lighter suspension component, he might have more options to choose from for add-on equipment. For example, if necessary, he could pick a heavier roller for a more intensive soil reconsolidation, and the overall allowed axle load would not be exceeded with the lighter suspension component.

From a welded construction to a cast component

Originally the Catros-2TS was a rather complex welded part with a weight of 245 kg, including a total of 16.5 m of weld seams needed to join the single parts. This amount of welding made production very time- and cost-intensive. Approximately 350 units of this component are manufactured each year. To meet the goals of optimizing the component's manufacturing process and increasing its longevity, Amazone engineers not only gave the component's design a closer look, but also



CAE model of the original welded construction



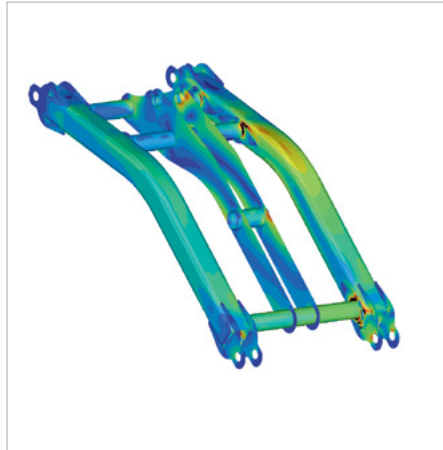
In addition to a design space, non-design space areas were defined in solidThinking Inspire as well, where the structure was not be modified, for example at support points or cylinder connections.



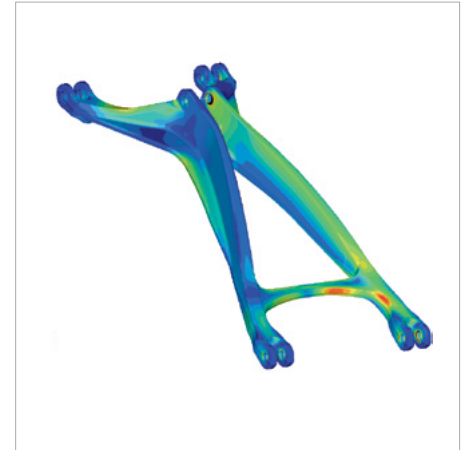
Based on previously defined loads and boundaries solidThinking Inspire calculates the optimal structure.



Refining of the optimized geometry in solidThinking Inspire



When compared to the welded construction (left), the casted version realized a lower weight and smoother transitions of the structure, resulting in fewer stiffness variations.



evaluated the potential benefits a new manufacturing method, in combination with topology optimization, could offer.

Simulation and casting technology for an optimized suspension component

The first step was to evaluate the weight savings and performance increase of the component if produced using a casting process. To do so, the engineers conducted an upfront topology optimization. In addition, Amazone employed a simulation-driven design process to eliminate unnecessary design iterations and reach a final design faster. These tasks were handled with Altair Engineering's structural solver and optimization tool OptiStruct and solidThinking Inspire.

The engineers expected several advantages from the casting method. Since the component can be casted in one piece and needs no welds, production is much simpler and the process less error-prone. The engineers expected to see a significant cost reduction and optimization potential for the manufacturing process, resulting from the optimized structural design created with the optimization tools.

To optimize the structure, the engineers used solidThinking Inspire. First they defined the possible design space and the boundary conditions, such as loads,

required stiffness, and manufacturing restrictions. Non-design space areas were defined as well, where the structure was not be modified, for example at support points or cylinder connections. Calculation time was further reduced by defining and applying a symmetry plane, which helped to receive results faster. With these inputs, the software calculated how much material was needed and at which position it had to be placed in order to meet requirements such as structural strength.

From the optimization result, the engineers created a detailed design which was then evaluated in a FE analysis with OptiStruct. When compared to the welded construction, the casted version realized a lower weight and smoother transitions of the structure, resulting in fewer stiffness variations. The overall loading in the casted material of the new design was significantly lower compared to the loadings in the weld seams of the original assembly. Thanks to the load-specific structure of the casting part, subsequent physical tests showed durability increased by a factor of 2.5 while the weight was reduced by 8 percent.

Benefits and outlook

The new version of the suspension component is already in operation and has reduced Amazone's manufacturing costs by one-third compared to the

former welded construction. Thanks to the reusability of the casting mold, tooling costs were quickly amortized. Customers have benefitted from a higher flexibility in add-on modules and improved product longevity.

Currently, Amazone engineers are looking into further optimization of the cast part structure and the manufacturing process by leveraging a combination of topology optimization and 3D printing. Altair has presented a best practice example of this approach with its partner voxjet. In this process, a lost-wax casting mold is created with 3D printing and the structure of the component is optimized and inspired by natural shapes, which fit perfectly to what can be realized in 3D printing. Simulation and optimization runs have already been concluded and resulted in a further potential weight saving of about 11 percent, while keeping durability and stiffness at the same level as with the casted part. Final cost calculations are still pending and will be one of the key factors of Amazone's decision whether or not to use this process for series production.



Physical tests of the casting part showed durability increased by a factor of 2.5.



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About Altair

Founded in 1985, Altair is focused on the development and application of simulation technology to synthesize and optimize designs, processes and decisions for improved business performance. Privately held with more than 2,600 employees, Altair is headquartered in Troy, Michigan, USA with more than 45 offices throughout 20 countries, and serves more than 5,000 corporate clients across broad industry segments. Our passion is developing and applying technology in new and inventive ways to help our clients succeed through increased innovation intelligence. We innovate constantly in the way we design, the products we create and the business models we experiment with. We aggressively employ our software tools and product development methods, leveraging high-performance computing and data analytics, so that we can play an enabling role in the great things our clients are accomplishing. We strongly believe that bringing simulation software and rapid manufacturing technology forward in the design process can be a source of inspiration along with a winning response to accelerated product lifecycles. Learn more at www.altair.com

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Altair Engineering, Inc., World Headquarters: 1820 E. Big Beaver Rd., Troy, MI 48083-2031 USA
Phone: +1.248.614.2400 • Fax: +1.248.614.2411 • www.altair.com • info@altair.com

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