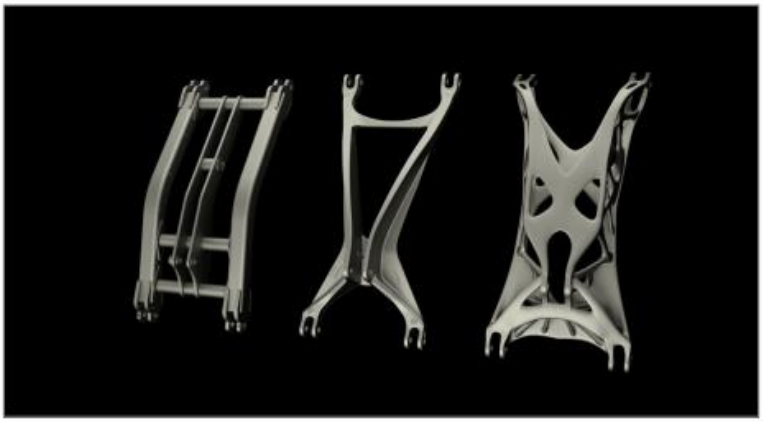
SUCCESS STORY

AMAZONE

voxeljet Altair

A Rocker Arm's Diet - How to Increase Durability and Stiffness of an Agricultural Machine Part while Reducing Weight with 3D Printing and Casting



Altair, voxeljet and Procast Guss supported Amazone in a further study and jointly created a technology demonstrator of the rocker arm, using a new process Altair and voxeljet had created to combine the advantages of 3D printing and casting.

From Welding to Casting

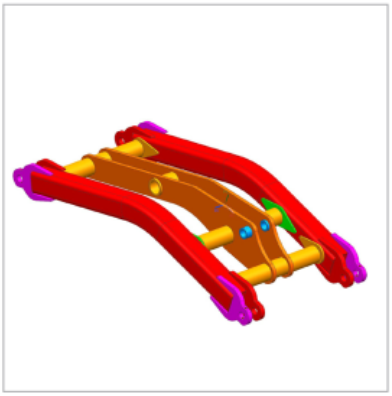
To get to a new design for the casted part, Amazone conducted a topology optimization. To optimize the structure, the engineers used solidThinking Inspire. First, they defined the possible design space and the boundary conditions, such as loads, required stiffness, and manufacturing restrictions. Non-design space areas were determined as well, where the structure must not be modified, for example at support points or cylinder connections. With these inputs, the software calculated how much material was needed, at which position, to meet requirements such as structural strength.

From the optimization result, the engineers created a detailed design which was then evaluated in an 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 increased durability by a factor of 2.5 while the weight was reduced by 8 percent.

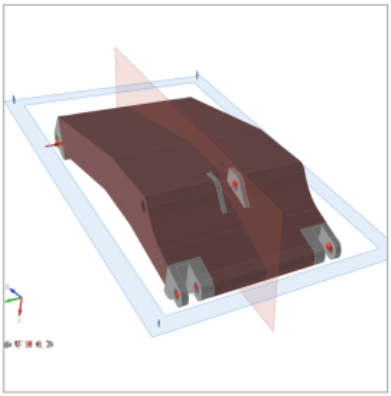
The new version of the rocker arm component is already in operation and has reduced Amazone's manufacturing costs by one-third compared to the formerly welded construction. Thanks to the reusability of the casting mold, tooling costs were quickly amortized. Customers have benefitted from a higher flexibility in add-on modules and improved product longevity.

Taking Casting to a New Level by Leveraging 3D Printing

Impressed by the excellent results received with this re-design and change of manufacturing method, the engineers are now looking into even further improvements. Additive manufacturing or the combination of

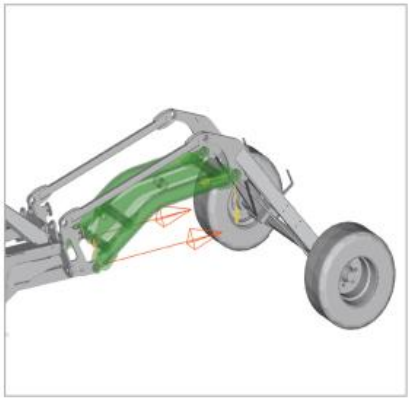


CAE model of the original welded construction



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.



Loads derived from from solidThinking Inspire motion analysis.

FE-simulation final part.

Velocities of casting process in Click2Cast simulation.

additive manufacturing and casting could potentially provide even better results. Therefore the project was taken a step further. Altair, voxeljet and Procast Guss supported Amazone in a further study and jointly created a technology demonstrator of the rocker arm, using a new process Altair and voxeljet had created to combine the advantages of 3D printing and casting. Components produced with this process stand out with dramatic performance improvements and the solid potential for serial manufacturing and mass production. Bringing design optimization, fill and solidification analysis, casting, and 3D printing together addresses the challenges of lightweight design in a new way and enables the setup of an innovative design and manufacturing process that enhances performance and efficiency. In this combined process additive manufacturing is used to print a casting mold offering a much higher design freedom than traditional ways to produce those molds. Furthermore, the design can be inspired by natural, bionic shapes for perfect fit, which used to be impossible to manufacture before and can now be realized in 3D printing.

Topology and Casting Simulation

The first step was a new topology optimization. Again, the design space was defined and loads were derived from a motion analysis with Inspire and then applied to the model. After running the optimization, which also took manufacturability into account, the new part resulted in a further weight saving of about 11 percent, while keeping durability and stiffness at the same level as with the casted part.

To make sure that the new design could be casted, the engineers also conducted a casting simulation with solidThinking's Click2Cast tool. Click2Cast (C2C) casting simulation was used at two points – the beginning and end – in the design process. In the early phase, C2C allowed designers to test the manufacturability of the component design and optimize it, avoiding internal defects and analyzing critical areas while also reducing iterations between the design and production departments. At the end of the design phase, C2C was used again to simulate the full mold filling process and thermal solidification, helping create the most efficient manufacturing method and guaranteeing a controlled filling process for increased quality and thus minimizing any waste in energy, time, and material.

Reduce Turbulence with Simulated and Printed Gating Systems

Turbulence is always a factor in the flow of molten metal as it can trap gases in the casting material and cause defects. It can be reduced by the design of a gating system that promotes a more laminar flow of the liquid metal. Therefore, with the aid of simulation and 3DP in combination, almost any shapes are possible reducing the risk of casting defects ensuring a very tranquil, controlled fill which prevents oxidation of the alloy due to turbulence during the filling process and thus improves casting quality further.

In the next step, voxeljet had to produce entire tooling (cope, drag, and mold) for the casting process. voxeljet is a leading manufacturer of 3D printing systems and parts for industrial applications, specialized on Powder-Binder-Jetting of plastic and sand.

Before printing, a digital core and mold set was designed for the optimized demonstrator. The final cast set consisted of only four pieces. All pieces were then 3D printed in silica sand, using a VX4000 printer with a build envelope of 4.000 x 2.000 x 1.000 mm. Once all pieces were printed, they are ready for the cast process. Within a few days, the mold set was printed, packed, and shipped to Procast Guss, the casting expert Altair and voxeljet teamed up with to get the part casted.

With a production capacity of 40,000 tons of casted products Procast Guss produces unit weights of 0,5 – 350 kg of machine molded castings. The range of cast iron materials offered by them varies from grey cast iron and spheroidal cast iron to SiMo and ADI to highly alloyed austenitic or wear-resistant

3D printed sand form for casting, made by voxeljet.

Bionic inspiration - final casted part ready to be shipped to Hannover Messe 2017.

materials. The material used in this process was the EN GJS 500 -14 cast iron. The casting expert applied a die coating to receive a smoother surface before the actual casting process. Then they combined the four parts into one mold. After the part was casted last manual adjustments like separating the non-essential parts, left over from the casting process, from the final component. Finally the entire part was cleaned to receive an optimum result.

Conclusion

The new rocker arm, printed and casted for the first time as a demonstrator, in real size and ready to go has a weight of only 200 kg, which is another 11 percent less than the traditionally casted part. At the same time the new rocker arm is as stiff and durable as the traditionally casted part.

3D printing in combination with both topology and casting simulation is an extremely powerful tool offering improved part quality by optimized, low-turbulence feeding systems assuring an energy and material efficient production. For the next decade 3D printing in combination with simulation allow new generations of product designs challenging conventional design limitations resulting in complex consolidated parts. What needs to be done? Designers need to adopt the freedom of design these technologies offer to design for additive and design for function rather than design for ease of manufacture.

Content of the Story and picture are done in teamwork between Amazone, Altair, Voxeljet and Procast Guss