Case study

Lightweight additive technology for increased efficiency in the packaging industry

Quick and easy optimisation of highly individual grippers in automation technology

The packaging industry is highly automated thus making the quick and safe packaging of goods possible, requiring lightweight design as a core element in product development.

The lighter the gripping instruments are, the more efficient and faster this process becomes. With MSC Apex Generative Design, lightweight designs can be created quickly and easily for many different gripper designs.

Grip, transport, deposit, pack. These are the essential tasks of packaging machines, which pack the individual production goods safely and reliably with their highly automated gripping and conveying elements. The large differences in weight, size and geometry of the products mean that the grippers are usually very individual and often very complex. In addition, there is a requirement to design the moving masses to be as light as possible, but at the same time as rigid as possible, thus saving energy during operation and still ensure safe transport. This leads to high demands on product development, since the classic design or optimisation of such individual and complex gripping units is particularly costly and time-consuming.

The challenge

End customers and trade demand an ever greater variety of packaging. At the same time, packaging and materials should become significantly more sustainable in the future. These trends demand short reaction times and that manufacturers adapt very quickly to market conditions. This can only be achieved with highly flexible, high-performance packaging machines and rapid development. New technologies are required to meet the demand for highly individual packaged goods and to reduce the amount of material and energy consumed.

These requirements also apply to this particular Gerhard Schubert GmbH application. The family-owned company from Crailsheim in Germany offers innovative packaging machines featuring an intelligent, modular design and exceptional customer benefits. The development of a new gripper unit for gripping and transporting a packaging tray should also meet this requirement. An optimisation with a classical approach and software did not bring satisfactory results and also entailed a high development effort. The analysis of the gripper component showed the occurrence of stress peaks and insufficient stiffness, both of which are core requirements for grippers. A new approach was necessary in order to achieve a lightweight design.

The solution

A combination of Generative Design and Additive Manufacturing promised a solution. With Generative Design even complex lightweight designs can be created quickly and easily. The low effort allows the optimisation of highly customised simple and complex grippers even for small quantities. The generated structures can be produced with additive manufacturing in an uncomplicated, digital and immediate manner; even very light and highly complex structures are easy to produce.

MSC Apex Generative Design was used as a powerful yet easy-to-use software. For the present use case, the initial geometry has been loaded as a CAD model in MSC Apex Generative Design. The optimisation model was designed on the basis of this geometry, with the necessary connection areas and the permitted design space, with PA12 plastic specified as the material. The intuitive user interface with its powerful geometry functions made it possible to transform the sophisticated initial geometry into a start-ready optimisation model in less than an hour. Before the model can be completed and the actual optimisation started, another 15 minutes are needed to add the boundary conditions and the target parameters for the optimisation.

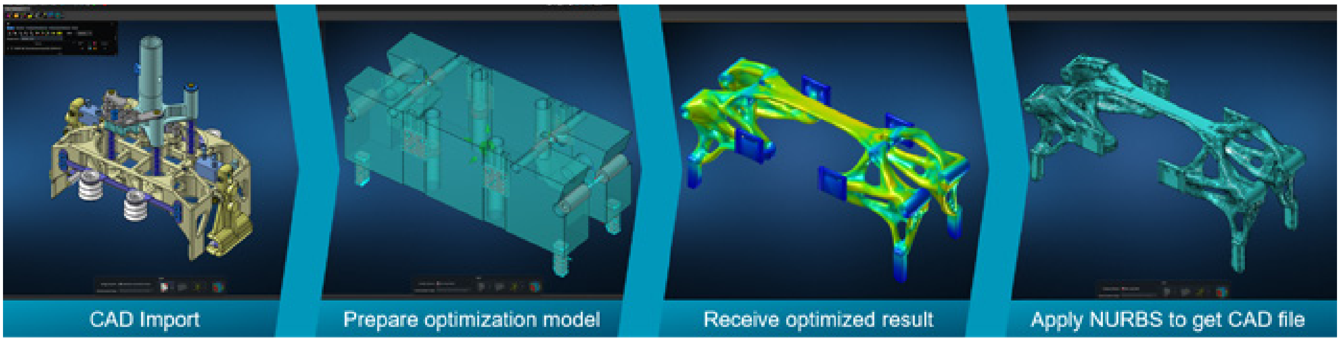

Figure 1: From CAD import for preparation of the model to CAD export for validation with MSC Nastran, optimisations can be implemented quickly and completely in MSC Apex Generative Design.

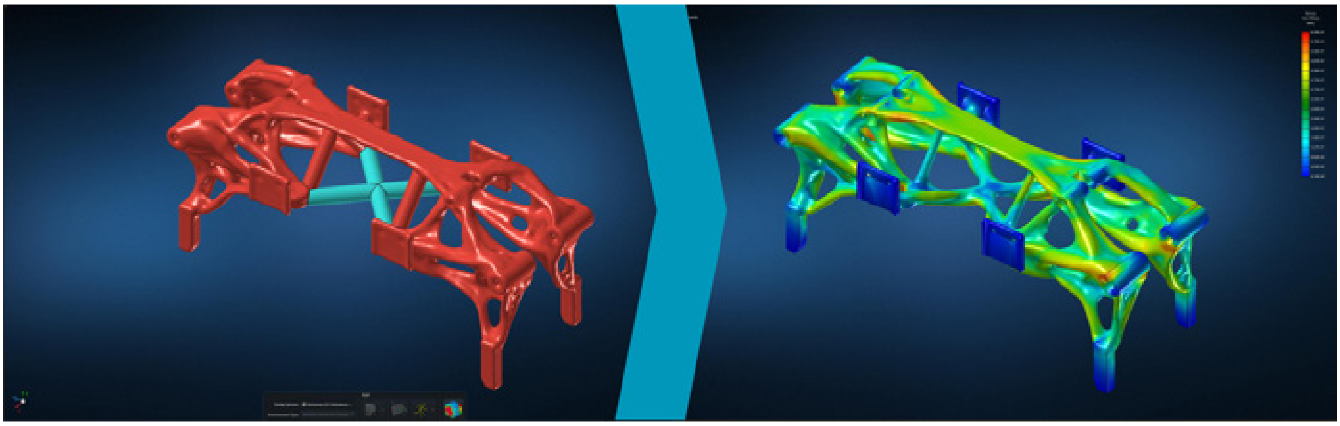

Figure 2: Subsequent changes can be inserted quickly with the geometry tools and then connected cleanly and meaningfully with just a few optimisation iterations.

The result

Only 18 minutes were needed by the optimisation server to create a lightweight design. This short computing time makes it possible to try out different parameters and variants without difficulty, in order to choose the most suitable design. For example, a variant may be particularly lightweight, but is difficult to clean due to its complex structure. Therefore, a less complex design is initially selected. At just 150 g, this is nevertheless a true lightweight - compared to 340 g for the original component (PA12), a weight reduction of 56%!

To provide additional stiffening for special load cases, the customer asked for cross-shaped struts inserted in the mid-section. To do this, they were roughly inserted into the optimised structure at the correct position by the implementing engineer with the help of the geometry tool in MSC Apex Generative Design. This new structure was again processed in several iterations by the algorithm to create a clean connection and smooth transitions. The remarkable aspect: Despite additional struts, the weight has hardly changed, the algorithm has cleanly attached the struts and removed the now superfluous material from other areas. A new local optimum could be found to solve the optimisation task, demonstrating the wide range of solutions that Generative Design can produce for a given problem.

Verification and manufacturing simulation

The selected variants are returned to CAD with a few mouse clicks using the integrated Mesh-to-CAD function. As NURBS models, they could then be imported directly into MSC Apex Structures and verified there with the familiar MSC Nastran algorithms. The results show a significant improvement with a four-fold increase in stiffness with also significantly lower stress under load.

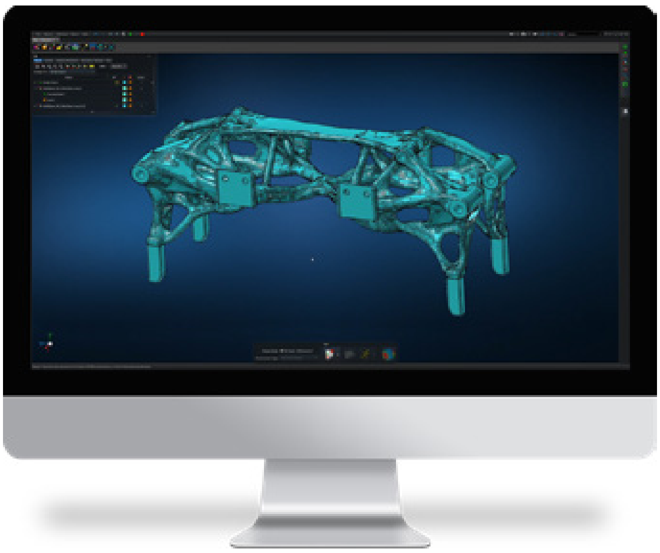

Figure 3: A retransition to standard CAD formats based on NURBS can be achieved at the touch of a button, even with complex structures

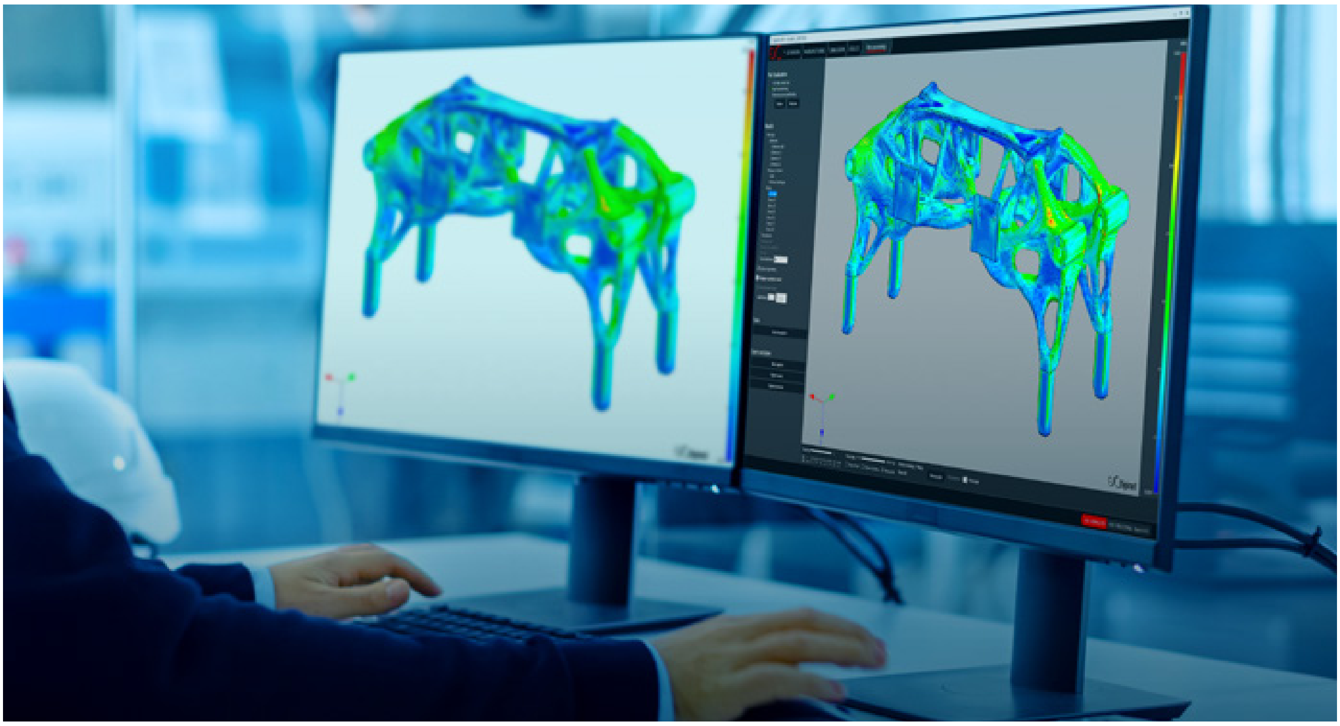

Figure 4: Manufacturing simulation of plastic printed parts avoids excessive deformation for maximum accuracy in the demanding gripper use

In the next step, the production of the design in plastic is simulated and optimised. To do this, it was imported into Digimat AM, laid flat on the platform and the mesh was generated for optimisation. The analysis showed very low overall component distortion with only two outlying areas having excessive deviation. These deviations can be compensated for with Digimat AM by creating a pre-deformed structure so that a correct structure exists after successful building.

The company has an additive manufacturing facility for metal, so a metal variant was also to be built for test purposes, also to test use at higher temperatures. For this purpose, a further optimisation was started using an aluminium alloy material. However, the installation space for the component was not sufficient, so the structure was split at the upper strut and a flange was added, which was reconnected in a suitable and complete way with some optimisation iterations. The production of the now two-part design could then be simulated with Simufact Additive. The components are positioned so that they both fit together on the building platform. The software calculated all the necessary support structures and created the mesh for the simulation. This revealed that here, too, warpage would have to be expected. With the help of warpage compensation this could however be reduced to a minimum.

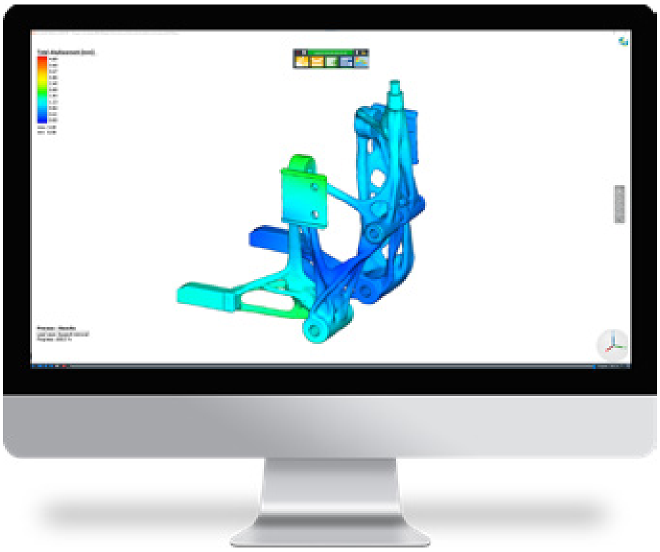

Figure 5: With Simufact Additive, metal-based production can be simulated in advance. The positioning, support structures and manufacturing parameters can thus be optimised and distortion and high stresses can be avoided.

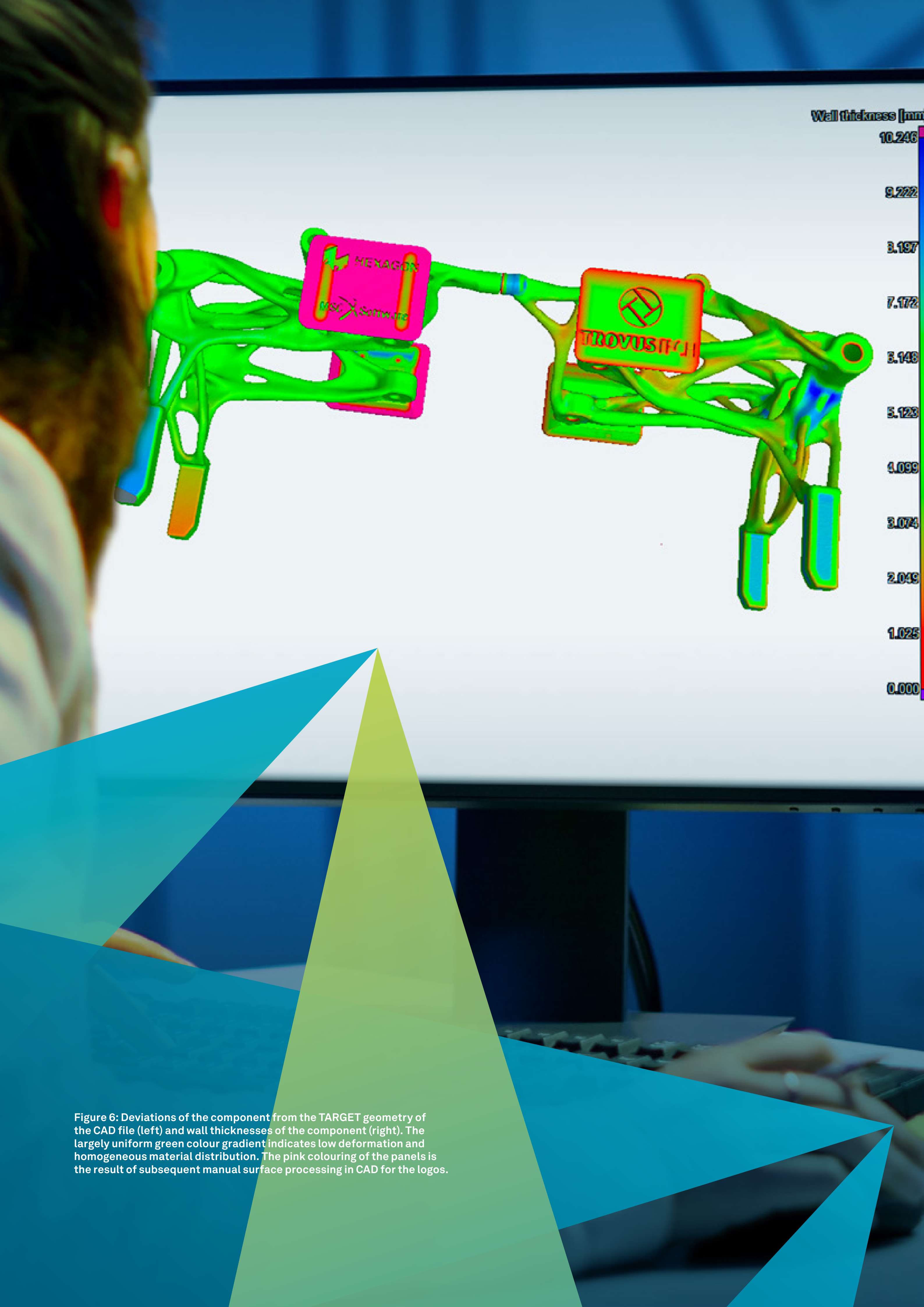

Figure 6: Deviations of the component from the TARGET geometry of the CAD file (left) and wall thicknesses of the component (right). The largely uniform green colour gradient indicates low deformation and homogeneous material distribution. The pink colouring of the panels is the result of subsequent manual surface processing in CAD for the logos.

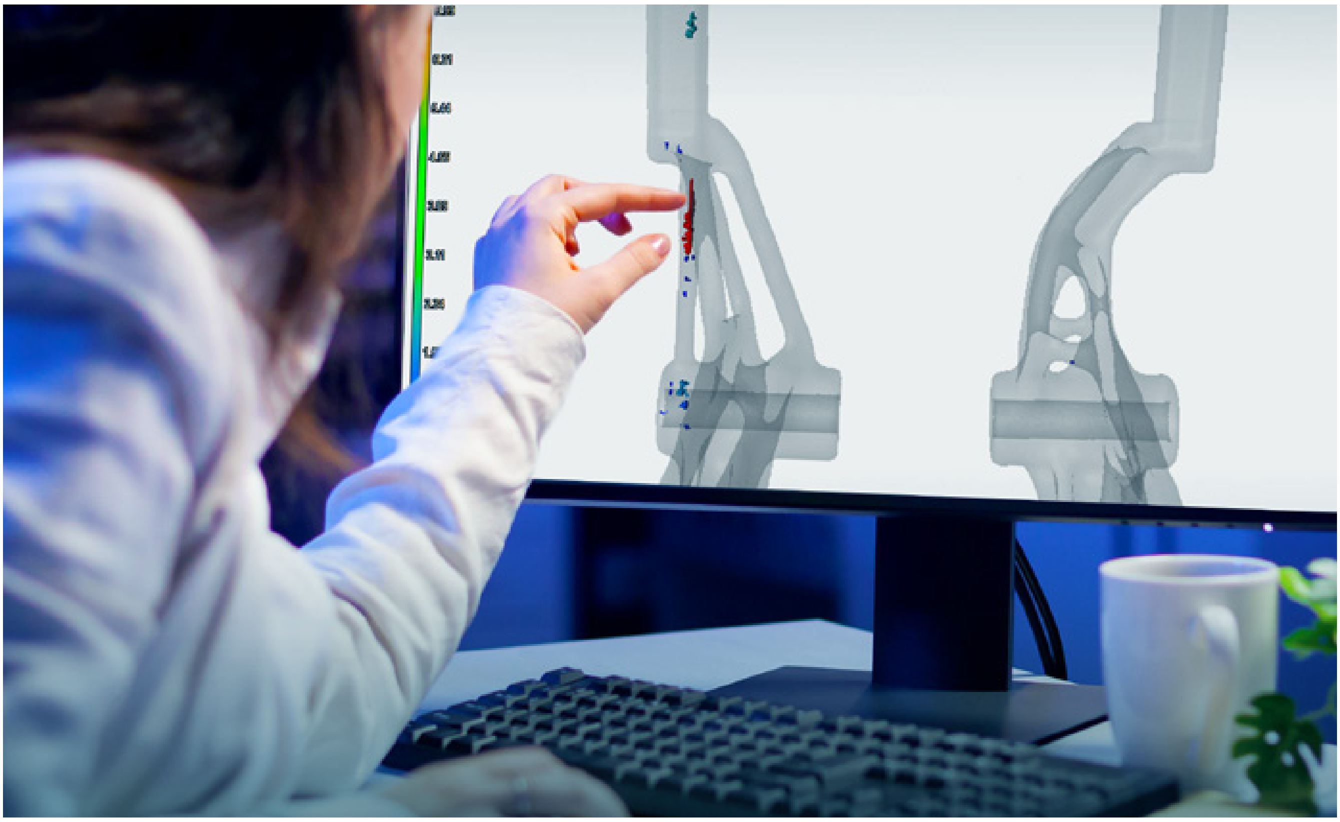

Figure 7: There are some pores in one of the legs of the component. However, an analysis by VGSTUDIO MAX shows no impact on the application when under load

Analysis of the component using CT scan data

The metal version was then manufactured in aluminium and examined with a non-destructive CT scan after production. The VGSTUDIO MAX software was used for the analysis of the resulting CT data. The detailed, digital image can be compared in the software with the original CAD data to clearly show any deviations. As can be seen in the picture (Figure 6), the production shows a slight deviation in the legs of the component, in which also some pores (Figure 7) can be found in the scan (enlarged for illustration). The analysis of the deviations and the material thickness (Figure 6) shows that the component has a nice, even colouring as a whole. The deviation on the panels is due to the subsequent, manually inserted area with lettering. The deviation towards the outside can be milled without any problems. The almost continuous green colouring of the wall thickness shows the excellent homogeneous material distribution which is necessary to ensure successful additive manufacturing.

Summary

All in all, the entire scope of performance of MSC Apex Generative Design and other MSC tools could be demonstrated here. In addition to the powerful CAD import functions providing a simple and direct path to the optimisation model, various designs could be generated extremely quickly. Subsequent adjustments such as additional struts and flanges could also be designed and optimally integrated, a return to NURBS-based CAD formats is created with a few mouse clicks and allows direct validation with MSC Nastran. Digimat-AM and Simufact Additive can then be used to simulate and optimise production, thus guaranteeing an excellent final result. CT scans were used to check the real component. The data analysis with VGSTUDIO MAX shows a good overall result, which could optimally be prepared for production and use with digital design and manufacturing simulation from MSC Software.

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