HEXAGON | MSC Software

Case study

Accelerate product development of complex hood hinges with Generative Design

Automotive engineering: Enabling complex hinges for sports cars with integrated lightweight design

In a joint innovation project, EDAG Engineering, voestalpine Additive Manufacturing Center and Simufact optimized a conventionally designed hinge of an engine hood and redesigned it for additive manufacturing. The result generated with MSC Apex Generative Design is considerably lighter and uses significantly fewer parts.

In most cases, hinges are simple parts with a basic function. They become more complex when they allow special kinematics and have to fit in the limited engine compartment of a car.

However, these types of hinges are significantly larger and usually cannot be installed in small cars or sports cars. In addition, they are considerably heavier, adding additional weight to the vehicle - contrary to the current need to make cars more lightweight for lower fuel consumption. The complex kinematics result in a high component count of 20-40 parts per hinge, and small quantities of such assemblies are not economically feasible using conventional manufacturing processes.

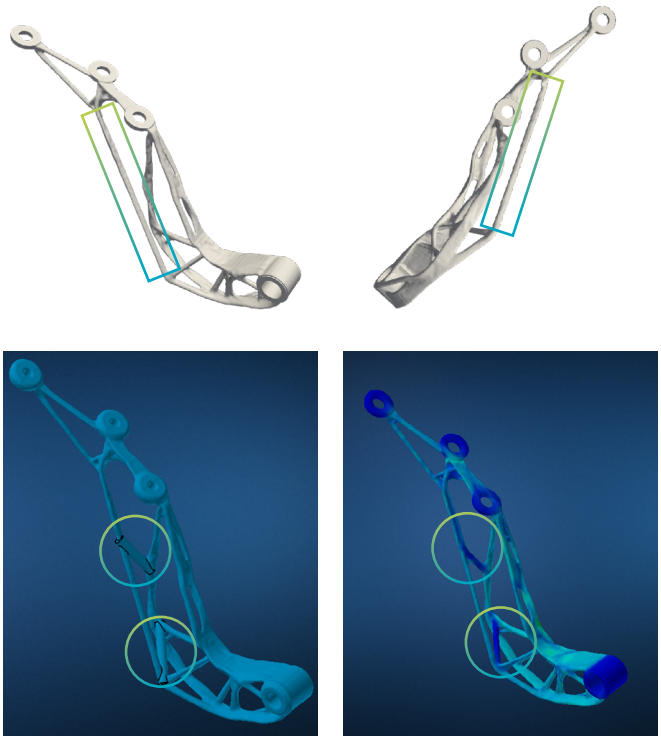
Weight-intensive, conventional design of an engine hood hinge with a high component count

Therefore, the goal and challenge of the innovation project was to achieve maximum lightweight construction and, with a high degree of functional integration, to greatly reduce the number of parts while also ensuring functioning kinematics. For this purpose, the hinge at hand was divided into an upper and lower subsection and considered separately. The team used the versatile possibilities of additive manufacturing to rethink the part, redesign it and finally manufacture it additively.

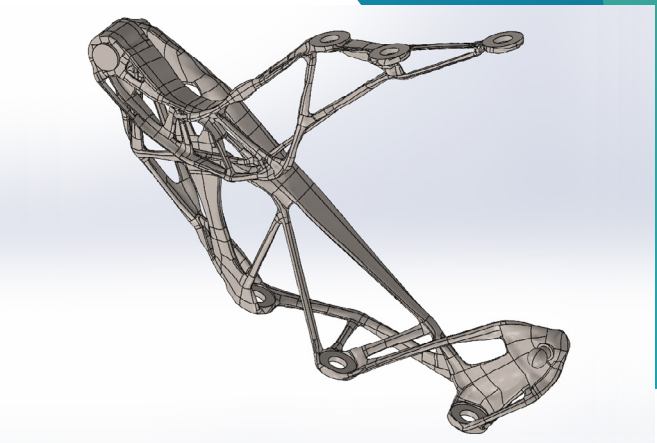
Integrated lightweight construction with Generative Design

The user imported the respective CAD model into MSC Apex Generative Design to optimise the lower and upper assembly. Based on this, the necessary design and non-design areas, including all connecting elements to the primary structure, were defined in the model preparation and 316L steel was chosen as the material. The occurring forces were then added and combined into different load cases for the optimization. A maximum stress value, which the structure must not exceed, serves a constraint for the optimization.

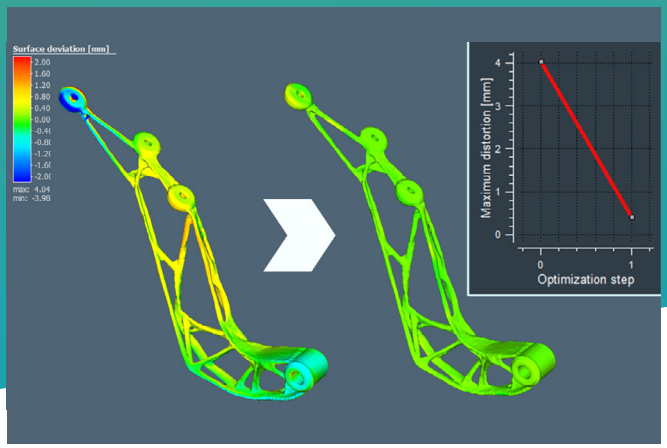
A geometry has thus been generated for the upper part element that reduces 15 parts to one core component plus three additional add-on parts and reduces the part weight from almost 800g to 200g. However, when analysing the generated structure, it became apparent that the algorithm had developed a very long strut, which the engineer wanted to strengthen with an additional connection. To do this, he imported the already generated result back into the model preparation and used the geometry tools of MSC Apex Generative Design to sketch a strut at the point where the connection was to be created. The strut only needs to be roughly inserted for this, as the algorithm cleanly attaches the strut with a few optimisation iterations and fits it into the overall structure. This resulted in another variant with an additional strut, which provides more stability than the previously generated geometry. At the same time, it was possible to reduce the material slightly in other areas of the structure so that the optimised part still weighs 200g and achieves a weight reduction of 75%.



To support the long strut, two additional struts were subsequently added to the optimization result and cleanly connected and inserted with further calculation iterations



Optimization result of MSC Apex Generative Design in NURBS-based CAD exchange format, which can be generated quickly and easily with the integrated mesh-to-CAD functionality



With Simufact Additive, the distortion could be significantly reduced: On the left is the simulation of the printing process without optimization, with over 2mm deviation; on the right is the optimized variant with only 0.14mm deviation

For the hood hinge's lower part, the procedure was the same for the model structure; the optimisation also reduces the number of parts, and the weight is also lowered by almost 40%. The generated structure does not require any further adjustments. It can be transferred directly to a NURBS-based CAD exchange format using the mesh-to-CAD functionality integrated into MSC Apex Generative Design.

Overall, the optimisation results show very good, homogeneous stress curves and provide a weight saving of 53% for the entire hood hinge assembly. The part count has also been significantly reduced by the software to 6 instead of the original 19 parts, fully in line with the objective.

Manufacturing simulation and distortion compensation

The process simulation with Simufact Additive was able to solve two significant challenges for printing the part: The support structure optimisation and the compensation of distortions. The geometry data generated by MSC Apex Generative Design was loaded into the Simufact Additive simulation software and fully calculated within a few hours. The entire production process, including post-processing, can be entered into the software and simulated accordingly and, for example, removal from the printing plate and a potential heat post-treatment or similar.

The software can optimise the orientation for printing to enable a near-optimal print result with few support structures. Similarly, any distortions that occur during the printing process can also be determined, and the CAD geometry automatically modified so that it is very close to the target geometry at the end. Using this method, it was possible to reduce warpage from over 2mm to less than 0.2mm for the lower group of parts and from 4mm to 0.42mm for the upper part. With the help of this simulation, the software can thus ensure error-free production of high quality.

Summary

With the help of MSC Apex Generative Design, the previously heavy and extensive assembly could be fundamentally redesigned. Together with the project partners, an innovative hood hinge has been realised.

The generatively generated organic lightweight structure significantly reduces the weight and, due to the functional integration, the previously high number of components of the entire assembly has also been reduced to a minimum.

Adjustments to the design can be made manually by the user directly in the software and neatly integrated. A file in a standard CAD format is generated with just a few mouse clicks, without any manual work for reverse engineering.

The manufacturing simulation of the generated structure with Simufact Additive optimises critical elements of manufacturing such as warpage and induced stresses so that the parts can be manufactured meeting the quality criteria - enabled by the consistent use of Virtual Engineering!

Hexagon is a global leader in sensor, software and autonomous solutions. We are putting data to work to boost efficiency, productivity, and quality across industrial, manufacturing, infrastructure, safety, and mobility applications.

Our technologies are shaping urban and production ecosystems to become increasingly connected and autonomous – ensuring a scalable, sustainable future.

MSC Software, part of Hexagon's Manufacturing Intelligence division, is one of the ten original software companies and a global leader in helping product manufacturers to advance their engineering methods with simulation software and services. Learn more at mscsoftware.com. Hexagon's Manufacturing Intelligence division provides solutions that utilise data from design and engineering, production and metrology to make manufacturing smarter.

Learn more about Hexagon (Nasdaq Stockholm: HEXA B) at hexagon.com and follow us @HexagonAB.

Printed in UK. July 2021