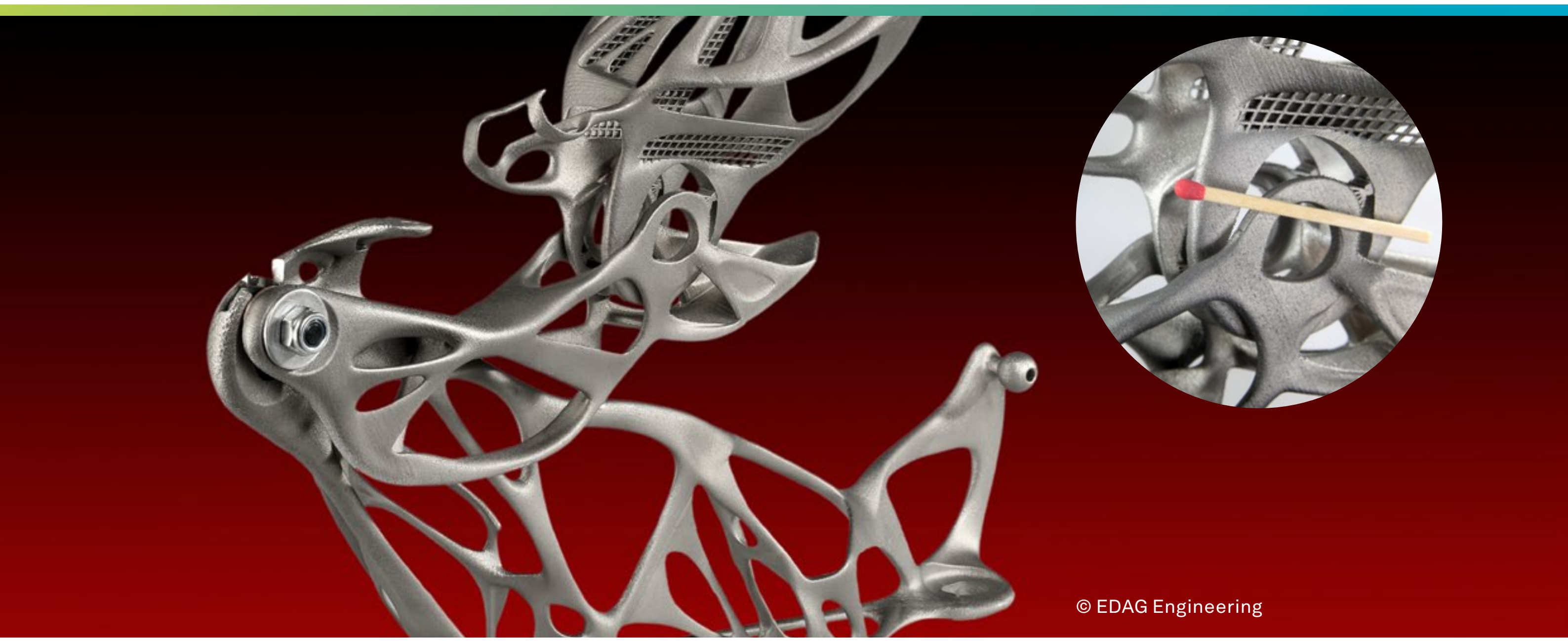
Case study

LightHinge+

An innovation project of EDAG engineering, voestalpine Additive Manufacturing Center and Simufact.



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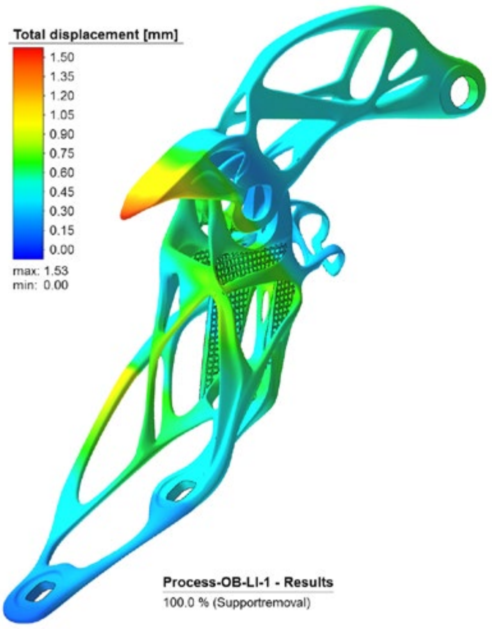
Additive manufacturing makes it possible: Ultimate weight reduction, integration of a pedestrian protection function, distortion optimized tool-less production with little rework for small series.

In a common innovation project called LightHinge+, EDAG Engineering, voestalpine Additive Manufacturing Center and Simufact Engineering jointly developed a new hood hinge. The project team used the extended possibilities of additive production in order to re-think the component, to re-construct it and subsequently to manufacture it additively. As a result, the new hinge was built with 50% weight reduction compared to the original part, and with the additional advantage to have nearly the entire pedestrian protection functionality integrated within one part. It takes fewer component parts and less assembly steps to build the new hood hinge.



Simulated distortion in the upper part

Challenge:
Re-construction of a conventional hinge hood aiming at substantial weight reduction, fewer component parts, less assembly steps, and integrated pedestrian protection functionality - to be manufactured using metal additive manufacturing methods.

Solution:
In order to reduce the number of try-out steps, Simufact simulated the distortions in the AM parts. By distortion compensation countermeasures the parts were produced in shorter time meeting quality goals.

Products used:

Simufact Additive

Customer:
EDAG Engineering,
voestalpine Additive Manufacturing Center

The design was done supported by topology optimization, which finally led to a bionic-like extremely filigree and lightweight structure. Such parts can only be reasonably produced by utilization of AM technology.

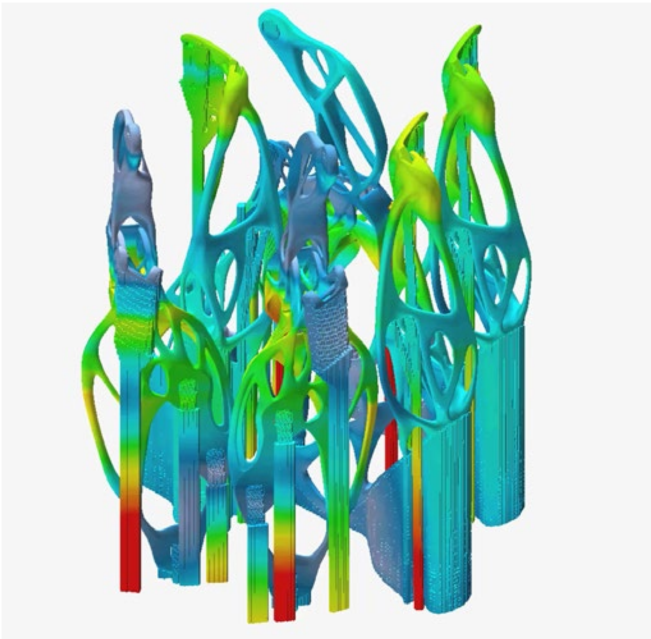
Project challenges

1. Establish the ‘right’ support structures, i.e. the optimal geometry and the amount. Support structures are necessary to prevent the collapse of the part during the build process, which would lead to an immediate stop of the production process. However, it is always the objective to have as less as possible supports because the material required for these support structures makes the build process even longer and more expensive and support removal becomes more extensive.

2. Minimize distortion and the residual stresses in the printed component due to the concentrated heat input with high heating and cooling rates during the build process. A distorted hinge can in turn deviate one or two millimeters from the targeted geometry. Producing parts with the right geometry within the given tolerances is rather difficult and requires typically lots of time and cost consuming try-outs in the shop floor. By replacing – or at least dramatically reducing – the current physical try & error process with a holistic simulation approach, engineers will be able to address those weaknesses in a more optimized manner.

Additive Manufacturing process simulation

Both challenges – the support structure issue as well as the distortion problem – could be resolved by means of process simulation. Within the LightHinge+ project the focus of virtual engineering was on the distortion problem, nevertheless the significant reduction of required support structures could also be realized.

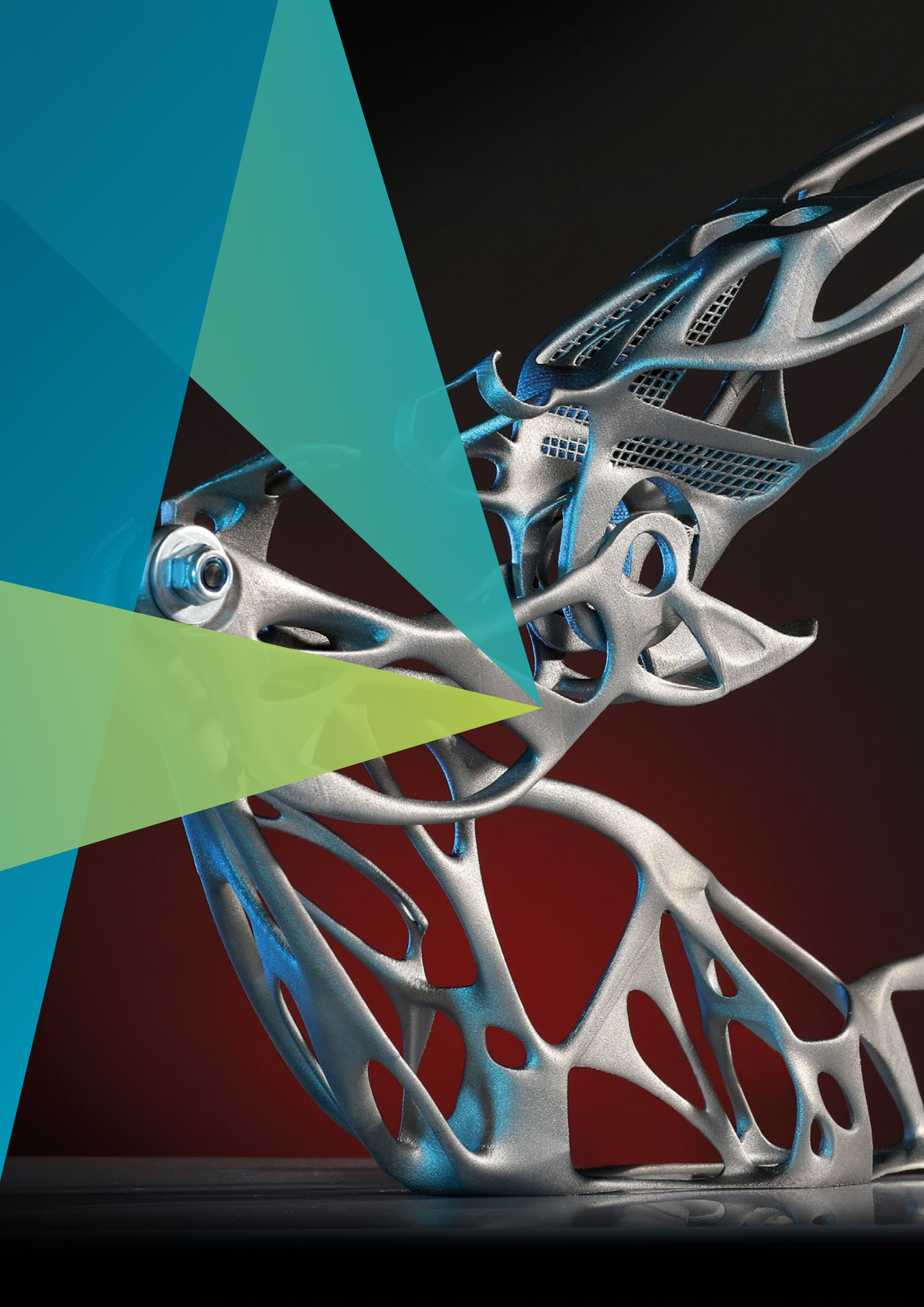


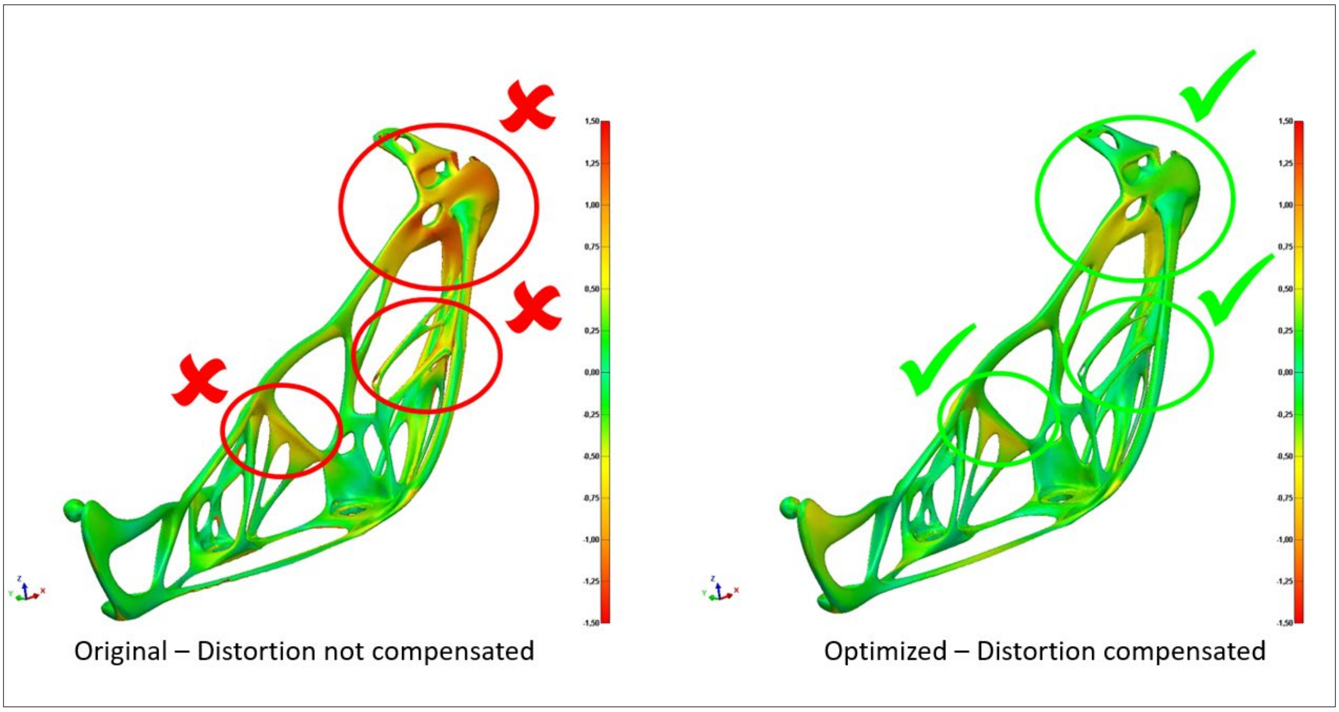
Simulation of multiple parts in the build space

Comparison hood hinge: Additive vs. traditional construction

With the use of Simufact Additive, a whole process chain of additive manufacturing can be simulated. The process typically starts with the design phase, followed by the basic model preparation including the definition of the support structure but also generating the build data for the machine. In a simulation-supported environment, the model data will be taken by a simulation tool such as Simufact Additive to run the build process virtually. The process chain can also include a heat treatment process and for aerospace parts the HIP process (Hot Isostatic Pressing) as well. Also, it is necessary to take into account the behavior of the support structure and possibly the base plate. In addition, the release of the part from the baseplate and the removal of the supports can be essential to examine the deformation behavior. In the LightHinge+ project a macroscopic approach, based on the inherent strain method, was used for running the distortion simulation. The advantage of this technology is the short simulation time: The build process of very complex parts can be simulated within a few hours. Another benefit is the simple and very efficient description of the physics of the build process based on few parameters, which easily can be examined based on a cantilever-test, a small specimen printed in the same AM machine. Even though this is a simplified approach, the deformation results are matching very well and give valuable answers to optimize the AM process.

The finite element model of the printed part is also very easy to generate. It is a so-called voxel-mesh, a mesh with regular hexahedral elements that entirely contains the components (parts and support structures) and is generated layer by layer. Though this approach seems to represent the real structure more or less roughly, a special technology adopted by Simufact allows the realistic consideration of the real part geometry. The simulation project starts with a very coarse voxel mesh, which runs in less than an hour. This approach is used to gain experience with the manufacturing process in terms of the distortion of the structure. To find the leverage between the simulation speed and the required quality of the results few variants with finer voxel representation will finally lead to the realistic deformation of the printed structure.





Comparison of the distortions before and after the distortion compensation in the lower part

Distortion compensation

A special functionality of Simufact Additive is the active compensation of the distortion. Since 3D printing is a die-less manufacturing technology, no tools have to be re-worked or re-designed to compensate the part distortion. In the case of additive manufacturing just the CAD-geometry files (parts and support structures) for the printing machine need to be modified. For this purpose, Simufact Additive provides a compensation functionality, which modifies the target geometry of the build process. After the build process, final cooling-down and removal of baseplate and support structures the total distortion is naturally in a similar amount than in the first approach, but fortunately in a direction which comes much closer to the required CAD geometry. This compensation process can happen several times iteratively, until the required quality criteria are met.

In the LightHinge+ project, the compensation was successful after the first loop of simulation. So that the compensated geometry CAD could be used to print the optimized part with less distortion.

Conclusion

EDAG Engineering, voestalpine Additive Manufacturing Center and Simufact Engineering have been the right partners to realize a vision of a new, innovative hood hinge. LightHinge+ dispenses with weight-consuming and complex kinematics of several individual parts, but achieve an additional degree of freedom in the movement kinematics by means of a bionic structure in combination with an additively manufactured breakaway structure. Breakaway structures and ultralight printed kinematics interact with the pyrotechnically triggered components, which lift the active bonnet in the area of the hinge to protect pedestrians in the event of an impact. This brand-new concept comes along with half of weight reduction compared with the initial component.

The development of this structure was enabled and supported by consequently usage of virtual engineering in terms of simulation of the entire build process. The compensation of the deformation finally allows the build of the parts following the required quality criteria.

simufact engineering gmbh
Tempowerkring 19
21079 Hamburg, Germany
Phone: +49 40 790 128-000
info@simufact.com

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