Exemplary illustration of an AM node integration

Generative Engineering Approach for a B-pillar Car Body Node

AUTHORS

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Additive manufacturing and the new development world of generative engineering lead to stiffer and lighter car body structures. Thanks to this generative and bionic design approach, realized with the ELISE software platform, Hyundai was able to reduce the weight of a B-pillar node by 47 %, increase the crash performance by 20 % and shorten the development time by 80 %.

REDUCING THE WEIGHT OF VEHICLES

The automotive industry faces new challenges every day. New styling trends, scientific discoveries and stricter emission regulations force companies to constantly create new design and production methods. They must constantly reduce the weight of their vehicles while improving their performance efficiency.

Two major enabler technologies of the automotive future are Additive Manufacturing (AM) technology as well as the new development world of generative engineering. One provides design freedom and a tool-less manufacturing process; the other one offers a yet unknown automation of product development pro-

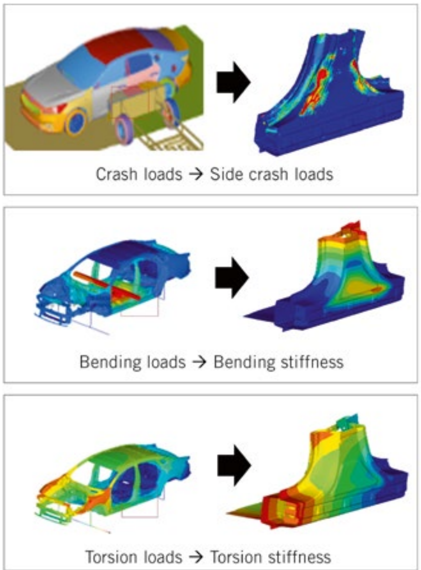

FIGURE 1 Design space of the B-pillar node and critical load cases for side crash, bending and torsion (blurred representations) (© Hyundai)

cesses. In automotive development, the combination of these two future technologies enables the construction of highly efficient vehicle structures in a significantly shorter development time.

GENERATIVE ENGINEERING – AVOIDING WAITING PERIODS

Anyone who develops technical components knows regular waiting periods. Idle times occur, for example, when coordination with other departments becomes necessary. Such R&D loops are an essential part of the development process in every company, but also dead time. The reason is in the complex and often cumbersome processes of companies: An engineer creates the part design specification, which is passed on to a colleague. It is calculated whether the design meets the strength criteria, and the plan is returned for revision. After a few loops of this kind, the project manager may get involved and demand a cheaper material or a switch to another production method. And then the entire development process starts all over again.

What if only one expert collected the project-relevant data from the specific departments, digitized it and left individual development steps and iterations to an intelligent software? Then development processes would not only run much faster; the computer assistance would also produce completely new and possibly better designs.

This approach is already reality, this future is already here. The new method is called Generative Engineering and together with the intelligent software platform ELISE they offer an innovative approach to product development. Its first users agree: this approach will revolutionize the way engineers work in the future. With the support of the intelligent software, developers will not only design better products, they will also save time and resources.

CREATION OF A B-PILLAR NODE AT HYUNDAI

One of the companies, which already uses generative engineering in practice, is the Hyundai Motor Europe Technical Center (HMETC) in Rüsselsheim (Germany). There, experience was gathered with the new development framework. For testing the software platform ELISE, a B-pillar node was chosen, as this part represents a critical area of the body of a passenger car in the event of a side impact crash. It must be able to absorb a lot of energy, resist torsion and bending and at the same time needs to be very stiff – in effect, hardly compatible objectives, **FIGURE 1**. Hyundai explained that it was important to see what the new technology could do, which is why the biggest challenge was chosen.

Hyundai engineers have already solved this challenge using conventional methods, but it was time-consuming development work. Especially for the efficient design of highly stressed part nodes complex bionic structures are required, which can be created in conventional CAD programs only with great effort. However, with the generative engineering method in the software platform ELISE, the design space could be analyzed on the basis of critical load cases and replaced by bionic lightweight design structures with specific mechanical properties using generative algorithms, **FIGURE 2**.

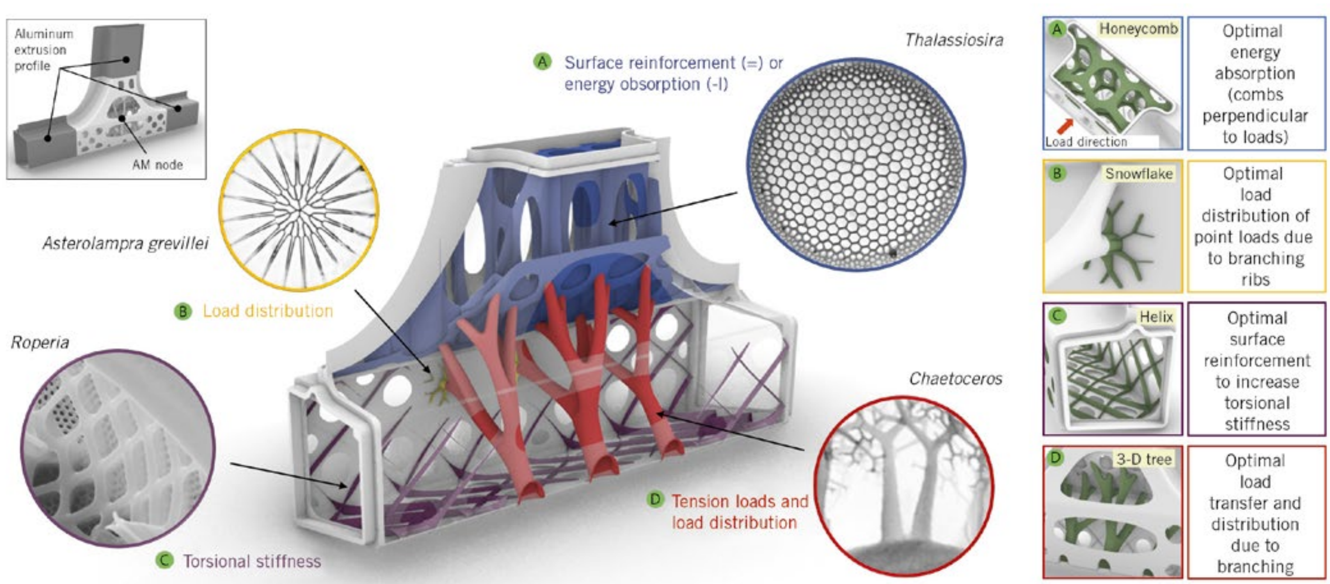

FIGURE 2 Algorithms for generating bionic structures with specific mechanical properties (© ELISE and AWI)

No manual design work was required to create these complex structures, everything is basically generated by the software. The bionic algorithms of the software are partly based on research results of the bionics department at the Alfred Wegener Institute (AWI) in Bremerhaven (Germany) [1]. From there, the company ELISE made its spin-off as a start-up in the year 2018.

VALIDATION AND PERFORMANCE

To validate the additive manufactured B-pillar node, it was analyzed with respect to its maximum intrusion in a sub-component model during the AEMDB side impact crash. The results in **FIGURE 3** (top) show an optimal load distribution from the B-pillar to the sill due to the specific design features. **FIGURE 3** (top) compares the bionic AM aluminum model with the steel reference part with respect to the maximum intrusion of the B-pillar into the passenger compartment. The bionic concept has about 20 % less intrusion.

In addition, the energy absorption of the AM aluminum node had to be verified, **FIGURE 3** (bottom). This plastic deformability is generally hard to achieve when a structural design is developed considering only topology optimization results. This usually leads to very stiff parts. However, an optimal compromise between stiffness and plastic deformability is sought. Here the bionic design also fulfills all expectations. The upper part of the node is plastically deformed by the impactor and results in a similar force-deformation curve shape as in the steel reference part, **FIGURE 3** (bottom).

Thanks to the generative and bionic design method in the software platform ELISE, the weight of the B-pillar node has been reduced by 47 %, crash performance has been increased by 20 % and development time has been shortened by up to 80 %, while complying with all critical requirements. Using additive manufacturing, the engineers were also able to reduce the number of individual parts by 90 %.

TECHNICAL DNA OF THE PART

The innovative method required a new way of thinking. With generative engineering, the developer takes a completely new approach to solve the task. First of all, they define design spaces, possible materials, load cases, performance criteria, production-related constraints and process costs in the software platform. This technical data is then processed by components for topology optimization, CAD features, bionic algorithms and optimization methods. The individual components interconnect to an entire network on the software canvas and form a "technical DNA" of the part, **FIGURE 4**.

Since each component processes parameter values or imported data, it can be changed by the developer themselves or in the context of a parameter study. As soon as this happens, the software processes the new data sets and generates the corresponding variations of the part, as shown schematically in **FIGURE 5**. The processing of new data takes place throughout the entire technical DNA, and the developer receives not just one design, but hundreds in a very short time.

As a result, Hyundai engineers were able to save a great deal of development time by conducting the complex crash simulations only with the two most promising concept variants found by the parameter study (Design of Experiments, DoE). A great starting point, since in the end only minor tweaks to some parameters were necessary to meet all requirements. The part is fully parameterized, and the data exchange between different software tools is completely automatic. Therefore, it is possible to react very quickly to new boundary conditions. Until now, engineers usually had to start from scratch when making any change. Thanks to computers and intelligent software, solutions are also created that may look completely different than the engineers had imagined. In the case of the B-pillar node, a complex and almost organic-looking structure was created in the computer that no human being would have thought of.

MANY IDEAS FOR NEW PROJECTS

The highly efficient design was a result of combining two innovative approaches: generative engineering and additive manufacturing. Especially the combination of both methods is a game-chan-

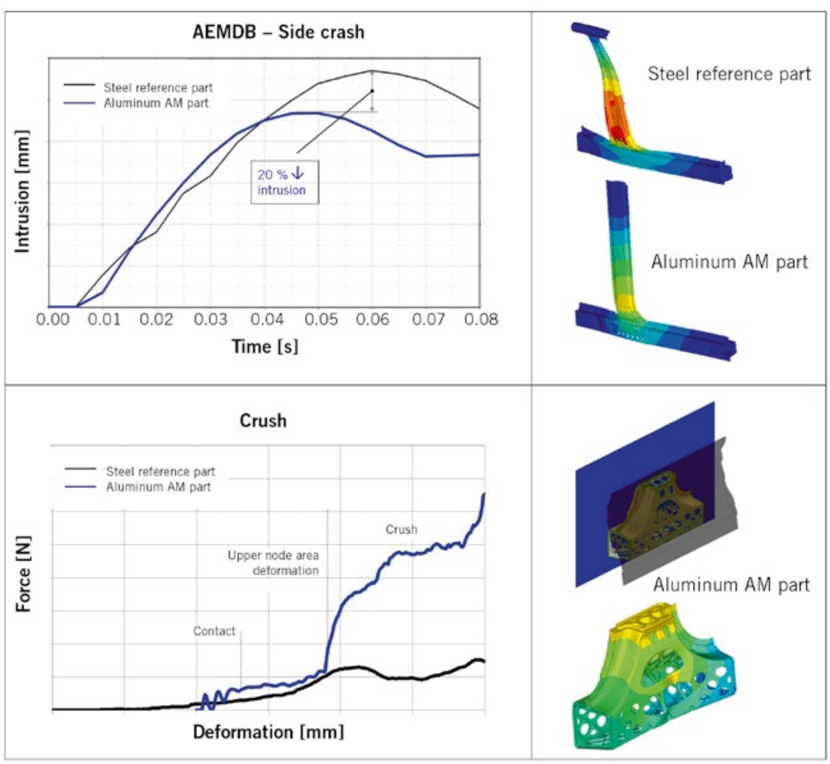

FIGURE 3 Simulation of an AEMDB side impact crash with a reference and an AM part (right) – time path of the maximal intrusion point (sub-component model, top left); simulation of crush – path of force over deformation (bottom left) (blurred representations) (© Hyundai)

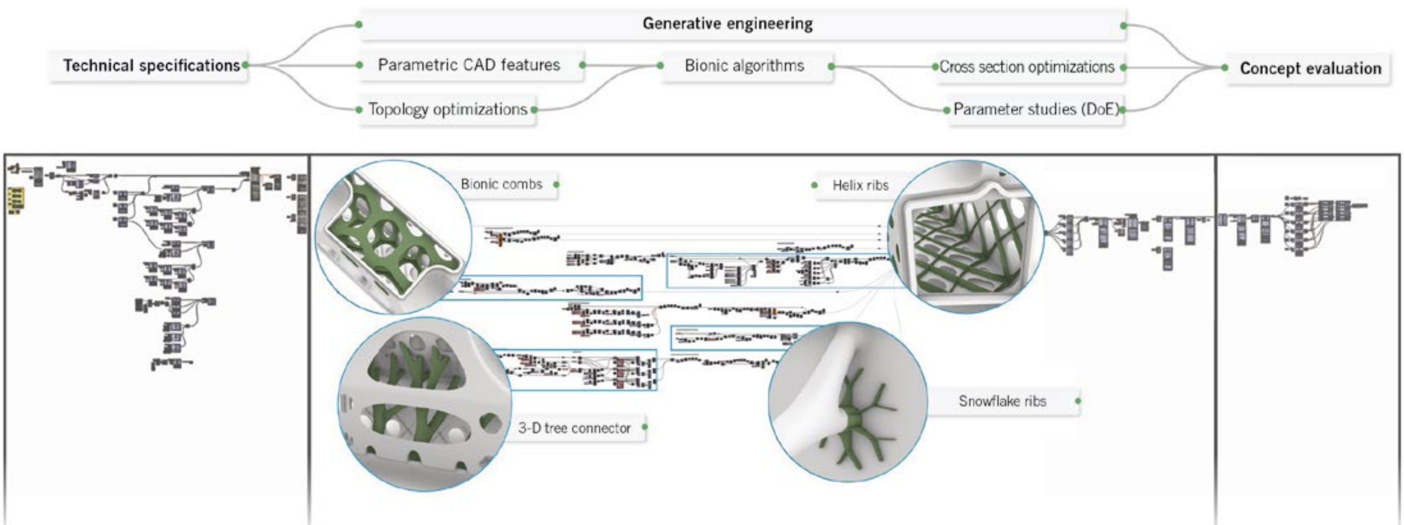

FIGURE 4 Technical DNA of the bionic B-pillar node from technical specification to concept evaluation (© ELISE)

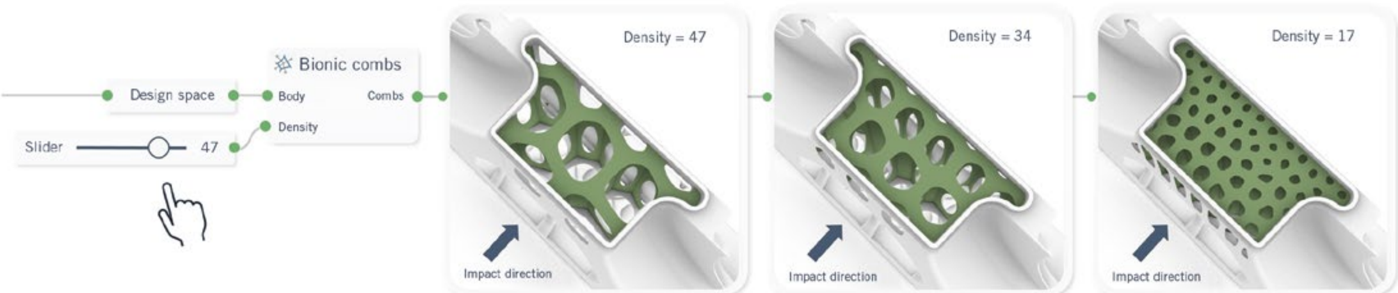

FIGURE 5 Bionic algorithm – construction algorithm applied to a design space and controlled through parameters (© ELISE)

ger. In particular, great things will be expected from generative engineering. One will see less standardization in the industry in the future. Besides, users do not need a new qualification for this; only the focus of their development work will change. This will lower the hurdles for product development even more.

Hyundai is set to promote the technology among its employees. The key argument is that the use of generative engineering could not only lead to better and more efficient products in the future but also drastically reduce development times. Keeping this in mind, one could gradually replace manual design and at the same time create more efficient design solutions.

REFERENCE

[1] Maier, M.: Entwicklung einer systematischen Vorgehensweise für bionischen Leichtbau. Bremerhaven, Alfred-Wegener-Institut, PhD thesis, 2015

THANKS

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