Lightness.NRW: Final report

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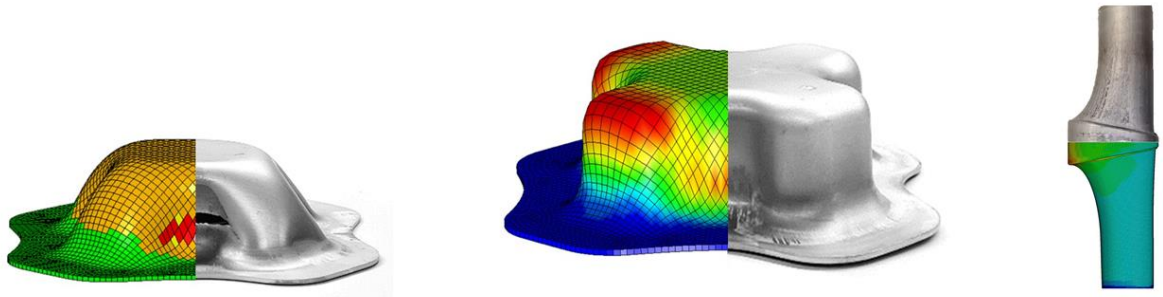
As part of the Lightness.NRW project, a hot die forming (HDF) process was developed that allows high-strength and maximum-strength aluminum alloys – as sheet metal or tubular semi-finished products – to be formed into ultra-lightweight structural components with highly complex geometries. The potential of HDF technology for lightweight structures in large-scale vehicle production was demonstrated by means of laboratory and demonstrator components and component studies. In order to utilize the full technological potential with regard to ultra-lightweight structures, a process simulation and a component simulation for static and dynamic applications that is based on experimental results were also developed.



Components created during the project from a combination of FEM simulation and experiment. The plate and tube-based components were successfully formed from high-strength alloys using the HDF technology.

Only the comprehensive project consortium, set up to cover all aspects of the value chain, was able to answer the complex questions that arise along the whole process chain. The capabilities and competencies of the consortium partners range from the development of alloys, processes and equipment, through the establishment of an accompanying simulation methodology for describing the forming process and component behavior, right up to the development and production of real demonstrators and their final experimental characterization. Based on the development and selection of a high-strength aluminum alloy that is suitable for HDF technology, the performance of the innovative forming technology for producing complex aluminum structural components was demonstrated and experimentally validated by the successful manufacture of two technology demonstrators – crossmatch and tube node. This process was backed up by FE-based process and component simulations in order to

achieve a gradual optimization of the tool and component geometry. Based on the calculated mechanical characteristics (static and dynamic), a material card was developed that enables the targeted design and dimensioning of aluminum lightweight structures.

Consequently, this resulted in the development and validation of a powerful CAE simulation methodology as well as a material card and material database that can also be used outside of the project. Using the results of the experimental tests and the findings gained from the manufacturing process of the demonstrator components with regard to the maximum degree of deformation, design guidelines and thus potential applications in the automotive sector could also be elaborated. A large number of static and dynamic tests on the technology demonstrator components served as a reliable data basis for assessing the potential of HDF technology. The effects of post-treatment on the component properties were also examined by means of simulations and experiments, in order to ensure optimized heat treatment to achieve the desired mechanical component properties.

The design of a plant concept for the integration of HDF technology into a large-scale production environment constitutes the successful completion of an important step within the project from laboratory scale to series production. For this purpose, a process facility, including all equipment, preparation and supply units, and associated handling systems, was virtually realized using the example of the manufactured tube node, taking into account cycle times in the large-scale series production of vehicles. Based on this virtual representation of the overall facility, it was possible to evaluate the manufacturing costs and the environmental balance, and to determine general suitability for large-scale series production with the assistance of the end user from the automotive industry.

In this way, the foundation has been laid for the establishment of HDF technology in large-scale production applications. This is supported by the final evaluation of the component characteristics achieved, which show that HDF technology represents a great opportunity for energy- and resource-efficient lightweight construction. In the years to come, this technology can make a major contribution to ensuring that complex (structural) components, made of high-strength aluminum alloys, that cannot be

manufactured cost-effectively, if indeed at all, can be widely used in series production and thus enable ultra-lightweight metal construction.