Aspects of a **designtool for springback compensation**

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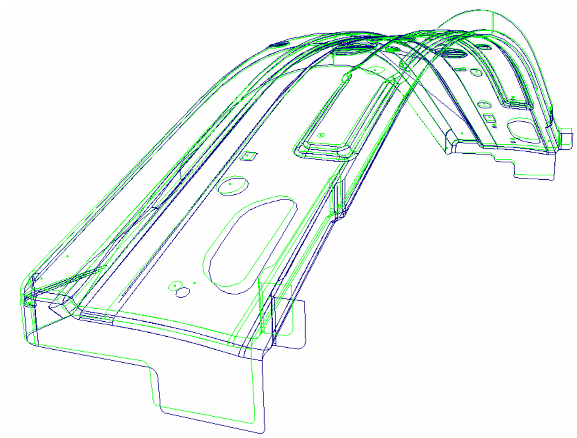

Many products in the automotive industry are produced with the deep drawing process. When the tools are released after the forming stage, the product springs back due to the action of internal stresses. Because the geometric tolerances can be tight for sheet metal products, this shape deviation can be unacceptable. In many cases springback compensation is needed: the tools of the deep drawing process are changed so, that the product becomes geometrically accurate. In the industry, this is currently a costly and time consuming process of producing prototype products and redesigning the tools manually. The goal of this project was to develop a software tool that can automatically perform this optimisation process, using the results of finite elements (FE) deep drawing simulations.

To evaluate springback problems, the main factors are not only the geometrical accuracy but also the assembly forces; In some cases, the product can be bent back into the right shape during assembly. For some products, these forces are too high, or the shape of the assembled product may be unacceptable. Then, the first goal is to reduce springback. The deep drawing process can be optimised in various ways, mainly by influencing the material flow into the die cavity. Redesigning the structure of the product can be effective as well.

Even when the product design has been optimised, and the deep drawing process has been set up carefully, springback compensation has to be carried out to improve the geometrical accuracy of many products. To speed up the manual springback compensation process, the use of finite elements calculations instead of real prototype tools is currently tested in the industry. Several completely automatic springback compensation algorithms have been reported and tested in scientific literature. The idea of the Displacement Adjustment (DA) method is to use the shape deviation between the deep drawn product and the desired shape, multiplied with a negative factor, as a compensation function for the geometry of the tools. In literature the DA method has proven to be the most reliable and fast.

In this project, the control surface (CS) algorithm has been developed. Here a surface with a limited set of parameters is used to compare and evaluate the desired product shape and the deep drawn product, and to modify the deep drawing tools. With the control surfaces, the DA principle is again used for compensation. The control surface allows only a limited set of shape modifications such as bending, torsion and camber. The advantages of this method are that the modification of the geometry can be carried out with a CAD system as well, and that it is possible to control the algorithm manually. The algorithm is demonstrated first with a cylindrical control surface.

To make the algorithm usable in the industry, a version using a flexible parametric description for the control surface has been implemented. With this type of control surface, the mathematics behind the algorithm become more complex. The details of each step in the algorithm are discussed in detail. Then the algorithm is tested out with two products. The first product is a structural part provided by DaimlerChrysler, which is compensated in one iteration only. The resulting reduction in shape deviation amounts 64%. The results of the algorithm can be strongly improved by applying more iterations. This is demonstrated with the second example, a fuel tank cap. With this product it is also shown how local compensation can be used to raise the algorithm's effectivity. For this, some user interaction is needed. Here, 66% reduction in shape deviation is reached. The CS algorithm has been compared to the DA method. For the structural part, the DA method performed slightly better, as expected. For the fuel tank cap, no comparison could be carried out due to problems with the tool modification in the DA method and due to practical limitations of the finite elements program.

The smooth and continuous description of geometry in CAD files is required for the generation of NC code for the milling robot that produces the deep drawing tools. So, to make the algorithm useable, the same geometry modification that is applied to the tool meshes needs to be applied to the CAD data of the tools. This is problematic since CAD files and meshes have an incompatible description of geometry. In the program ICEM-surf the an identical control surface principle is included and with this function, the CAD geometry has been modified in the same way as the meshes.

The algorithm is not yet industrially applicable in this form. Both FE simulation and the springback compensation algorithm need to become more accurate. However, the project has shown how the complete process from FE simulation to modification of CAD files can be performed, and the results look promising. With FE deep drawing simulations and the springback compensation algorithm, the process setup of a deep drawing process will become significantly faster in future.