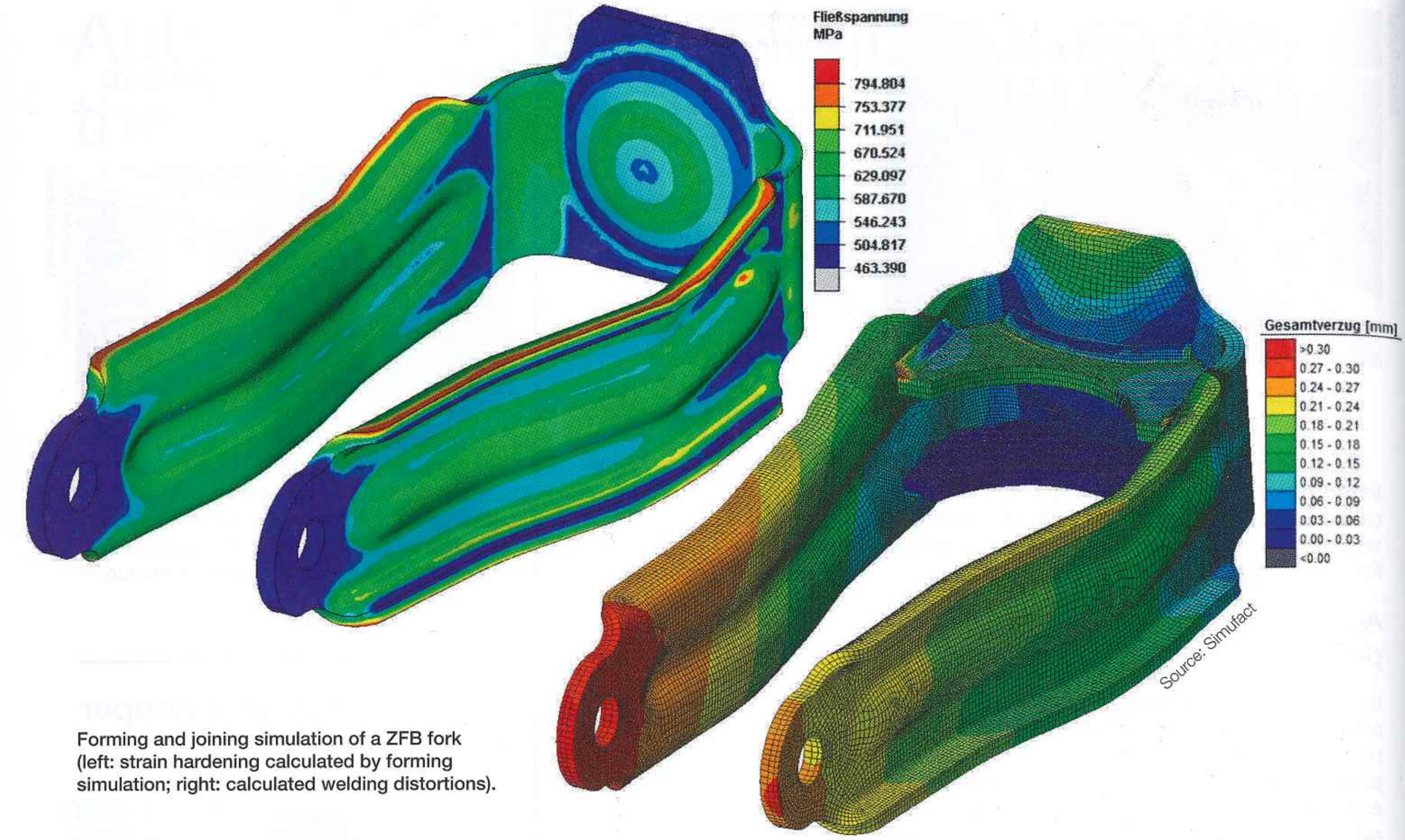

Forming and joining simulation of a ZFB fork (left: strain hardening calculated by forming simulation; right: calculated welding distortions).

Simulation secures and expands sheet metal forming

Hendrik Schafstall and Ingo Neubauer

Simulation provides a detailed view of manufacturing processes. The software takes into account the relevant physical aspects and provides application-focused functions.

ETMM

INFO

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At Simufact, feasibility is assessed by way of a realistic prediction of dimensional accuracy, cracking behaviour, possible crack formation and exhausted deformation capability. Based on the simulation results, product properties such as wall thickness distribution, edge curvature and hardness distribution resulting from strain hardening can be output.

This information helps to put decisions regarding method planning and tool design on a sound basis. Since the simulation software can be used directly by the tool designer thanks to application-oriented user guidance, the simulation can be carried out directly with the functional surface geometries of the tools. The geometric mapping of drawing bars is also possible in order to reproduce their effect on the forming process with the greatest possible accuracy. Compared to the use of replacement models, this procedure offers the advantage that, in addition to the required forming forces, the condition of the material after passing through the drawing bead is also mapped in detail.

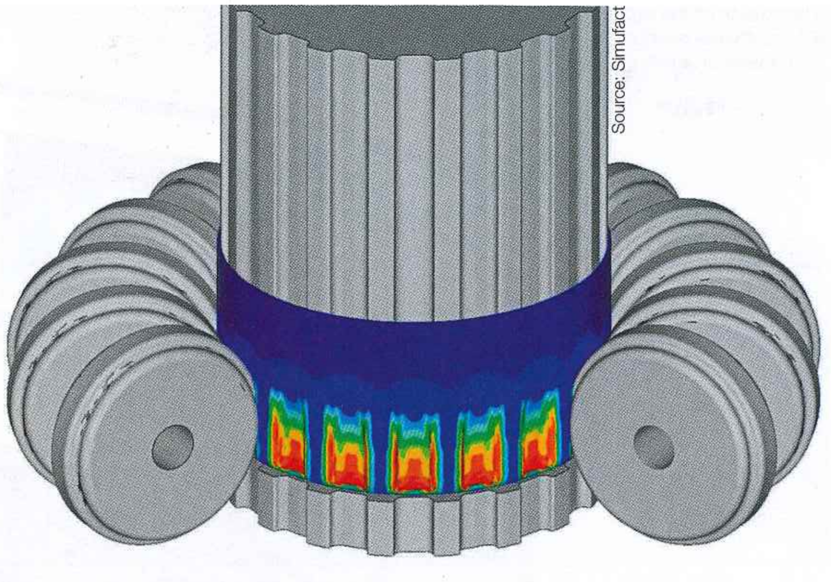
On the product development side, there is a trend towards more complex components with higher strength requirements, which entails correspondingly high development costs for production. The lightweight construction potential of sheet metal components also leads to the manufacture of components that were previously designed as solid formed parts by sheet metal forming processes. In addition, forming processes are increasingly being combined, for example, to integrate functional elements such as gear teeth or threaded sleeves into sheet metal components by integrating stamping and cross-flow processes.

A good example of this is the sheet metal forging process, which enables the integration and expansion of sheet metal components as an overriding objective, but results in a significant increase in component complexity.

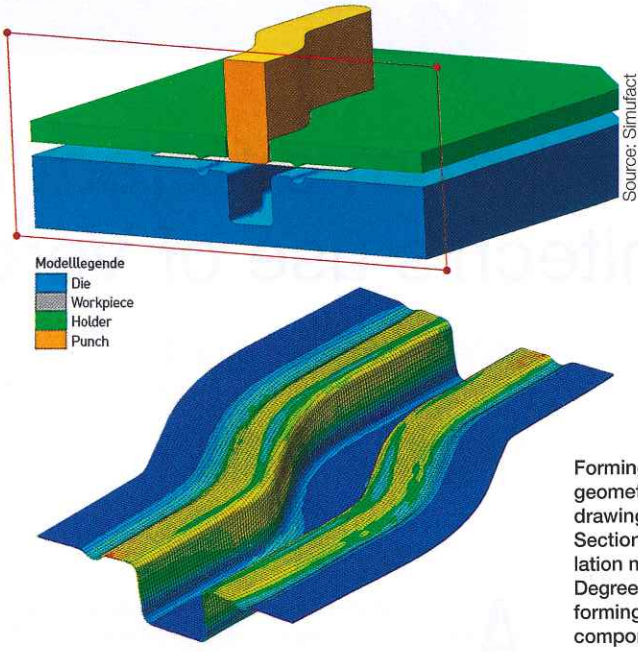
As an essential feature of this forming process, solid forming processes such as upsetting or extrusion are applied to deep-drawn or stretched intermediate form geometries or realised in a combined process within a tool system. It is indispensable especially for complex tools to secure a constructive design via simulation to improve economic efficiency. A process simulation requires the application and combination of simulation-specific technologies developed for the modelling of the individual processes.

The modelling tools of the Simufact products enable the user to map all possibilities of the real process design in his calculation model. This way, process combinations such as sheet metal forming can be represented in detail on the simulation model. Mapping algorithms enable precise data transfer in order to switch from shell models to solid models, if necessary. Thus, all functions typically required for the simulation of cold forming processes can be used. These include fully automatic re-networking in the event of major deformation and the use of ductile damage criteria to predict areas at risk of cracking. The software thus supports all users who require a complete application for mapping their forming processes.

Products are created by assembling individual parts using a joining technology adapted to the component requirements, materials and quantities. This must be regarded as part of the manufacturing process chain, as it influences the dimensional accuracy and technical properties of the entire assembly. For this reason, it makes sense to map assembly and joining processes in the virtual process chain with the same level of detail accuracy as is used for modelling the shape of the individual components.



Tool system for the production of lamellar beams by means of solid sheet metal forming.



Forming simulation with geometrically modelled drawing beads. Top: Section through the simulation model. Below: Degree of comparative forming on the formed component.

Combination of forming and joining processes

Industrial joining processes such as spot or path welding as well as forming joining processes such as clinching or punch riveting can be simulated in detail with Simufact software. All Simufact products use a compatible solver so that process chains from forming and joining processes can also be mapped across programs. The central strut fork (ZFB) is used as an example. The component is formed from semi-finished sheet metal in a multi-stage forming process and completed by arc welding with web plates on the fork head. The method plan for the forming process was validated by simulation calculations. A volume model was used for this procedure in order to map the effects of the narrow bending radii with comparatively large material thicknesses. From the calculations it was possible to deduce that the forming results in an increase in the yield strength from approx. 460 to approx. 795 MPa.

To determine the component distortion to be expected from the joining process and its compensation, it can be mapped in detail in a weld structure simulation. This was done for the ZSB fork both with and without consideration of strain hardening from the previous forming process. It has been shown that work hardening in the material leads to different deformations of the component geometry with an unchanged clamping concept. The investigations carried out in co-operation with the Vollmann Group revealed the following: The distortions at the welding group calculated by neglecting this strain hardening were outside the required tolerances and would have required compensation measures at the fixing device. On the other hand, the results of the calculations with consideration of strain hardening from the forming process showed compliance with the required dimensional tolerances and also a better agreement with the real distortions from the later experimental implementation.

It can be concluded that a reliable prediction of distortion from a joining simulation also requires consideration of the forming history of the components to be joined. Therefore, it is possible to prevent making wrong decisions in the production-technical implementation of a process.
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