

THE VIRTUAL WELD

Welding simulation supports process understanding in sheet metal forming, says Dr. Hendrik Schafstall

ISMR SAYS:

"Newly launched software now enables the reliable simulation of welding structures for companies applying industrial welding processes in (serial) production"



Fig 2. Welding simulation of a carrier. Right image: Max. temperature. Left image: Residual stress after cooling and unclamping.

Most manufacturing companies rely on empirical data and experience when designing and welding components. Goal-oriented improvements and the adjustment of manufacturing processes often require a considerable amount of time and effort. Typically, for example, welding distortions can only be found and corrected in downstream fabrication steps.

However, the process accompanying the use of welding simulation enables a detailed examination of the entire manufacturing process and the design of improved welding processes by, for example, the goal-oriented development of clamping concepts. Newly launched software now enables the reliable simulation of welding structures for companies applying industrial welding processes in (serial) production.

The need for welding

Economical and high quality manufacturing of products in the metalworking industry is unthinkable without the use of modern joining processes. Globally competitive high quality production nowadays calls for the professional and cost-effective application of different manufacturing processes, utilising respective component properties when adjusting different production steps. Here, welding technology is crucial.

In comparison to other joining processes, welding is beneficial for form and force closure,

which allows for maximum force transmission with minimum weld thickness to reduce component weight and usability for repairs. The disadvantages of welding include thermal distortion at the weld and in the welding assembly, structural changes in the weld zone and (sometimes) quality assurance. Weld errors are only detectable at great expense using x-ray or ultrasonic analysis. Therefore, process reliability and robustness are extremely important.

Quality-assured manufacturing through welding

The goal of welding is to create a reproducible, reliable product with minimal distortions, while maintaining low production costs without the need for expensive rework and quality control. Expertise and experience in the design and application of welding are required.

Up until now, welding processes have been primarily designed using empirical studies and relying on the experience of welding experts. Welding is a complex manufacturing process incorporating a number of different factors such as the welding principle; the welding sequence; the welding source; introduced energy; welding speed (if applicable); filler materials as well as the material combination

and the material thickness (geometry), all of which need to be adjusted.

The clamping concept; the start and end of the clamping; the gripping points; their geometry and acting forces also have a significant effect on the final result in terms of possible distortions (see Figure 1 below).

Reliable process design using modern simulation software

It is complex to design a reliable welding process due to the interactions and the large number of possible combinations. By using modern simulation software, detailed information during the welding process can be visualised and different process combinations can be calculated in advance. The specific identification and systematic study of process-defining parameters and their effect on the result are possible to gauge.

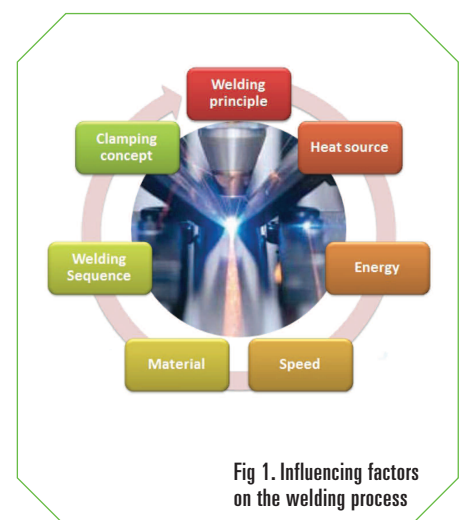


Fig 1. Influencing factors on the welding process

“By using modern simulation software, detailed information during the welding process can be visualised and different process combinations can be calculated in advance.”

For a long time, welding simulation has only been used by academics and in research facilities, because the modelling and calculation required for experts were too complicated in application. Real-world production using simulation software was out of the question.

However, in 2005/2006, the German automotive industry initiated the development of a new welding simulation programme. The goal was to provide a production tool for welding experts, giving them a better understanding of the processes and enabling the virtual design and improvement of the process.

The development contract was awarded to the German software company, Simufact Engineering (based in Hamburg), which already had many years of experience in metalforming. On this basis, the Simufact.welding program was developed over the past seven years as an easy-to-use industrial application, tailored to the specific demands of the manufacturing industry without requiring additional simulation expertise. For all calculations, the Marc-Solver (which had been in commercial development for over fifty years) was used. Welding-specific extensions and adjustments were made in the Marc-Solver.

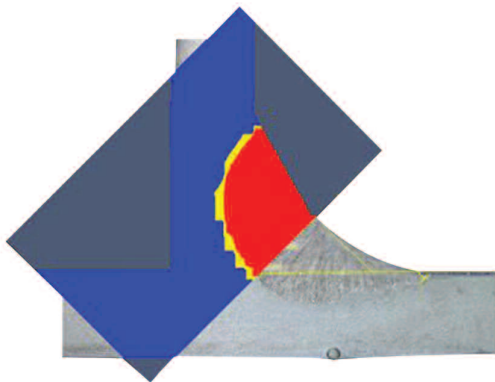


Fig 3: Comparison of weld pool experiment vs simulation

The key to this production program is the graphical user interface (GUI). It was designed using welding expert terminology so that input is consistent with production specifications. Clamping concepts, weld paths, introduced energy and the welding sequence with its speeds and breaks are all taken into account, as well as adequate time management provision. No additional abstractions or simplifications are required from the user; instead, the simulation process can be set up like the real manufacturing process (see Figure 3).

Calibration of the heat source which leads to the weld pool, however, is always necessary because the simulation uses a model heat source for heat introduction. Several different models, depending upon welding principles and materials, are available for selection.

Process optimisation is possible because, for example, the weld sequence, paths and clamping concepts can be easily exchanged, calculated anew, analysed and compared. This allows targeted comparison with factors influencing total distortion, temperature distribution, residual stress and structural changes. Customised options are available for assessing results (see Figures 2/4).

Linking simulation with manufacturing processes

With the help of the Simufact.welding simulation software, it is possible to design reliable welding processes based upon manufacturing data. However, as each component has a previous history, the welded component group will be further processed or is subject to specific loads.

Because of the open data structure, it is now possible to use the simulated joints in further stress analyses maintaining calculated local structural changes, mechanical resistance and residual stresses as well as distortions. Simufact.welding also enables users to carry over the data from previous manufacturing processes as the basis of the welding simulation, as shown in Figure 5. The calculated distortion changes by a factor of three, depending on whether or not the history was taken into account or just the CAD geometry was used. Accurate assessments of the conditions after welding can be made this way.

The inclusion of data from up- and downstream manufacturing steps contributes to process optimisation and enables correct adjustment of the processes. For example, process temperatures during a forming process

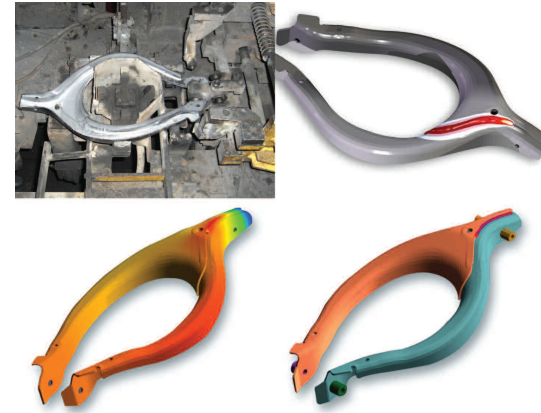


Fig 4: Welding of a component in a clamping device: real part and simulation (lower right distortion, upper right temperature distribution)

can be used in a simultaneous welding process or to control the introduced residual stresses of the forming process to produce a weld with minimal distortion or even to pre-composite the distortion in the pre-stage. The virtual linking and examination of welding processes offers a wide range of benefits for economical and reliable design of the manufacturing steps.

The newly developed Simufact.welding simulation program is a sustainable solution to modernise welding simulation and apply it to real-world production. The program is continually being developed and tailored to the dynamic requirements of the industry.

Simufact.welding allows for a deeper and more detailed understanding of the welding process to design more reliable, economic processes with less distortion in advance.

For more details, see www.simufact.de

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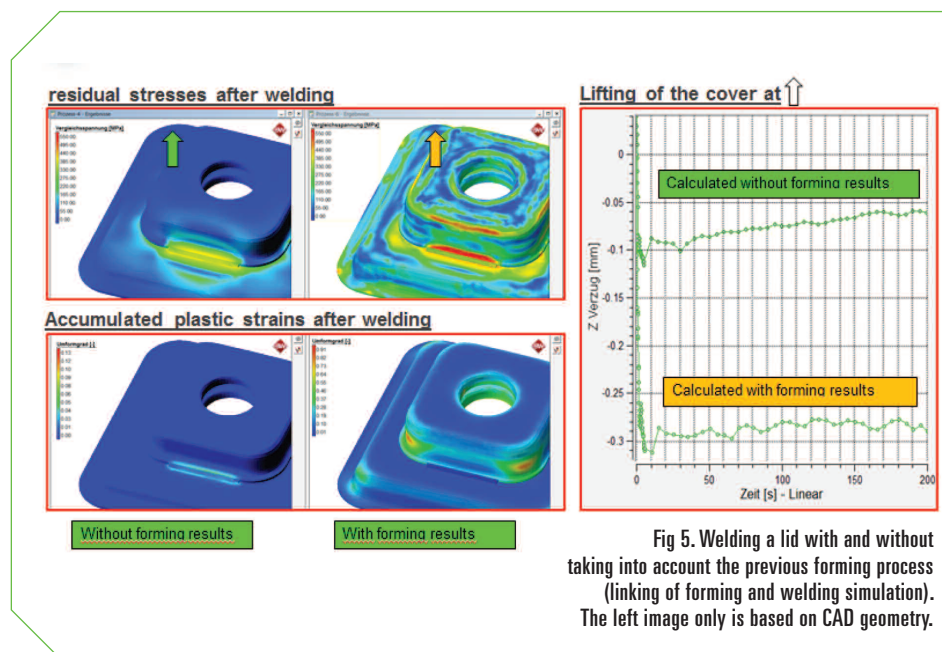


Fig 5: Welding a lid with and without taking into account the previous forming process (linking of forming and welding simulation). The left image only is based on CAD geometry.