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Thermomechanical Simulation of Laser Welding in AutoForm Assembly

Overview

Laser welding results in thermal deformations (see Figure 1), which are especially critical in industries that demand high precision, such as automotive manufacturing. To predict these distortions, a substitute model is employed. This model translates thermal loads from welding into mechanical equivalents and applies them near the weld seam. The mechanical problem is then solved using the finite element method. However, this approach does not account for transient thermomechanical effects, which may impact its accuracy. This study evaluates the model's accuracy by comparing its results with those from a transient thermomechanical welding model and experimental data.

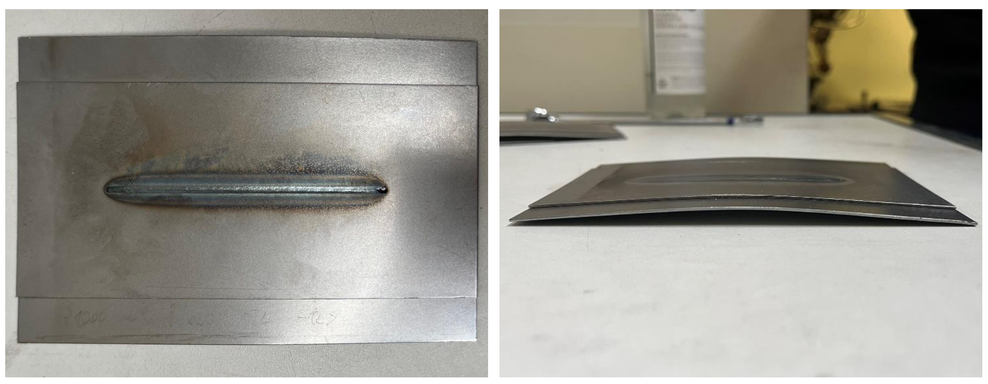

Figure 1: Distortions from laser welding.

Thermomechanical Simulation and Experiments

The substitution welding model is integrated into the FE-software AutoForm Assembly, which simulates the car assembly process. In this study the transient thermomechanical model was implemented within the same software framework. The key difference between these models lies in the thermal analysis performed by the transient model, which accounts for the effects of heat application and distribution throughout the process.

Welding experiments were conducted to provide real-life data for comparison with the simulation results, as shown in Figure 2. These experiments involved welding two metal sheets using varying parameters. Subsequently, the welded parts were 3D scanned and utilized in the comparative analysis that followed.

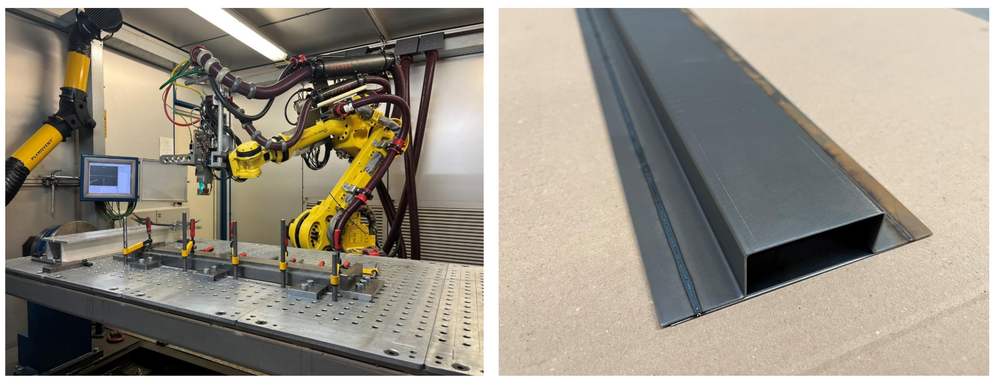

Figure 2: Experiments on welding two plates.

Analysis of the Results

The comparison demonstrated good agreement in overall deflections, as illustrated in Figure 3. This figure also displays the CPU time required by both models, highlighting a significant difference between them.

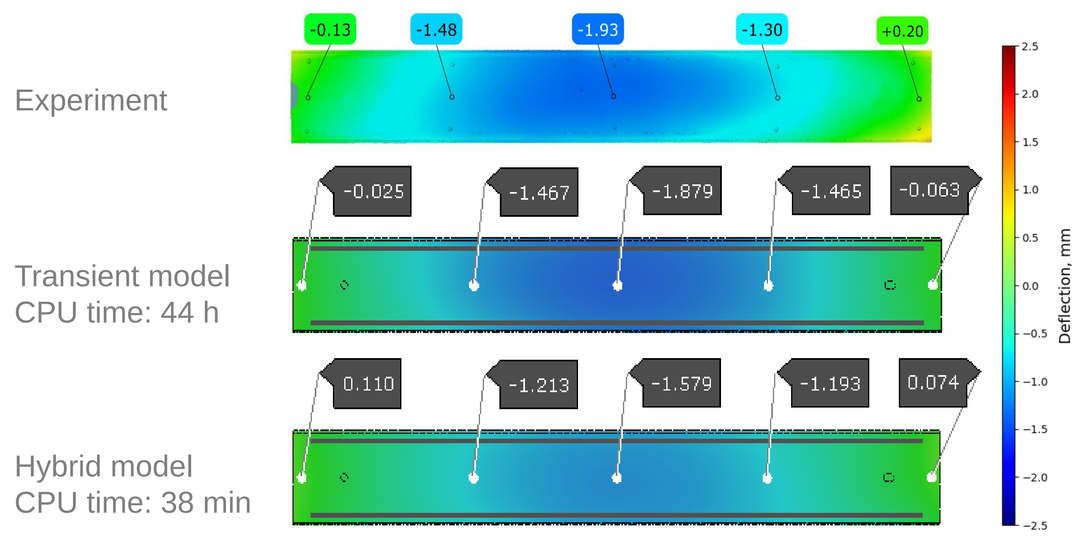

Figure 3: Deflections in the normal to the plate direction.

The in-plane forces transverse to the seam were analyzed between the transient and substitution models. The comparison, shown in the figure 4, reveals that the width of the stress-affected zone is nearly identical across both models. Additionally, despite the artificially flat distribution in the substitution model, the integral values between models align closely. These findings confirm that the substitution model can accurately predict welding distortions with fewer computational resources.

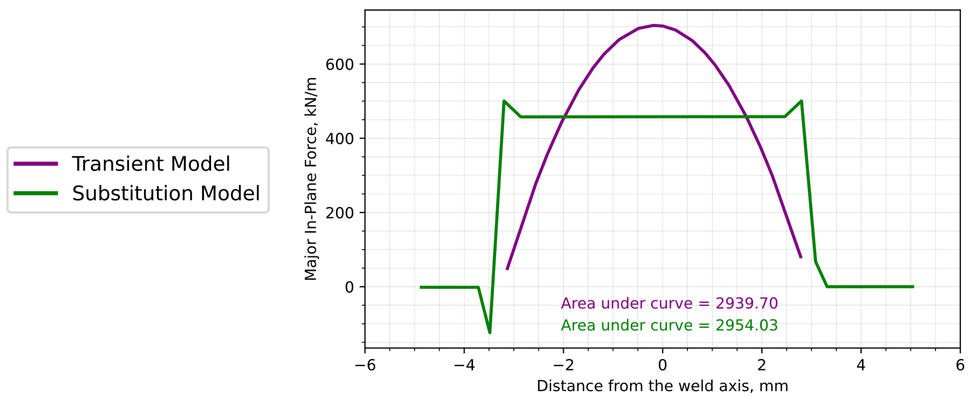

Figure 4: Distribution of the major in-plane force transverse to the weld seam.

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