

Distortion minimization for milling of formed thick sheet metal components

Motivation

Forming of thick sheets and subsequent milling operations represent an efficient process route for manufacturing a wide range of structural components in industrial applications. An example of the step sequence is shown in Fig. 1. Compared with machining from bulk source material, the wear of the milling tools and the wrought material required can be substantially reduced. Currently, the achievable geometric tolerances are limited by the release and redistribution of forming-induced residual stresses in the part during milling.

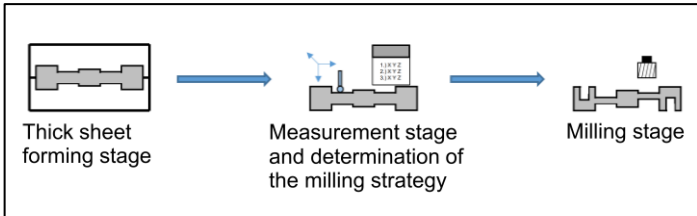


Fig. 1: Process route for forming of thick sheets and subsequent milling.

Approach

A systematic approach to reduce the geometric distortion of the manufactured components is investigated. For this purpose, the process sequence is implemented experimentally on a demonstrator component as shown in Fig. 2. In parallel, a numerical process model is developed to determine the achievable prediction accuracy of the residual stress state across the process stages.

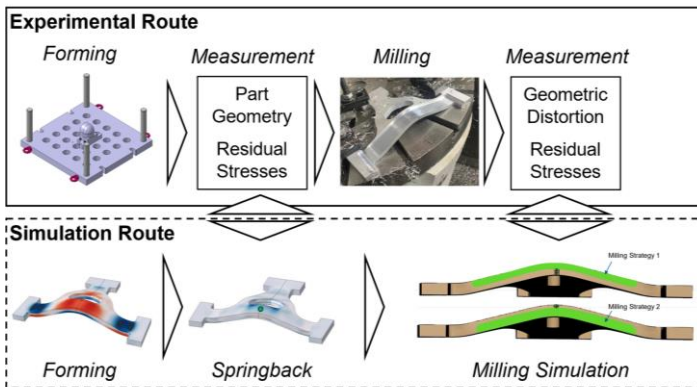


Fig. 2: Simulation model and experimentally performed process route, including the measurement strategy.

To compare the predictions of the simulation model with the experimental results, measurement data of the component geometry, the strain at the component surface and the residual stresses are applied.

Results

The inter-process simulation model enables a prediction of the resulting residual stress distribution and the component geometry for the individual stages of the process chain. Exemplary results after the springback of the forming stage are shown in Fig. 3.

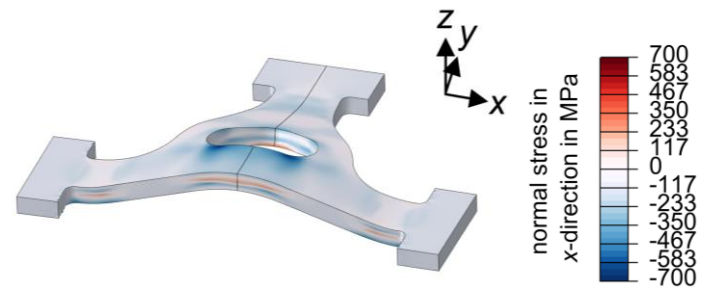


Fig. 3: Predicted geometry and residual stress distribution of the numerical process model after the springback of the forming stage.

Measurements of the residual stresses using the hole drilling method as shown in Fig. 4 indicate a high correlation with the numerical predictions. Based on these results, the distortion of the final component geometry can be significantly influenced by adjusting the milling strategy.

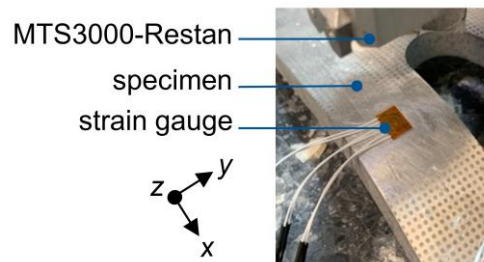


Fig. 4: MTS3000-Restan hole-drilling residual stress measurement on the thick sheet component.