Robust Optimization in Sheet Metal forming: application to the U-Rail

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ABSTRACT

Sheet metal forming is a process widely used in modern industry. Due to its economic impact, and given that small errors may cause significant quality problems in the geometric precision required, it is rather important to predict and compensate undesired effects such as springback [1]. The aim of this work is to compute the optimal variables to a forming process taking into account springback compensation and ensuring the robustness and feasibility of the entire process.

To achieve this goal, a sensitivity study is performed with respect to the chosen design variables (tools geometry and external forces). The results of this study are employed to adjust the optimization algorithm, namely the objective function and starting points. The choice of the objective function also takes into consideration the range of values that each variable can take. A multi-start strategy is adopted to ensure the algorithm's robustness to noise. The calibrated optimization strategy is then applied to a sheet metal forming, being the structural integrity of the resultant part verified at the end of the process.

The implementation of this optimization process is done through an integrated code, which computes the error between the desired shape and the geometries obtained from a set of design variables. Those variables are afterwards optimized, being the old values automatically replaced by the new ones in the input files. A new simulation is then performed, resorting to FEM simulation software, which returns a new part that is in turn evaluated, closing the cycle. This Finite Element Model Updating (FEMU) process is repeated until an optimal solution is attained. The design variables are monitored along all the optimization process to avoid unrealistic values. The forming tools shape is parametrized with NURBS to straightforward change their geometry and profit from the use of this model representation by the CAE software.

Similarly, the sensitivity study is done through an automated code which runs simulations for all the design of experience (DoE) points chosen. After each simulation, the geometric disparity between the resultant part and the reference one is computed. The structural integrity of the part is verified with respect to the sheet's thinning during the forming process.

The methodology presented in this work are applied to the U-Rail example, which is a component prone to experience strong springback [1]. Firstly, the influence of the design variables in the final part geometry is analyzed. Finally, an optimization of those variables is performed, including springback compensation. The results are compared with the ones obtained by other optimization approaches.

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