Optimisation of Forming Processes

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Introduction

Metal forming simulation has become an established tool in the sheet forming industry during the last decade. The simulation tool, e.g. Finite Element Analysis (see Figure 1), is used to check the manufacturability and geometry of the desired part. To be able to achieve an optimal process, several parameter variations must be investigated. Therefore, many simulations must be carried out with different process parameters and with different tool geometries. Currently, this requires a lot of expensive and time-consuming manual work, based on experience. It is for this reason that there is a strong need for an optimisation strategy, which is able to find the optimal settings for sheet forming processes.
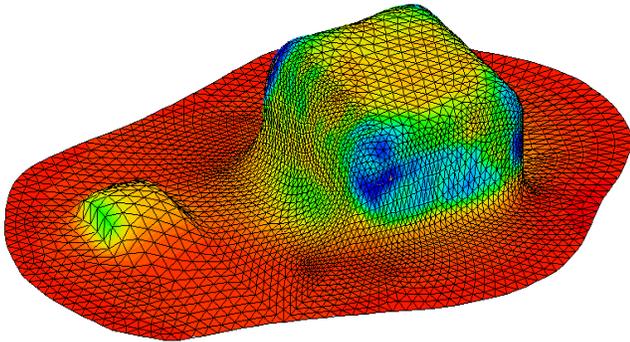

Figure 1: Finite Element simulation of the deepdrawing process

Objective

The aim of the project is the design of an optimisation strategy for sheet metal forming processes. This strategy should be generally applicable, but for demonstration purposes the project focus is on deepdrawing, hydroforming and warm forming. The definition of possible objective functions (e.g. low cost, robust process, etc.) and constraints comprises a significant part of the project.

Methods

The current work is in an early stage of investigating which algorithms are available for optimisation in combination with the Finite Element Method (FEM) and are additionally applicable to forming processes. Two possible methods are already distinguished: direct optimisation and Response Surface Methodology.

Direct optimisation The most straightforward way for optimisation in combination with FEM is direct optimisation, which is depicted in Figure 2. Using this method, the results of a FEM calculation are imported into an optimisation algorithm. This algorithm performs one iterate in the direction of optimality after which another FEM calculation is performed. This goes on until optimality is reached. A major drawback of this method is the extensive number of time-consuming FEM calculations that have to be performed.
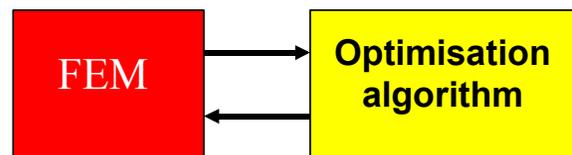

Figure 2: Direct optimisation

Response Surface Methodology An alternative way for optimisation in combination with FEM is Response Surface Methodology or RSM (Figure 3). Using RSM, a number of FEM calculations is performed to result in a set of numerical experimental data. From these data, a so-called metamodel or Response Surface model is obtained. This metamodel is subsequently optimised, which is a much more efficient way than optimising the original Finite Element model. Finally, the results of the metamodel optimisation are evaluated by running a last FEM calculation with the optimal settings.
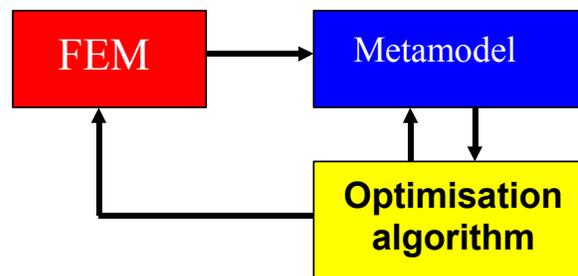

Figure 3: Response Surface Methodology

Future work

Future work will comprise a more thorough investigation on optimisation strategies in combination with FEM and forming processes. Together with interested NIMR industrial partners, a strategy will be chosen and implemented in a "Demonstration of Concept" to show the effectivity of the selected strategy.

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