Optimisation of the Initial Tube Geometry for Tube Hydroforming

A mathematical approach

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Tube hydroforming uses a combination of internal pressure and axial feeding to form complex parts, like exhausts, engine cradles and roof rails. Tubes used for hydroforming are mostly round of shape and are

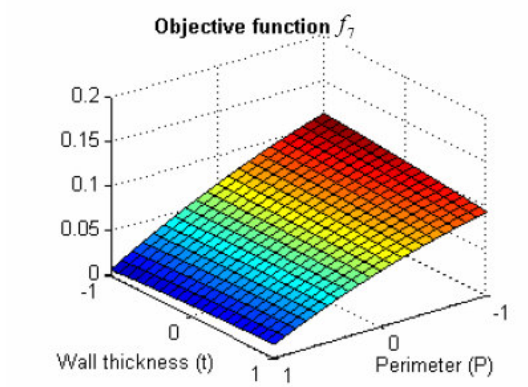

Figure 5.9. Metamodel as function of the perimeter

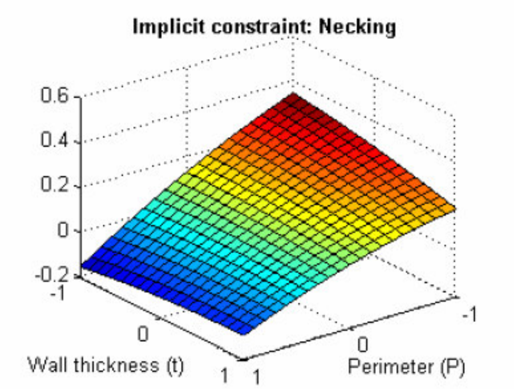

Figure 5.10. Metamodel of the implicit constrain

subjected to several forming steps prior to hydroforming. These steps are necessary to fit the tube in the die cavity and successfully produce the hydroformed part. To reduce the number of production steps prior to hydroforming, the initial tube geometry should be improved. To find this geometry a research study is conducted using an optimisation strategy. The optimisation described in this report is based on Response Surface Methodology. This technique uses a number of finite element simulations, executed according to an experimental design. An objective function is used to evaluate the results of the finite element simulations and is a function of the design variables describing the initial tube geometry. From the collected data a response surface (metamodel) is build with linear regression analysis, which is an approximation of the objective function. The optimum of the metamodel is found using a line search technique in Matlab. In this report the optimisation of a tube to a square die is described. To find the optimum the initial tube geometry is described with design variables, which are altered according to an experimental design and subsequently simulated using the finite element package DiekA. The simulated hydroform products are evaluated by determining the wall thickness distribution. The optimisation searches for the tube with a uniform distribution. From the optimisation it is found that the largest influence on the wall thickness distribution is not so much a single design variable, but the perimeter of the initial tube. The larger the perimeter of the initial tube, the more uniform the wall thickness distribution. A further study by altering the constraint concerning the maximum allowable perimeter resulted in a preference for square tubes with a small radius and a small dent in the sides of the box.

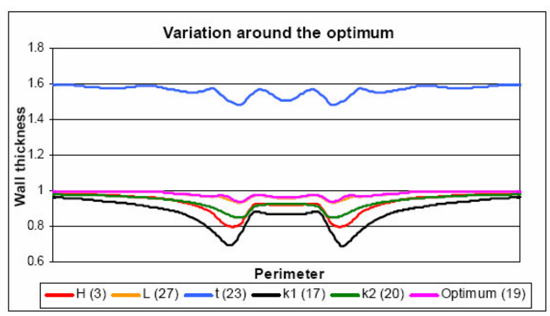

Figure 5.11. The behaviour of the wall thickness around the optimum