Chair of Metal Forming and Casting (*utg*)
Department of Mechanical Engineering
Technical University of Munich

Property-controlled freeform bending process

Process design considering material properties of the semi-finished product

Motivation

The freeform bending machine is able to bend tubes and profiles of various radii without any tool change. The biggest advantage of the freeform bending with movable die is the seamlessly connection of different radii in one part. Particularly suitable areas of application for this machine are those involving work pieces of different sizes with large radii.

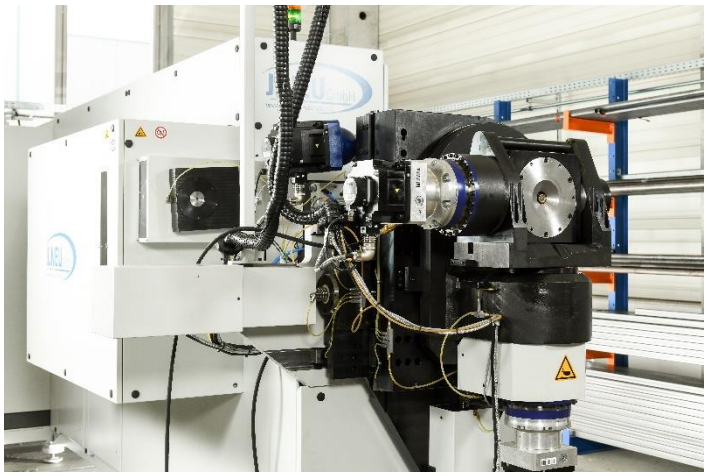

Figure 1: Freeform bending machine with six simultaneous axis.

The principal objective of the proposed research project is the development and industrial implementation of a property-controlled freeform bending process. In addition to the control of the work piece geometry, its mechanical properties (e.g. strength, ductility, grain size distribution and residual stress) will be influenced during forming.

Approach

The central innovative idea of this proposal is the development of a model-based closed-loop control system, which consists of process-parallel soft sensors and physical or empirical models. This system enables process monitoring before and after forming as well as the control of mechanical properties. Especially innovative is the model-based inline monitoring of mechanical properties with a combined system of sensors and soft sensors. Therefore, micro magnetic sensors and Ultra Sonic Contact Impedance (UCI) measurements are correlated in an Extended Kalman Filter with the desired mechanical properties.

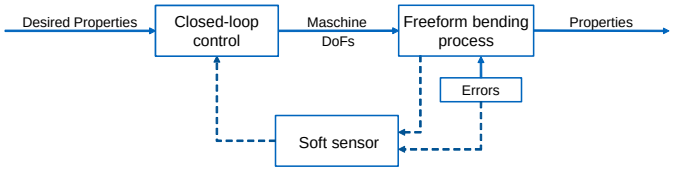

Figure 2: Property-control structure.

Results

The basic controllability of component properties based on a soft sensor was demonstrated. Therefore, non-tangential bending is introduced, which allows a decoupling of geometry and mechanical properties by changing the die to a non-tangential position. [1] In order for the process to be controlled considering the mechanical properties, a correlation scheme based on hardness was formulated, which allows in-line prediction of local strength, ductility and residual stresses. [2] In addition, a preliminary control structure based on a phenomenological surrogate model was established, which is the basis for an accurate cause-and-effect analysis. [3]

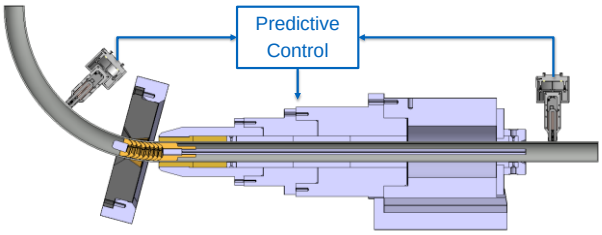

Figure 3: Schematic depiction of property-controlled freeform bending

Conclusion

The measurement, use and control of local component properties through the massive use of measuring and material technology, control systems and process engineering leads to a paradigm shift in the design of the freeform bending process.

Daniel Maier, M.Sc.(TUM)
Walther-Meißner-Str. 4
85748 Garching

Tel. +49 89 289 13997
Fax +49 89 289 13738
daniel.maier@tum.de
www.mec.ed.tum.de

Funded by:
DFG Deutsche Forschungsgemeinschaft
SPP 2183

Partner:
Chair of Automatic Control (TUM)
Steel Institute IEHK (RWTH)