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Forming – Production Families with Consistent Quality

SFB 805 | Subproject B2 | Phase 3

The third and final phase of subproject B2 in the Collaborative Research Center 805 was successfully completed in March 2021 for all project areas. In the subproject controlled production chains, for example, components with individually defined stiffness were produced on the 3D Servo Sress (3DSP) by means of incremental forming, and machine learning algorithms for predicting tool wear were developed. The individual part tracking sub-area used individual characteristics based on a data matrix applied in-line by needle embossing to uniquely identify components throughout their entire production cycle. In the area of equipment diagnostics and control, a stable control algorithm for the press deflection of the 3DSP was developed using a kinematic and stiffness model.

Project description

Research topics of subproject B2 "Forming - Production Families with Constant Quality" are the monitoring and control of component, process and machine states as well as the extension of the developed methods from flexible, controlled forming processes to controlled multi-technology process chains.

The starting point is the results from CRC Phase 2, in which uncertainty in forming processes were reduced by increasing flexibility and integrating control loops. This was advanced by the development of the 3D Servo Press, which can perform previously unknown movements of the tool tip with three degrees of freedom. As a result, a wide range of product variants can be manufactured, enabling producers to respond more flexibly to fluctuating demand. The increase in the number of degrees of freedom and thus in the overall complexity is also accompanied by control engineering challenges, which on the one hand relate to the position and force controls of the production machine, and on the other hand address the component-individual control of properties.

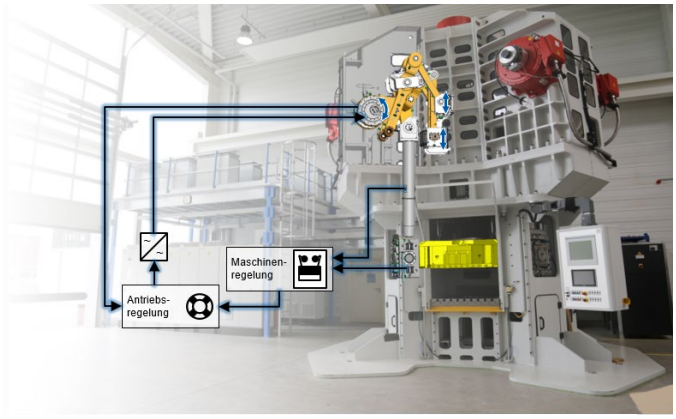

Figure 1: Control concept of the 3D Servo Press via the forces and torques affecting the ram

This results in the central objectives of phase 3: (1) Development of a linked production process chain and its representation by a mathematical model. On this basis, a control loop of the process chain is to be created, which contributes to the improvement of component qualities. (2) Development of basic principles for the introduction of single-part traceability in forming processes.

Project data

Term	Jan. 2017 – Mär. 2021
Processor	Dirk Molitor, M. Sc. Thiemo Germann, M. Sc.
Department	Process Chains and Forming Units; Functional and Composite Structures

Sponsor

DFG Deutsche Forschungsgemeinschaft
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On the basis of these fundamentals, methods of feature insertion are developed, applied and implemented through an entire process chain. (3) Development of multi-body simulation models, which can calculate system variables that cannot be measured directly by feeding in sensor data, for use in condition monitoring and multivariable control.

Results

Overall, phase 3 was completed with great success. A control loop was developed for the mapping of a linked production chain, which delivered simulatively as well as numerically stable results. Furthermore, by means of the control and the 3DSP, a specific adjustment of the component stiffness during the production could be achieved via SPIF. For the purpose of single part tracing, an in-line needle embossing process was developed, which enables permanent part marking without negative influences on the performance characteristics. The indented features could then be observed over the entire production chain and the use of the extensible actuators used as an example. By means of a stiffness model of the 3DSP, the 3rd objective could also be achieved. By applying external forces and moments to the press slide, it was possible to calculate the deflection of the press as a function of the drive positions and thus counteract the press deflection.

In addition, different control approaches were successfully tested for their stability.

In addition to more than 10 publications, 2 dissertations have been written as part of the sub-project.

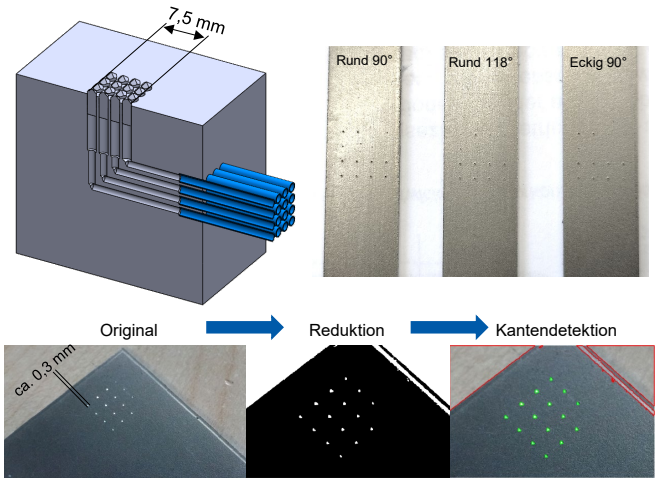

Figure 2: Design of the needle embossing tool, as well as pattern design by automated image processing

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