MPC

Model predictive control with integrated position observer for adjusting component quality during incremental forming of vulcanized fiber

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Abstract

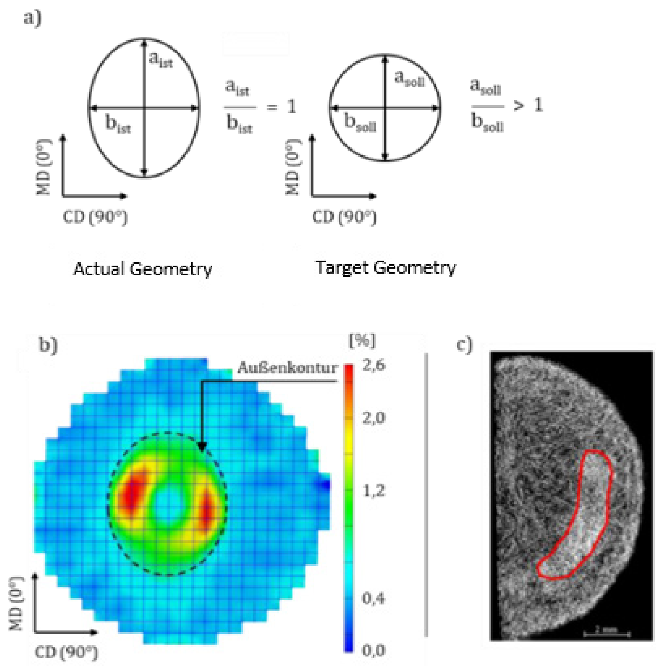
In recent years, public interest in sustainable and resource-saving materials has increased the research focus on paper-based materials for use in a wide range of specialized areas, such as the packaging industry or lightweight structural engineering. In order to increase, not only formability and process limits but also component quality, one goal of the subproject is to apply control engineering approaches and specifically influence the forming process and quality despite anisotropic material properties.

Project description

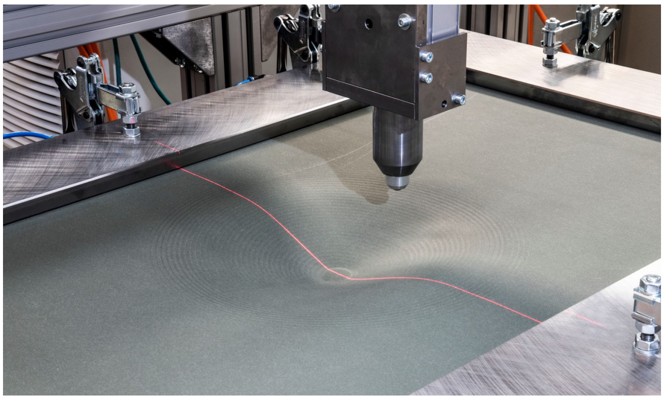
Within the framework of the SFB 805 subproject, the possibilities of a model predictive control (MPC) of component properties of fiber-based materials are investigated. The approach of controlling component geometry by means of this concept has already proven successful in Single Point Incremental Forming (SPIF) of metallic materials. Likewise, the adaptation of this forming process, known from metal forming, for fiber materials has been further advanced and investigated at the Institute for Production Engineering and Forming Machines (PtU). The challenge of the project is to make the application of the control concept applicable to a paper-based material with production-related anisotropic material properties (cf. Figure 1).

In the first step of the project, a 3-axis gantry system was equipped with a self-developed control software for automated motion commands and successfully put into operation. Furthermore, the test rig was structurally retrofitted with two line lasers, which allow the geometry acquisition of the components in three different spatial directions after each incremental forming step or after completion of the process (cf. Figure 2).

In the second part of the project, the process limits for the production of rotationally symmetrical vulcanized fiber components and the variation of various process parameters of the SPIF process were determined. In addition, the measurement system for geometry determination was implemented and an evaluation routine was developed on the software side. This allows conclusions to be drawn about the deviation between the nominal and actual geometry of the components and thus about the quality of the products.



[1] a) Expected final geometry in comparison to an outer contour after circular tool movements (actual final geometry), b) Representation of the resulting outer contour based on the main strain distribution in radial direction, c) CT image with compacted fibers in the marked area [P. Stein, W. Franke, F. Hoppe et al., "Control of anisotropic shape deviation in single point incremental forming of paperboard," Proceedings of the international conference of global network for innovative technology and awam international conference in civil engineering, vol. 2017, pp. 1–6.]



[2] 3-Axis Gantry System with Vulcanized Fiber Cone during Geometry Determination by Means of Line Laser

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Results

Through extensive investigations, the process limits for the incremental forming of vulcanized fiber could be determined empirically and the component geometry determined with the aid of the measuring system. A process model is then created based on the experimental results and additional simulations of the process, and the model-predictive controller can then make adjustments to the path curves of the incremental forming planes. A final validation to increase part quality by reduced geometry deviation is the subject of current work.

Acknowledgement

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