Paper forming with steam

Application of steam in the forming of fiber-based materials

Editor Nicola Jessen M. Sc.
Duration December 2020 – November 2022
Department Functional and Composite Structures
Funded by BMWK | AiF | IGF

Abstract

Thanks to Dr Wilken Franke's dissertation „Forming of natural fibre materials under the influence of water vapour", it is known that the introduction of water vapour during deep drawing of paper causes an extension of the process limits. The process sequence as well as the effect of different moisture distributions was unexplored so far. Therefore, the aim of this project was to investigate the design of the steam injection and the additional extension of the process limits by a two-stage process. In complement to this, a further development of the numerical model is part of the project in order to improve engineering processes.

Project description

The research project investigates how steam can be introduced into deep drawing processes of natural fibre-based materials in order to improve the achievable drawing depth as well as the wrinkle pattern. In addition, the controllability of anisotropy through the targeted introduction of different amounts of steam in different areas will be investigated. For this purpose, several materials are initially characterised and examined for their deep-drawing suitability. After a tool has been designed based on preliminary investigations, the control and regulation of the tool as well as the steam injection and temperature control are to be carried out. This enables investigations of the steamed deep drawing process with different papers and an iterative adaptation of the process. Subsequently, the extension to a two-stage forming process is to be carried out. This offers the possibility to further increase the drawing depth and to integrate additional geometry control into the process. The two-stage process is likewise tested with different papers and iteratively improved.

The numerical model of the material is improved to design the processes and the different steam application. The data from the material characterisations are incorporated in this context. The improvement of the numerical models also promises a more cost-effective and efficient process design in the long term, both in research and industry.

Results

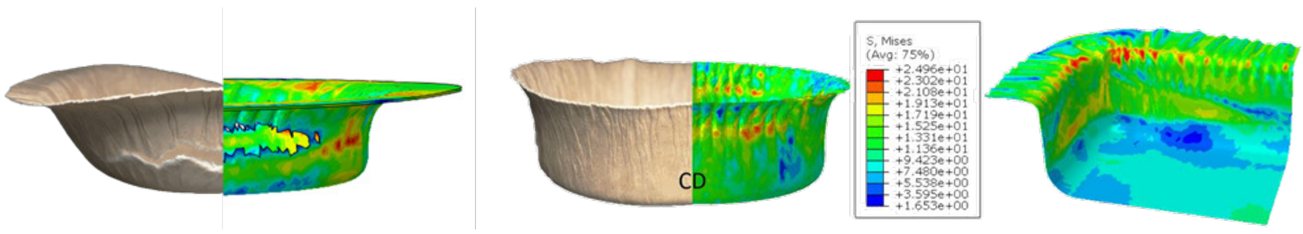
The implementation of the work to achieve the aforementioned goals has also opened up new research topics in addition to the planned results.

Firstly, the tool as well as the steam injection and temperature control could be successfully implemented. Determining the process windows for different papers revealed how the steam injection geometry can improve the process depending on the target. It was found that the introduction of increased amounts of steam in radius areas resulted in increased wrinkle compression. Increased steam injection in MD, on the other hand, was able to counteract the anisotropy.

The subsequent design of the two-stage process was carried out with different processes in the first stage. Thereby, a more significant improvement resulted from the active-media-based forming with subsequent deep drawing compared to the two-stage deep-drawing. Increase in the achievable drawing depth is verifiable for all papers, but varies depending on the material.

In order to simplify the investigation of the different geometries of the two-stage process, additively manufactured tools have been used in preliminary investigations. The application already took place in the past in the active-media-based forming process with great success. This success could also be determined in the deep-drawing process with a fixed tool within the scope of the project. The achievable drawing depth was significantly higher with the additively manufactured tools than in processes with metallic tools of the same geometry. The cause is assumed to be tribological properties as well as the elasticity of additive tools with reduced infill.

Furthermore, the extension of the numerical material model based on the material data of the different papers has taken place. The results show that the process limits can be reproduced well both in the deep drawing process and in the forming process based on active media. Consequently, processes can be numerically predicted in the future and thus put into operation more quickly.



[1] Comparison between numerical simulation and formed paperboards

Institute for Production Engineering and Forming Machines – PtU
Prof. Dr.-Ing. Dipl.-Wirtsch.-Ing. Peter Groche | info@ptu.tu-darmstadt.de

[2] Two-step forming process: first: active media based forming (left), second: deep drawing (right)

Acknowledgement

The IGF project 21562 N of the research association „ Kuratorium für Forschung und Technik der Zellstoff- und Papierindustrie „ was funded by the German Federal Ministry of Economic Affairs and Climate Action via the AiF within the framework of the IGF program on the basis of a resolution of the German Bundestag. We would also like to thank the project partners for their support.

Funded by

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

AiF Forschungsnetzwerk Mittelstand

DIE PAPIERINDUSTRIE

iGF Industrielle Gemeinschaftsforschung

Institute for Production Engineering and Forming Machines – PtU
Prof. Dr.-Ing. Dipl.-Wirtsch.-Ing. Peter Groche | info@ptu.tu-darmstadt.de

PtU FORMING EXCELLENCE

TECHNISCHE UNIVERSITÄT DARMSTADT