UniVorsUm

Development of a universal Method for Predicting the Formability of Paper-based Materials in Deep Drawing and Hydroforming

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Abstract

As part of the „UniVorsUm“ project, a method for evaluating the formability of different papers was developed. In cooperation with the Papiertechnische Stiftung and the Steinbeis University of Applied Sciences, many new insights into a wide variety of papers were gained. To develop the method, a broad spectrum of materials was analysed in various characterisation tests and numerous material parameters were recorded. In parallel, the papers were formed in the forming processes under consideration, i.e. deep-drawing with rigid tools and deep-drawing based on active media, and meaningful quality parameters were determined. The recorded material characteristics were correlated with the quality parameters in order to determine a generally applicable method for predicting formability.

Project description

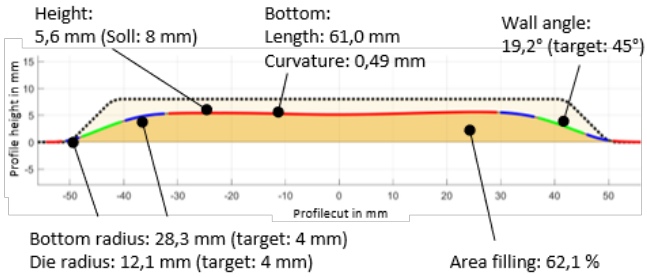
In close cooperation with the Papiertechnische Stiftung (PTS) and the Steinbeis University of Applied Sciences, work is being done on the development of evaluation standards for the forming of paper by deep-drawing with rigid tools and active-media-based deep-drawing. For this purpose, a broad spectrum of industrially available material grades as well as papers specially produced for forming in the laboratory are being examined in detail and used for the production of moulded parts. Quality parameters for describing forming results are worked out in close cooperation with the industry and applied to the geometries of the formed parts produced by the group. As a result, a large number of quality parameters are available for each material and each mould, which describe the forming result. At the PtU, the quality parameters are considered in the case of active-media-based forming.

The quality parameters obtained in the project network are subsequently brought together with the large number of material parameters that can be determined with the test stands and experimental facilities of the network. The focus of the material characterisation at the PtU is on the investigation of the material behaviour under biaxial tensile load and the friction behaviour. With the help of machine learning methods, the essential correlations of forming qualities and material properties are then identified, so that a detailed description of the forming suitability is possible with a reduced number of characteristic values. The knowledge acquired is then harmonised in a test methodology so that, as a consequence, a characteristic value and test standard can be created for the assessment of the forming quality of paper materials.

Results

At the PtU, a work package investigated the forming process based on active media numerically. The stresses on the material that are effective in the forming process could be derived. With the help of these stresses, it was possible to identify which parameters are particularly relevant for the characterisation tests and which value ranges are to be expected in the tests.

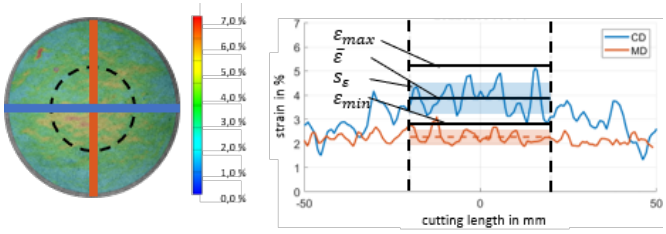
Forming tests were carried out on the broad range of materials selected by the group in consultation with the project committee. The focus of the tests at the PtU was on forming with active medium. Three different forming geometries were considered in order to take into account a wide range of potential product packaging applications. A process window was derived for each material and forming geometry in order to determine suitable process parameters with maximum forming quality. After digitalising the test specimens, meaningful quality parameters were determined. This revealed a strongly material-dependent quality of the formability. In parallel, deep-drawing with rigid tools was investigated at Steinbeis University.



[1] Section through a specimen after active-media-based forming with target geometry (dashed line) and actual geometry with identified quality variables

For method development, the material spectrum was analysed in various characterisation tests and numerous material parameters were recorded. The biaxial stress state was examined in a bulge test at the PtU. Through different designs of the test, elastic and plastic material behaviour could be mapped with the help of digital image correlation and used to quantify meaningful characteristic values. In friction tests, the side-dependent tribological properties of some of the papers examined were found to be particularly pronounced. At the other two participating research institutes, further tests were carried out for material characterisation. In addition to established test met-

hods such as the tensile test, methods adapted to forming such as the out-of-plane shear test were also considered.



[2] Local strains determined in the bulge test (left) and section along CD and MD as well as derived characterisation variables (right)

Under the leadership of PTS, the recorded material characteristics were correlated with the quality parameters in order to determine a generally applicable method for predicting formability. With the help of machine learning methods, it was possible to reduce the number of tests required for the prediction, which ensures a simplified implementation and application of the method.

For the paper packaging industry, this results in a test methodology according to which material properties a paper can be evaluated and selected for forming. At the same time, material manufacturers receive target values for the development of papers that can be formed particularly well.

Acknowledgement

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