Molded Pulp Products Manufacturing: Process Development, Characterization and Modeling

The matter of this thesis is the development, characterization and ultimately modeling of the manufacturing process of molded pulp products. In particular, focus was placed on studying and optimizing the drying step, as the cost of energy required may be from eight to twenty times that needed for pre-forming.

Moving towards the 2021 European ban on throwaway plastics, eco-friendly packaging solutions are strongly emerging and molded pulp will certainly become one of the most preferred replacements. Yet, increasing R&D effort is essential to meet the growing demand and consolidating best practices.

The overall objective of the project was to develop, characterize, and define a methodology for efficiently manufacturing molded pulp parts. This was done by applying a systematic approach based on geometrical tolerancing and metrology, analysis and experimental characterization of the molding process. A model of the drying process was also developed and validated. The research work focused solely on the most advanced manufacturing approach currently used in the molded pulp industry, i.e. thermoforming.

First, the state-of-the-art of the molded pulp industry is presented as a foundation for the following issues. The research method adopted in collecting the information focused exclusively on molded pulp.

The experimental part of the thesis commences with a description of the different methodologies and equipment employed. The objectives of the experiments were to study, understand and control the manufacturing process, as well as characterize the final parts. To do so, the effects and relations of the process parameters with the final product were studied.

Subsequently, a description of the physical phenomena occurring during a thermoforming process is outlined. Further, the process simulations of the drying step are evaluated regarding the comprehensiveness of the model and the experimental validation.

Afterwards, the concepts, methods and solutions presented in the previous chapters are applied to the manufacturing of the Green Fiber Bottle (GFB). The methodologies and model simulations were proven as valuable tool for the parts and process optimization.

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