DEVELOPMENT OF DESIGN AND MANUFACTURING GUIDELINES FOR ARBURG PLASTIC FREEFORMING

The Arburg Plastic Freeforming (APF) is an additive manufacturing process with which three-dimensional, thermoplastic plastic components can be produced. The components are produced layer by layer through the deposition of fine, molten plastic droplets. The aim of this research project is to determine the potential and process limits of the APF process. The focus is on the mechanical, geometrical and visual properties in correlation to the process parameters. In addition, the wetting behavior of the plastic droplets and the influence of the material degradation due to a possible thermal degradation will be investigated.

PROJECT OVERVIEW

DURATION

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PARTNER

Kunststofftechnik Paderborn (KTP)

FUNDED BY

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RESEACHER

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Objectives

The aim of this research project is the development of manufacturing and design guidelines for the Arburg Plastic Freeforming (APF) process. With these guidelines a quicker process design and optimization shall be achieved. Therefore, the key target values concerning the mechanical properties, the geometrical and visual properties of the components, warpage and material degradation must be taken into account separately. Through a detailed process understanding regarding the limits of and the influences on the process, the efficiency of the incremental steps of material qualifications and process parameter optimization shall be increased significantly. At the same time, the capabilities as well as the boundaries for the manufacturing of components using the APF should be identified in the course of this research project. For this, the properties of components manufactured using the APF process are compared to comonents fabricated trough injection molding and fused deposition modeling. All investigations are carried out with ABS.

Recent findings and procedure

At the beginning of the investigations, an analysis of the manufacturing restrictions was carried out. The focus was on the influenceable and non-influenceable manufacturing boundaries. In the course of the research project the key mechanical values for the characterization of additive manufactured specimens were determined. For the influencing factors the process specific process parameters e.g. formfactor, layer thickness as well as processing temperatures were investigated. The in the preliminary investigations acquired understanding of the process serves as the basis for a design of experiments (DOE). In the DOE the response surface method is chosen. With this method not only the main effects and interactions but also quadratic effects can be detected and described.

During the investigations the influences of the process parameters on the mechanical and visuall properties of components manufactured using the APF process are identified. Using the model of the process, obtained through the DOE, a process parameter optimization with a maximization of the target parameters (tensile strength, Young's modulus, elongation at break) has been achieved. The validation of the model shows a 15 % discrepancy between the model and the achieved values for the tensile strength and Young's modulus. For the elongation at break higher descrepancies were observed.

In the following progress of the research project the transferability of the model and the developed guidelines onto other materials is evaluated. Probably the effect of the influencing factors on the results will be similar. Besides, further investigations concerning the mechanical properties in the Z-direction shall be conducted. The previous results show a significant weakness of the specimen in the Z-direction. This causes a reduced maximum resilliance of parts. A process parameter optimization aimed at improving the properties in Z-direction is planned.

A challenge of this research project is the disruptive factor of the expected material degradation due to different building strategies. Therefore, it is an essential aim to gain a basic understanding of the expected material degradation in the APF process. The material degradation is investigated with regard to both the molecular mass distribution and its effects on the rheological behaviour. For this, the influence of material degradation of ABS on the characteristic material properties shall be investigated. With these results the maximal occurring material degradation of ABS during the process can be determined.

In addition, it will be investigated how the building strategy influences the dimensional stability of the additive produced parts. In this context, component dimensional stability describes the resulting warpage of the components and the achievable visual quality of the APF process. The visual quality is the ability of the system to produce detailed surface contours. The type of surface structure and the roughness are used as quality parameters.

Finally, the findings and results from the experimental investigations will be summarized in the form of design and manufacturing guidelines.

FIGURE 1 Arburg Freeformer (Source: Arburg)

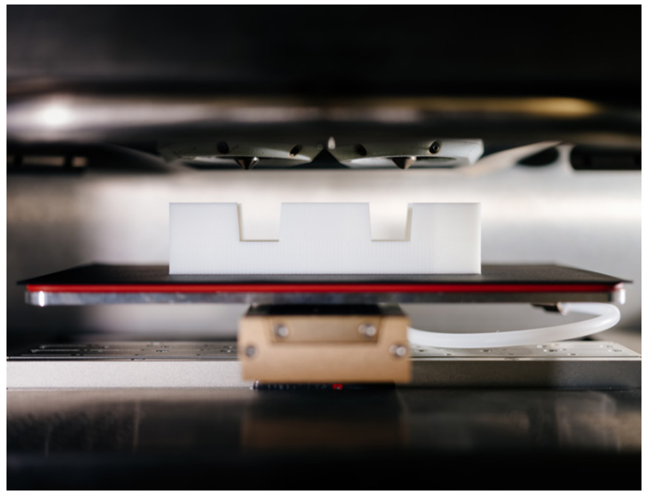

FIGURE 2 Manufacturing of test specimens for the analysis of the specific droplet deposition

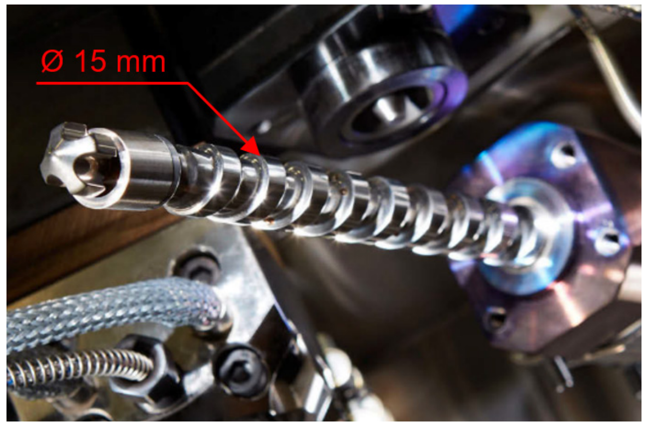

FIGURE 3 Analysis of material degradation: Screw in the Freeformer (Source: Arburg)