ASSESSMENT AND ENHANCEMENT OF THE PROCESSABILITY OF TPU IN FDM

The processing of soft materials in the FDM process brings new challanges for the process execution. Studies have already shown that the definition of the process parameters and, above all, the existing design limitations do not necessarily correspond to those of the processing of typical FDM polymers. Reasons for this are the soft elastic behavior of the deposited strands as well as the material behavior before and inside the extrusion head. This project identifies and improves the process limitations by selecting suitable geometries. At the same time, the process parameters are also adapted to the processing of a soft FDM material. Based on this, a procedure will be developed with which a material- and machine-independent improvement of the processing of TPU in FDM can be achieved.

PROJECT OVERVIEW

DURATION

05/2021 – 12/2021

PARTNER

Industrial Consortium of DMRC

FUNDED BY

Industrial Consortium of DMRC

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Motivation

For the design process as well as for the dimensioning of an additively manufactured component it is important to know the underlying process limits and ideally the design guidelines. In order to support users of additive manufacturing technologies in the design process, a number of research activities have been carried out at the DMRC in the last years. Initially, hard materials such as ABS-M30 and Ultem 9085 were in the focus of the investigations regarding Fused Deposition Modeling (FDM). However, the ongoing developments in the field of additive manufacturing also lead to the expansion of available materials and machines. Thus, the demand for materials with specific properties is also constantly increasing. One of these materials are Thermoplastic Polyurethanes (TPU), which have a soft elastic material behavior. Possible fields of application include their use as sealing inserts. For this purpose, the FDM process must be mastered when processing these soft materials, and the limitations of the processing must be known.
In this context, investigations have shown that the already developed and existing procedure for determining the design guidelines cannot be transferred to soft TPUs without adaptions. One issue is that some of the test specimens from the investigations for hard materials cannot be manufactured without restrictions using soft materials. Furthermore, the investigations have revealed that the potential of TPUs in FDM cannot be fully exploited with the standard process parameters used for processing soft materials.

Aim

Due to the partly special material behavior of soft thermoplastics, new process limits arise in the FDM. These process limits are to be determined and extended in this research project by simultaneously optimizing the FDM process parameters. The optimization of the process parameters is carried out for a selected soft material on only one machine. However, since the variety of materials and machines in FDM is increasing, the development of a method for parameter optimization and determination of design limits of soft materials is the focus of this research project. This should guarantee a high transferability to other machines and soft materials for the users of the technology. The overall objective of this research project is to develop a new method for optimizing the processability of soft materials in FDM with respect to process limits and design guidelines.

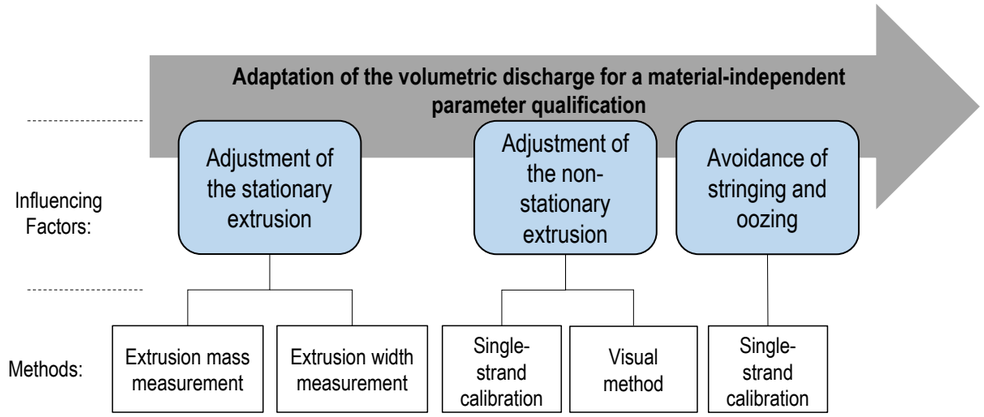

FIGURE 1 Procedure for the qualification of relevant process parameters

Determination of design limitations

The basis for the investigations is the selection of a suitable TPU material. Here, a TPU with a Shore hardness of 85A is selected. This material, which is considerably soft with regard to the FDM process, is expected to allow the procedure developed to be transferred to other, harder materials.
On that basis, the existing procedure for determining process limits and design guidelines is used first. For this purpose, the already existing test specimen geometries (e.g. for overhang angles, minimum wall thicknesses, unsupported construction height, etc.) are produced using the standard parameters available for the selected material. The analysis of the results focuses on the difficulties in processing soft materials. In addition, parallel to this, approaches are being developed to counteract these process limits and difficulties in processing in the FDM process. Test specimens, which do not seem to be useful for the processing of soft materials, will be adapted and further developed.

Optimization of process parameters

The optimization of the processing parameters is necessary to improve and extend the existing process limitations. When adjusting the parameters, the experience gained by the DMRC in recent years is applied and, if necessary, adapted to the special needs of the soft material. Thereby, the stationary and non-stationary movement of the FDM head as well as the movement of the FDM head without material discharge are considered. The result is a homogeneous strand geometry in a reliable manufacturing process which demonstrates and expands the possible areas of application for processing TPU in FDM. The optimization steps are performed by an iterative procedure with continuous validation of the results.

Derivation of a procedure for the processing of TPU in FDM

Based on the improved processing of the soft material, a methodology can be derived. The aim is to obtain a guideline for the processing of generally soft materials in FDM, with which a transfer to other materials and machines is possible. This should enable the users of the FDM-technology to rapidly improve the processing of other soft materials on the specific machines.

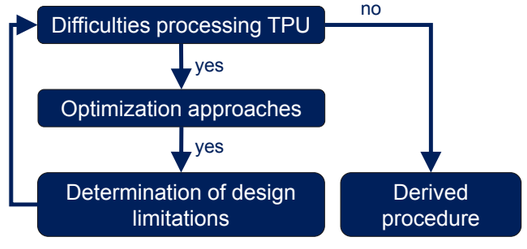

FIGURE 2 Project approach to develop a procedure for processing TPU materials in FDM