FDM-STRUCTURES FOR THE PARTIAL REINFORCEMENT OF HYBRID STRUCTURES

The mechanical properties of thin-walled plastic components are limited. One approach of improving the strength is to apply individual adapted Fused Deposition Modeling (FDM) structures onto the thin-walled components. To achieve an optimal reinforcing effect, the properties of the FDM-structure must be optimized first. This project will focus on the variation of the FDM process parameters, due to the fact that they have the most significant impact on the mechanical properties. The results of the parameter variation shall provide findings to develop design and process guidelines for FDM-structures that are used for the partial reinforcement of hybrid structures. Besides the mechanical properties, the lightweight potential of the FDM-structure must be also considered.

Objectives
The aim of the research project is the development and modeling of design and manufacturing guidelines for FDM reinforcement structures which are adapted to the load case and are to be used as partial reinforcement of hybrid structures. The research focus is on the strength optimization of the FDM reinforcement structure by means of a specific configuration of the manufacturing process in the FDM process. During the production of the FDM reinforcement structures, the process parameters are varied in addition to the building direction, as these have a major influence on the mechanical properties. Furthermore, depending on the shape of the FDM reinforcement structure, a targeted increase in strength or stiffness for the respective load case is to be achieved with the aid of topology optimization, whereby the generated structure is to have the lowest possible weight in order to save resources. In addition, the crack and fracture behavior is analyzed and the fatigue behavior of the FDM reinforcement structures is determined. Finally, the optimized FDM reinforcement structure in the composite system will increase the strength and stiffness of the base carrier. To achieve this, the manufacturing process of the hybrid structure must first be integrated into the existing GITBlow process.

Procedure
At the beginning of the research project, the analysis of the manufacturing restrictions for the FDM process was carried out. This includes the influenceable production parameters and the not influenceable production restrictions. The systematic determination and early analysis of these boundary conditions is necessary in order to clearly define the manufacturing limits for the subsequent investigations. In the next step, a statistical test plan with the Response Surface Method (RSM) was developed on the basis of the existing GITBlow process. The investigation of the summarizing manufacturing guidelines and the comprehensive process understanding enables the user to optimize the process design. In particular, FDM structures for the reinforcement of thin-walled plastic components are in the focus. However, the findings can also be used for the optimization of self-supporting, lightweight geometries and applications. In addition, the dynamic investigations revealed typical weak points and failure mechanisms of FDM structures, which should be taken into account during component design.

Summary
Through the experimental investigations, a detailed understanding of the FDM process was developed. The combination of the summarizing manufacturing guidelines and the comprehensive process understanding enables the user to optimize the process design. In particular, FDM structures for the reinforcement of thin-walled plastic components are in the focus. However, the findings can also be used for the optimization of self-supporting, lightweight geometries and applications. In addition, the dynamic investigations revealed typical weak points and failure mechanisms of FDM structures, which should be taken into account during component design.