

# PROCESSING OF ALTERNATIVE FDM MATERIALS 2.0

A widespread additive manufacturing process is the Fused Deposition Modeling (FDM). Not many high performance polymers are available. In theory, it is possible to process any thermoplastic polymer using the FDM process. For professional FDM machines, only a small number of different materials can be purchased. These materials are provided by the machine manufacturers and the material properties are often not sufficiently known. Therefore, this project investigates the processability of alternative high-performance polymers for the FDM process with regard to the warpage behavior.

## PROJECT OVERVIEW

### DURATION



01/2019 – 12/2019

### PARTNER



Industrial Consortium of DMRC

### FUNDED BY



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### Introduction and objectives

The Fused Deposition Modeling (FDM) process is an additive manufacturing process. Here, the components are generated by a heated thermoplastic strand that is deposited layer by layer. The used plastic filament is pulled into the FDM head with the help of motors, melted there and applied through a nozzle in a defined way onto a building platform or an already existing structure. Due to thermal fusion, the material bonds with the layer below and solidifies. The FDM process is one of the most frequently used additive manufacturing processes for the production of prototypes, tools, but also end products.

Due to the great popularity of the Fused Deposition Modeling process, the selection of materials on the materials market is growing. There is a wide range of plastics that can be processed using the FDM process. These materials can be modified by the admixture of additives in order to influence certain material properties such as fire resistance, chemical resistance, breaking strength or heat resistance in addition to the basic properties. In principle, almost all thermoplastics are suitable for the FDM process.

In the FDM process, a component is generated by a large number of individual layers. After the strand is deposited, each strand cools down separately and as a result material shrinkage occurs. This shrinkage behavior is caused, for example, by the change of the density of a polymer resulting from the temperature change from processing temperature to room temperature. The shrinkage that occurs leads to stresses in the component, which can cause the component to warp. Excessive warpage leads to areas in the component that bend upwards out of the manufacturing plane and thus negatively affect the manufacturing process. This is one reason why the choice of materials in the FDM process is limited compared to conventional plastic processing technologies.

The aim of the research project is to investigate the shrinkage and warpage behavior as an additional criterion for evaluating the processability of plastics in the FDM process. The focus of the material selection is on high-temperature materials. Here,

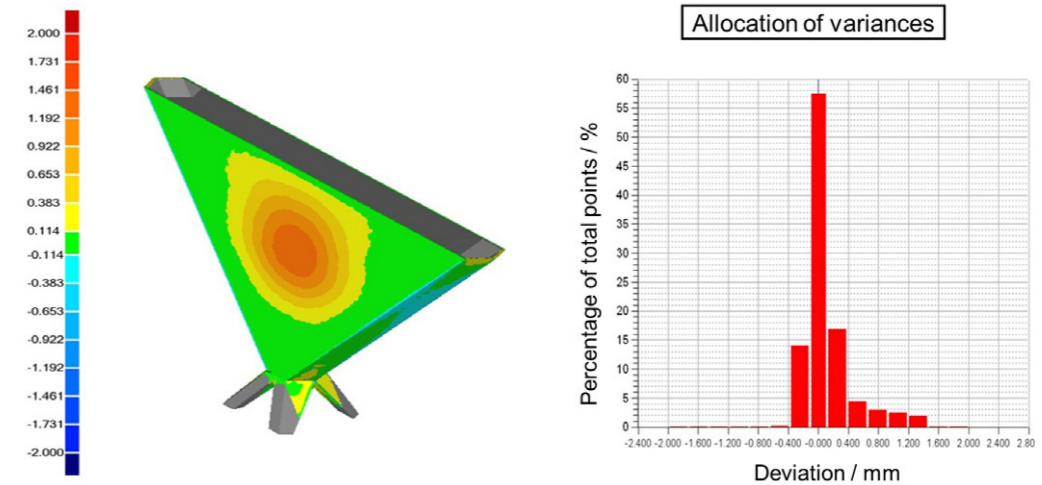


FIGURE 1 Three-dimensional deformation of the test specimen

the complete process chain from granules to component will be represented. This means that in the first step, filaments must be produced out of the standard granules (as starting material). In the following step, these are processed on an open parameter FDM system. Finally, the process parameters are optimized in consideration of the shrinkage behavior and the results of the project "Processing of alternative FDM materials 1.0".

### Review

In this previous project, the processability of different materials has been investigated with regard to the weld seam strength. For the characterization of the materials a weld factor was determined and the weld seam widths were evaluated in addition to the weld seam strength. During preliminary investigations, experimental points of a test plan with suitable temperature settings of the nozzle, the build chamber and the heating bed were determined. This test plan is also used for the investigation of the warpage behavior in order to compare the results of the two projects.

### Project contents

In the past project year, in close cooperation with industrial partners of the DMRC, the following materials were investigated for their processability in the FDM process: unreinforced polyether ether ketone (PEEK), thermally conductive PEEK, polyphenylsulphone (PPSU), glass-fibre reinforced polypropylene (PP) and polyamide (PA) 12. In test series, the warpage of test specimens was quantified using various measuring methods in order to be able to draw conclusions about the material shrinkage. Figure 1 shows an example of the amount of deformation of

the used test specimen geometry.

In the experimental investigations, the influence of the build chamber temperature and the nozzle temperature were investigated. For each material, five test points with material-specific temperature conditions were investigated. The temperature parameters were varied one after another and thus the influence on the shrinkage-related warpage of the test specimens was determined. Under the specific conditions, test specimens were manufactured using the FDM process and the amount of warpage caused by a shrinkage-related surface bulge of the test specimen was quantified. In addition to the influence of the different temperatures, also the influence of the position in the build chamber on the shrinkage behavior was investigated. Mechanical measuring equipment, a camera method and an automated 3D scanner were used to determine the warpage. Finally, the results of the previous project were applied to determine a process window for the individual materials in order to achieve the highest possible weld seam strength and at the same time minimum warpage.