PROCESSING OF ALTERNATIVE FDM MATERIALS

A widespread additive manufacturing process is the Fused Deposition Modeling (FDM). Not many high performance plastics 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.

PROJECT OVERVIEW

DURATION

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Processing of alternative FDM materials

The Fused Deposition Modeling (FDM) process is an additive manufacturing process. The components are generated by a liquified thermoplastic strand, which is deposited layer by layer. The used plastic filament is drawn into the FDM head by motors, melted there and deposited on the construction platform or on the existing structure through a nozzle. Due to thermal fusion, the material bonds with the underlying layer and solidifies. The FDM process is one of the most commonly used additive manufacturing processes for the manufacture of prototypes, tools and end products.

Due to the great popularity of the FDM process, the materials market is growing with new materials. There are a variety of plastics that can be processed using the FDM process. These materials can be modified by the addition of additives in order to influence not only the basic properties but also certain material properties such as fire resistance, chemical resistance, fracture resistance or heat resistance. In principle, almost all thermoplastics are suitable for the FDM process. They are used particularly frequently, for example: ABS, PLA, PI or PA.

The aim of the research project is to investigate the processability of alternative high-performance polymers for the FDM process. The complete process chain from granulate to component will be investigated. This means that in the first step filaments must be produced from the standard granulates (as starting material). In the next step, the filaments are processed on an open-parameter FDM machine. Finally, the process parameters are optimized. The main focus for the evaluation of the processing suitability is on the weld seam strength and the warpage behaviour of the materials due to material shrinkage.

Investigations of the weld seam strength

In the past project year, the following materials were tested with regard to their processability in the FDM process in close consultation with the DMRC industrial partners: Unreinforced polyetheretherketone (PEEK), carbon fibre reinforced PEEK, thermally conductive PEEK, glass fibre reinforced polypropylene and polyphenylene sulphide (PPS). In particular, PEEK and PPS are used for high temperature applications. The processing is demanding because special equipment is required to process high-temperature materials. The weld seam strength has been considered as a criterion for evaluating the processability.

During preliminary investigations, experimental points of a test plan with suitable temperature settings of the nozzle, the build chamber and the heating bed are developed and determined. Differences due to the selected process parameters can be identified with the help of manufactured components and the following determination of the weld seam strength. For this purpose, test specimens are produced out of the components, and the strengths of these test specimens are determined in a tensile test. The real weld area between the individual strands is then determined to calculate the weld seam strength of the individual test pieces by using microsections to measure the weld seam width (see Figure 1).

In order to improve the comparability of the various filaments with regard to their processability, the weld seam strength is related to the base material strength of the respective filament and a welding factor is calculated. In order to further characterize the materials and possible components from the materials, a weld seam width factor is identified and evaluated from the width of the weld seam and the width of the deposited strand.

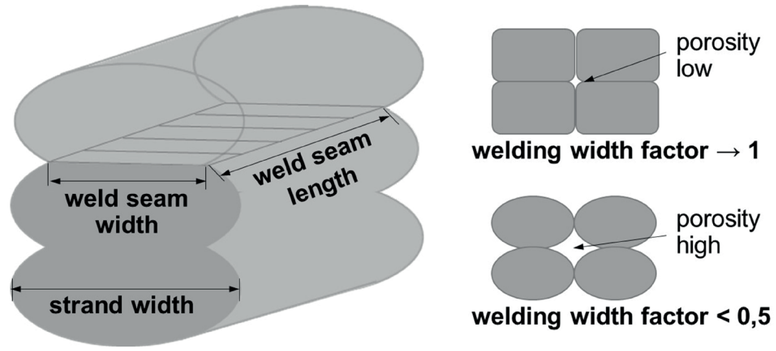

FIGURE 1 Structure of the welding surface and influence of the porosity of a component

Investigations of the warpage behavior

In the FDM process, the component is manufactured out of a large number of single layers. The strands are deposited in a defined manner, each strand cools down and shrinks separately. For example, the densities of polymers vary when the temperature changes from processing temperature to environmental temperature. The shrinkage that occurs leads to residual stresses in the component, which can lead to warpage. Excessive warpage leads to areas of the component that bend upwards from the production level and thus disrupt the process.

The aim of this section of the project is to analyse shrinkage and warpage behaviour as an additional criterion for processability. A selection of the materials that have been investigated so far with regard to the achievable weld seam strengths is used. The process parameters should be optimized under consideration of the shrinkage behaviour.

In contrast to shrinkage, warpage depends on many processing parameters and cannot be measured or taken from material data sheets. The shrinkage behaviour can be measured under defined conditions in a pvT measurement. The findings from the pvT measurements can be used in further investigations to adapt and estimate the processing conditions during the FDM process. The aim is to quantify and evaluate the warpage that occurs.