MATERIAL DEVELOPMENT OF NON-REINFORCED AND FIBER-REINFORCED POLYMERS FOR FUSED DEPOSTION MODELING

The aim of this project is to investigate the requirements for materials and semi-finished products that are processed in the Fused Deposition Modeling (FDM) process. By gainig a better understanding of the FDM process, a knowledge base should be created to increase the variety of materials that are available. This project is conducted in cooperation with Albis Plastic and in the NRW Fortschrittskolleg "Lightweight – Efficient – Mobile" (FK LEM). As one of the six Fortschrittkollegs established in 2014, the FK LEM is sponsored by the Ministry of Culture and Science of the German State of North Rhine-Westphalia.

PROJECT OVERVIEW

DURATION

06/2015 – 03/2019

PARTNER

ALBIS Plastics GmbH

FUNDED BY

- ALBIS Plastics GmbH
- Ministry of Culture and Science of the German State of North Rhine-Westphalia

RESEACHER

Research Leader
Prof. Dr.-Ing. Volker Schöppner

Research Assistant
Dr. Christian Schumacher

ALBIS

Ministerium für
Kultur und Wissenschaft
des Landes Nordrhein-Westfalen

Objectives

The Fused Deposition Modeling process is one of the most commonly used additive manufacturing processes. It is also known by the terms Fused Layer Modeling (FLM) or Fused Filament Fabrication (FFF). In the FDM process, the semi-finished product, commonly a wire of a thermoplastic polymer (the filament) is molten and forced through a nozzle. The continuous positioning of this nozzle allows the polymer to weld together strand by strand and layer by layer to produce a component. The energy for the welding of the individual strands largely results from the thermal energy of the deposited polymer melt.

It is desirable to be able to use a similarly wide variety of materials in the FDM process as, for example, in the profile extrusion or injection molding technology. Therefore, the processing suitability of any thermoplastic polymer should be predictable based on the material properties or process characteristics in advance of the processing. This is currently not possible because, in contrast to conventional methods, little is known about the required and desirable material properties for the processing in FDM.

Procedure

To compare and rate different materials for a manufacturing process the processing suitability of a material has to be definied. Therefor, significant characteristics like the process specific tensile strength of the welding seams or the warpage of manufactured parts are identified. Other factors like machine quality or data processing should have no or minimal influence on the investigated characteristics. For that reason machine and processing specific influences are identified prior to the investigations and custom-built specimens are created during this project to evaluate the identified characteristics.

After the specimens have been verified using well-know materials, for which a good processing suitability has been proven, series of tests are run for each characteristics with different polymers. Especially different Polyamide 6 (PA 6) and blend systems on the basis of PA 6 are created, processed and investigated during this project.

By varying important material properties, such as the viscosity or the cristallinity, suitable material properties are identified and connected to processing properties. To keep track of this the material properties are supervised during the whole project by methods like differential scanning calorimetry or high pressure capillary rheometry.

Findings

The properties of parts that are manufactured in the FDM process are mainly influenced by the machine quality and the data processing. For this reason, a machine- and process-independent rating of the processing suitability was developed during this project. Different process characteristics like the tensile strength of the welding seams and the process specific warpage were investigated for different materials. These criteria were quantified to rate the material specific processing suitability.

By considering the experimental investigations, the material specific processing suitability was connected to some important material properties. For that purpose e.g. the weld seam strength was compared to the tensile strength of injection molded parts and the warpage was compared to the shrinkage investigated in pvT measurements.

Additionally, the influences of fibre reinforcement was investigated regarding processing suitability and part properties. For the production of the short fiber reinforced parts and specimens, short-fiber reinforced filaments were processed. The process properties and the resulting part properties were investigated with regard to fiber-specific influences. Additionally, the effects of different process parameters on the fiber orientation and mechanical part properties were investigated.

FIGURE 1 Granules and filaments for FDM processing

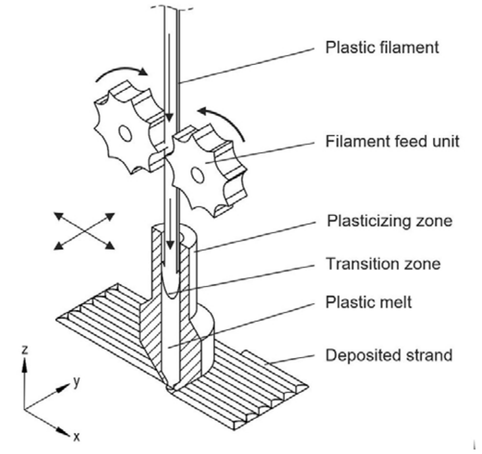

FIGURE 2 Process principle of the FDM process

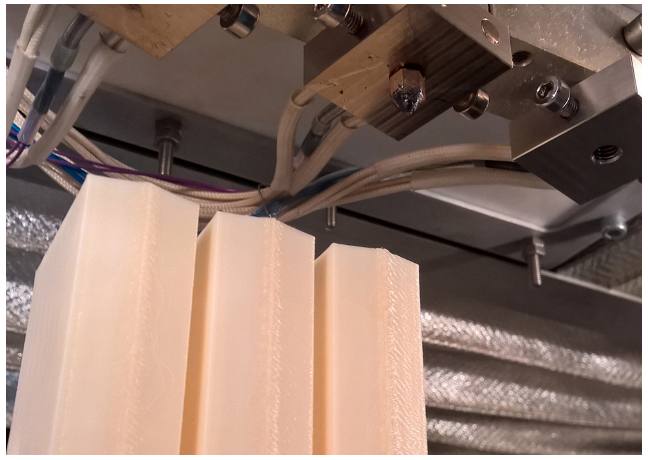

FIGURE 3 Custom built specimen in a build chamber of an FDM machine