FUSED DEPOSITION MODELING WITH METAL POWDER FILLED FILAMENTS 2021

Additively manufactured metal components are increasingly used in the industrial environment for the production of complex component geometries, small series or individualized products. A comparatively new approach for the production of metal components is the use of the Fused Deposition Modeling (FDM) process, in which a polymer filament filled with metal powder is used. In accordance to the conventional Metal Injection Molding (MIM) process, the polymer is removed from the manufactured part (green part) in a post-treatment step (brown part). Afterwards, the metal particles are sintered (final part). This project investigates the processing of a suitable support material. For this purpose, both the processing parameters and the process steps are considered.

PROJECT OVERVIEW

DURATION

05/2021 – 12/2021

PARTNER

Industrial Consortium of DMRC

FUNDED BY

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Motivation

According to the current state of the art, metallic end-use-parts can be produced with Selective Laser Melting (e.g. SLM) or Electron Beam Melting (EBM). Due to the high design freedom in the field of Additive Manufacturing (AM), these processes are increasingly used for complex parts, small series or individualized products. Disadvantages of the SLM process are the high investment costs for the machines that are equipped with one or more high-power lasers (> 300,000 €). In addition, high costs are incurred for peripheral equipment that is necessary for production: Sieving station, vacuum cleaner, blasting station and other post-processing machines.

Another possibility for the production of metallic AM parts is the use of the Fused Deposition Modeling (FDM) process based on polymer filaments filled with metal powder. In accordance to the conventional Metal Injection Molding (MIM) process, the polymer is removed from the finished FDM parts (green part) in a post-treatment step (brown part). Afterwards the metal particles are sintered (final part).

Since the filament contains a polymer and metal, it can be processed with conventional FDM machines that are available on the market. Possible fields of application could be the manufacturing of parts with internal structures that do not require external accessibility. Furthermore, the Metal-FDM process can be used to produce multi-material parts or parts with otherwise incompatible materials, which is not possible in the SLM or EBM process. Another advantage of the FDM process is that material is only used for the actual part as there is no need to fill the entire build chamber.

In previous projects on this topic at the DMRC first know-how about the technology has been gathered. Process parameters and material influences on the FDM processing were investigated and optimized. Mechanical properties were investigated for fully filled components and for partially filled components. First exemplary use cases were also attempted to be manufactured. The experiences during the project were recorded. It has been noticed that for the application and the production of components the biggest limitation is currently the lack of a debindable and sinterable support material.

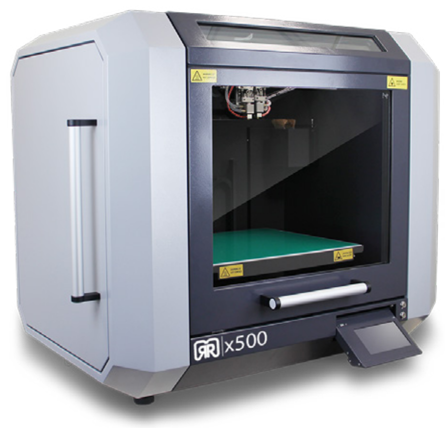

FIGURE 1 Machine used for the fabrication of green part specimens (Source: German RepRap)

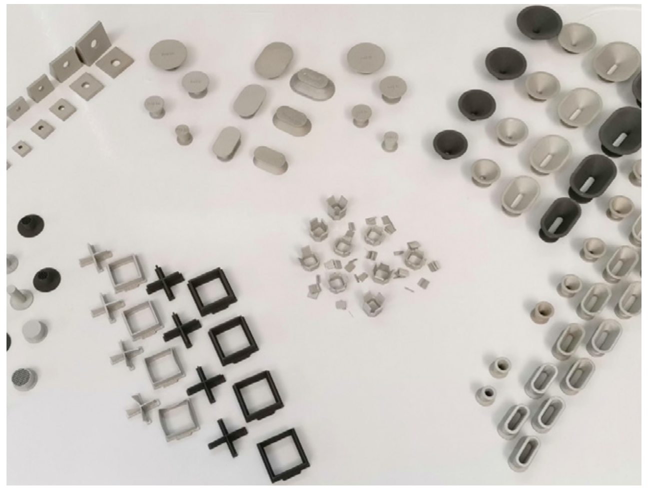

FIGURE 2 Process-related design limitations that illustrate the need of a support material

Aim

The aim of this project is to carry out first investigations on the support material currently being developed by BASF to evaluate and improve the processability. In this context, suitable process parameters should be determined and possible supporting strategies should be investigated. Finally, the results will be used to manufacture first complex geometry components out of 316L, which previously could not be manufactured due to their geometry and the necessity of supporting structures.

Proceeding

At first, FDM processing parameters are developed for the selected support material. For this purpose, a methodology developed at the DMRC is used to qualify the processing parameters. The evaluation of the optimized parameters is carried out on the green part on the basis of the resulting strand geometry. Thereby, not only a functioning parameter set will be found but also the material specific influences on the processing will be considered. Collapsing of the structure and a negative influence on the surface must be avoided.

On that basis, different supporting strategies are evaluated. These include the manufacturing of support structures that only use interface support as well as fully manufactured support. Moreover, the influence of the support strategies, density and strand deposition strategies along the whole process chain is examined.

The components are evaluated after the individual process steps with regard to existing defects and surface condition. This should not only validate the set process parameters, but also minimize the use of support material and the influence of the support material on the component properties. Thus, the aim of a rapid and reliable process should be achieved.

To illustrate the developed parameter set as well as the recorded influences on the component properties, complex geometries are manufactured, which require support material for production. In addition, a comparison with previous results is made in order to assess the potential of the support material in the processing of metal powder filled polymer filaments.