Friedrich-Alexander-Universität Erlangen-Nürnberg

LEHRSTUHL FÜR KUNSTSTOFFTECHNIK
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Fused Granulate and Metal Fused Filament Fabrication (FGF and MFFF)

Motivation

To expand the possibilities of filament fabrication as part of the additive manufacturing (AM) process, two strategies of fused granulate fabrication (FGF) and metal fused filament fabrication (MFFF) are discovered. The double robot machine [1] combines the FGF process with various different operations (Fig. 1). Beside conducing the temperature and geometry while printing it is also possible to include a milling process and insert a part through handling. Furthermore with one of the extruders dry endless fibers can be carried along by the polymer melt. By including a high amount of fillers the MFFF process allows to not only modify and enhance the mechanical properties in polymers, but further realizes additional functions.

Application

The FGF as part of large AM processes is not only able to produce individualized parts but also generates products for small series. Due to the hybrid manufacturing approach, this technology also enables functionalization and a topology optimized toolpath. The MFFF process enables the indirect AM of metal parts. Therewith, it is possible to produce e.g. individual tools or manufacturing aids in a cost effective and fast way. Further parts with complex interior geometries, such as tools for injection molding with contour cooling chanels can be realized.

Fig. 1: Dual robot machine

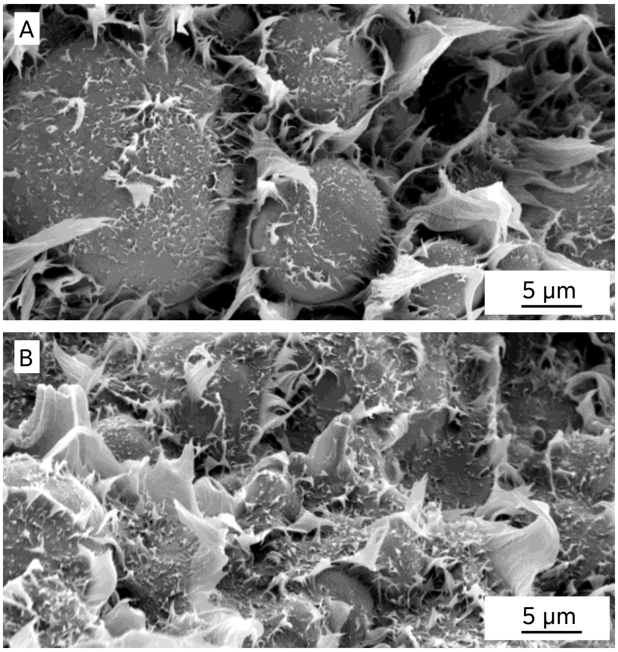

Fig. 2: SEM images of a metal filled filament (60 vol.-%):
A) base binder
B) base binder with addition

[1]: DFG large device INST 90/1036 FUGG

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Research focus

Within the FGF one of the foci at the Institute of Polymer Technology (LKT) is the integration of endless fibers and inserts or - more precise - an in-depth understanding of the interactions between the properties of the polymer materials and the process boundary conditions.

The comply the application properties within the MFFF process, the filler grade of the filament needs to be as high as possible and with that, the binder composition within the metal loaded filament plays a vital role. On the one side a high filler grade must be incorporated, which makes it stiffer and decreases the elongation at break (Fig. 3). On the other side, the material needs to have a low viscosity and further has to reveal a filament flexiblity, so that it can be processsed in MFFF. Here, the main research focus lies on improving processing characterisitics and increasing the filler grade of the filament.

Main research results

Within the FGF process it was found that the maximum achievable shear stress of the connection is independent of the manufacturing process of the pin. In addition, face milling of the joining surface (between the 1st and 2nd AM process) leads to a further increase in the maximum shear stress (Fig. 4).

As the binder composition plays an important role in the MFFF process, it was found that different kinds of waxes can be used in order to create a better particle-matrix-interaction. Furthermore, they also reveal major impact on the mechanical properties of the filament.

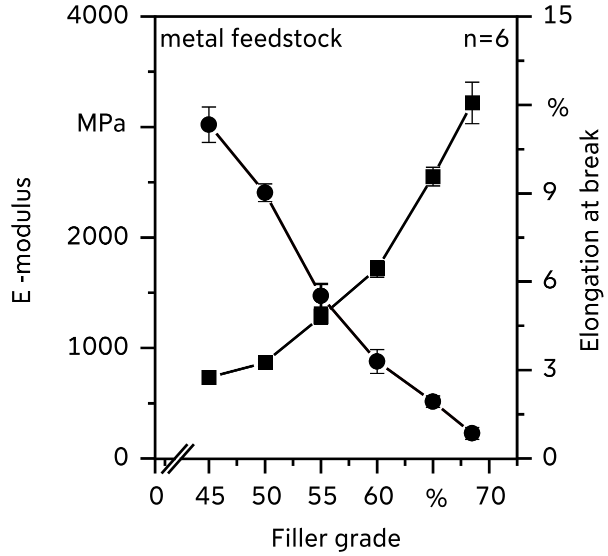

Fig. 3: Tensile testing results of metal feedstocks with different filler grades

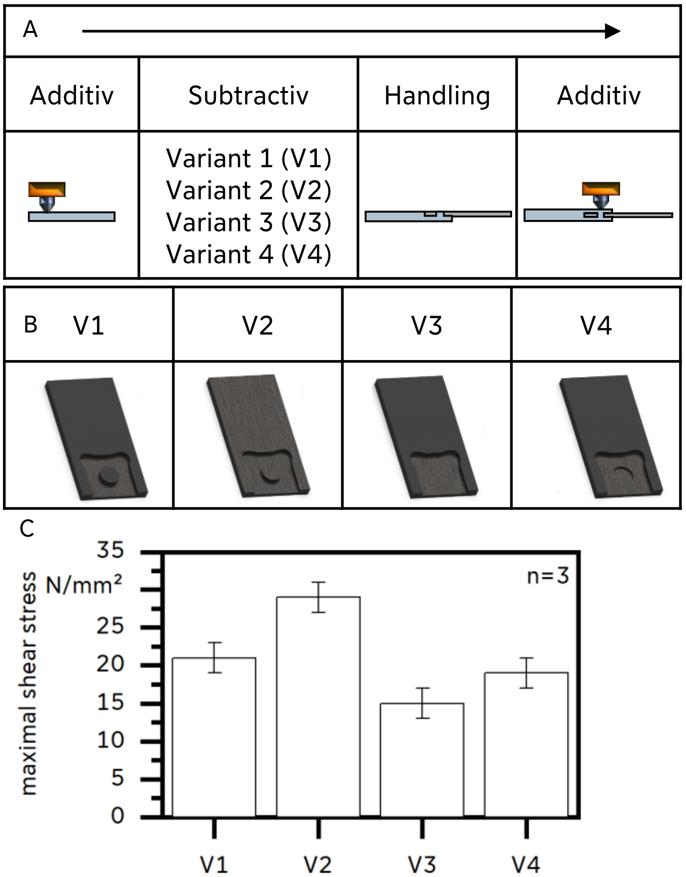

Fig. 4: Part integration in the FGF process:
A) process steps for shear specimens
B) different variants of the substractive step
C) maximal shear stress relative to variants

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