Feedstock development for the additive manufacturing of ceramic and metallic parts by FDM

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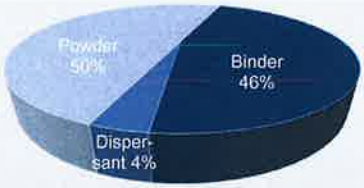
Motivation

3D-printing via FDM is a very cheap method to produce single plastic products without help of further tools. Pure ceramic or metallic parts are not producible yet. With respect to the fabrication of ceramic and metallic products it is necessary to develop a new material (feedstock) that contains powder as much as possible and melts easily in the printer nozzle.

General composition of the Feedstock

Feedstocks consists generally of

- ceramic or metal powder
- polymer binder and
- dispersant.

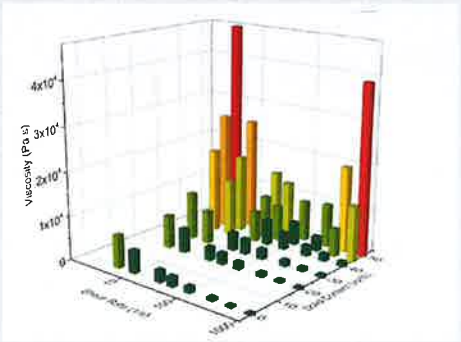


Compounding in volume percent at a solid content of 50 vol% and a dispersant content of 3,3 mg/m² powder

While printing of the materials the polymer binder system plays a major role. The binder should have a low viscosity and should be strong enough to fix the powder before and after printing. In the best case the highly filled material is flexible enough to allow winding of the filaments.

Rheological properties of the feedstocks

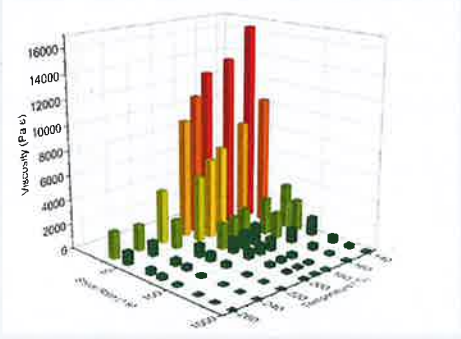
Powder filled polymers viscosity depends on the content of the solid particles. Therefore at around 55 vol% a limit is reached.



Viscosity of a Al_2O_3 filled ABS

Because filled ABS-feedstocks are very brittle, it ought to be replaced by other more flexible polymers.

The viscosity of different qualities of TPEs are measured. It depends of the processing temperature. Furthermore it decreases strongly with increasing shear rate.



Viscosity of a unfilled ThermoPlastic Elastomer (TPE) at different shear rates and temperatures

3D-printing

While printing the feedstock melts in the nozzle and will be extruded. The shear rates at the nozzle are calculated for common nozzle diameters and printing speeds in the lower table.

Table 1: Shear rates at the printer nozzle

Nozzle diameter [mm]	Printing speed [mm/s]			
	5	10	30	50
0,25	160	320	960	1600
0,4	100	200	600	1000
0,8	50	100	300	500

Comparing viscosity results of high filled feedstocks with the calculation, shear rates of 100 -200 s^{-1} should be applied.

Actually tensile specimen and bending test specimens were successful printed with solid contents of 40 vol% (~70 wt%).

Printed tensile and bending test specimen

Outlook

- Printing of feedstocks up to 50 vol% alumina
- Tensile and bending test of the green bodies
- Development of feedstocks with a more elastic binder (for example TPE)

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