FILLED MATERIALS

In recent years, selective laser sintering has evolved from a rapid prototyping technology to a process for the direct series production of sophisticated plastic components. In this context, the functional and mechanical properties of additively manufactured components are becoming increasingly important. However, there currently is only a limited selection of LS materials available, meaning that not all customer-specific requirements can be met. Particularly in the automotive and aerospace industries, filled plastics represent standard materials, as they can exhibit better mechanical properties, higher heat resistance or improved wear properties, depending on the filler.

PROJECT OVERVIEW

DURATION

05/2021 – 12/2021

PARTNER

FUNDED BY

Industrial Consortium of DMRC

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DMRC DIRECT MANUFACTURING RESEARCH CENTER RESEARCH INNOVATION EDUCATION

Project Goals

Although some filled laser sintering materials are already commercially available, for example filled variants of PA12 or PA6, these materials have not yet achieved a wide acceptance on the market. Currently, about 90% of LS components are still manufactured from unfilled PA12. In order to create new fields of application for selective laser sintering, the material variety should be extended by filled variants (dry blends) of polypropylene and polyamide 613 within this project. For this purpose, the influence of different fillers and the filler content on the mechanical properties will be analyzed, thus enabling application specific tailoring of material properties.

Experimental Investigations

Based on the experience of DMRC partners, polymer dry blends with different spherical fillers are investigated within the project. Spherical fillers tend to have a better processability than fibers or mineral fillers and exhibit less anisotropy. Fibers can reduce the powder flowability and tend to align in the recoating direction if they are not incorporated within the polymer particles. Within the project, glass beads (Silibeads), hollow glass beads (iM16k) and artificial quartz sand (Cerabeads#1700) are mixed with Untrasint PP 01 nat and Vestosint PA613 (3D 8754 HT1) polymer powders in a drum hoop mixer in different mixing ratios. In contrast to so-called compounds, the fillers are not incorporated within the polymer particles, but are present loosely in powder form in the resulting dry blends.

In the first step, the powder properties of the dry blends are considered. Particle size distributions and the flowability of the powder mixtures are determined. Furthermore, the influence on the melting behavior is quantified by means of DSC investigations and the melt viscosity of different blends is determined by MVR measurements. The fillers could have a nucleating effect, which could influence the recrystallization behavior and change the sintering process window.

After completion of the basic powder characterization, the processing properties of the dry blends will be investigated on an EOS P3 laser sintering system. It is expected that processing parameters such as laser power, scanning speed, hatch distance and build temperature will need to be adjusted compared to unfilled material. The altered flow properties of the dry blended powder may necessitate changes in recoater blade geometry to ensure a good powder bed surface. Furthermore, shrinkage factors may need to be adjusted to compensate for the effect of the fillers.

Special attention is paid during processing to possible segregation of the different particles inside the dry blend (polymer and filler). In the feed tanks of EOS P3 laser sintering systems, the powder is fluidized with compressed air in order to dissolve agglomerates and to achieve the best possible coating. However, depending on the density and particle morphology of the fillers, a segregation of polymer powder and filler may occur. This process must be prevented at all costs, as otherwise it is not possible to achieve constant material properties over the entire build height. Even if no segregation should occur in the feed tanks, the distribution of the fillers within the component volume is a critical factor. It must be checked whether the filler is evenly distributed by the mixing process, or whether filler agglomerates are formed which are not surrounded by plastic melt in the subsequent laser sintering process and thus form a defect.

After suitable processing parameters for the dry blends have been determined, the achievable mechanical properties are to be investigated at the end of the project. For this purpose, tensile test specimens made from dry blends with different fillers and filling ratios will be produced in the laser sintering process and tested according to DIN 527. An important target parameter is an increased Young's modulus compared to unfilled polymers. Furthermore, the heat deflection temperature of the components is to be improved by incorporating the fillers. Previous investigations have shown that the bonding of the fillers to the polymer matrix is of particular importance for the mechanical properties. Against this background, the effect of a silane coating on the fillers is investigated. As a failure mechanism, it is aimed that the components fail in the base material and not at the interface between fillers and polymer. At the end of the project, the DMRC partners will have formulations available for dry blends of PP and PA613 with spherical fillers, together with the corresponding material and processing properties.

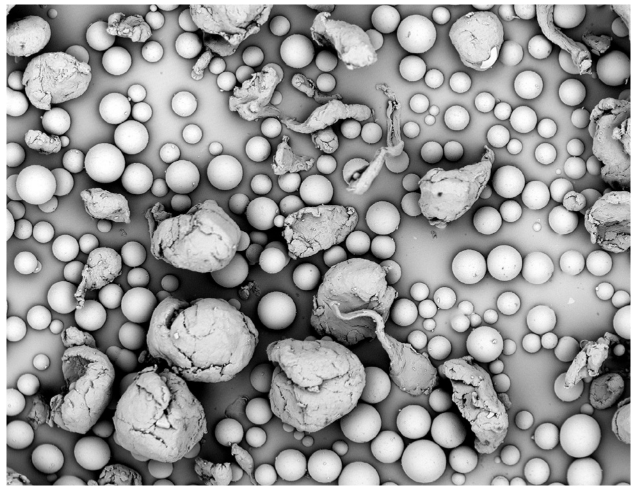

FIGURE 1 Dry-blended Ultrasint PP 01 nat with glass bubbles iM16k

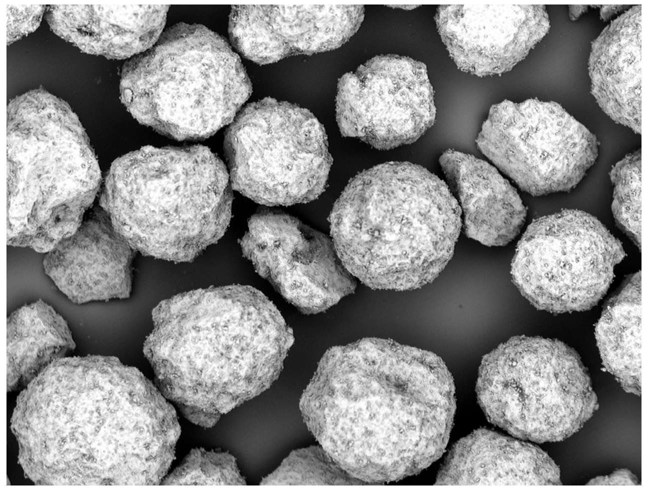

FIGURE 2 Artificial sand (Cerabeads#1700)