PA613 – LS POLYAMIDE FOR HIGH TEMPERATURE APPLICATIONS

The introduction of the selective laser sintering (SLS) process into the market of the direct manufacturing of components demands materials which meet the high requirements of the industry. PA613, a polyamide developed by Evonik to be used in high temperature applications for example in automotive or electronic industry, is tailored to the SLS process. Especially for these applications the long-term properties are of high importance and are investigated within the described project. In previous projects the material PA613 showed good processability on an EOS P396 laser sintering system and process parameters which result in high part quality were found. Together with determined short term properties the material can be classified within the range of high performance polymers.

PROJECT OVERVIEW

DURATION

01/2019 –12/2019

PARTNER

Industrial Consortium of DMRC
- especially EVONIK and EOS

FUNDED BY

Industrial Consortium of DMRC

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Motivation

Within previous DMRC Projects about PA613 a LS polyamide for high temperature applications, it could be verified that the new material, delivered by Evonik, shows good processability on the regular “low temperature” LS EOS P396 machine and mechanical part properties are about 25 % better than the ones of polyamide 12 build parts. However, beside higher strength, higher temperature resistance is required in advanced applications like electronics or automotive industry. The long-term temperature resistance is investigated within this project and supplements the necessary knowledge about the material. Further, fatigue behavior is regarded as also cyclic loads might play a role in future applications. All this helps to classify the material within the range of engineering plastics to become a new high performance material in industry, as PA613 is not known in conventional manufacturing. For this purpose, more information about part properties must be generated.

Preceding projects

In former projects the general processability of PA613, in terms of powder recoating behavior and process temperatures, could be verified. Furthermore, parameters and machine settings had to be found to manufacture robustly build parts. This was not only tested for virgin powder material but also for recycling powder. Since each new laser sintered material is affected by its own aging effects due to the process conditions, these and their extent must be found first. This was accompanied by an investigation of a suitable mixing ratio to manufacture components with high quality and to reuse as much material as possible which already served as support material in the process. For this purpose, test specimens with different mixing ratios of virgin and aged powder are built and surfaces as well as mechanical properties, for example, are regarded. Resulting characteristics are not only correlated to the refresh ratios but also to the MVR (Melt Volume Flow-Rate) value which helps to qualify the aging stage of the powder material.

The next step was a parameter development. In order to generate material properties that are as representative and as optimal as possible, a parameter development was carried out with the aid of statistical experimental design prior to the tests. The material PA613 showed in former investigations quite constant mechanical behavior for a wide range of laser energy input into the hatching scanning pattern. However, the contour parameters seem to influence even more the tensile properties especially in z-build direction. Following, the project focused the contour laser exposure parameters and strategy whereas the hatching was kept constant. Nevertheless, in order to reduce the experimental plan, a design of the experiments was created with the help of the statistical software Minitab 18 first. Test results were analyzed to detect correlations between varied parameters and build part quality. Finally, a response optimization was carried out.

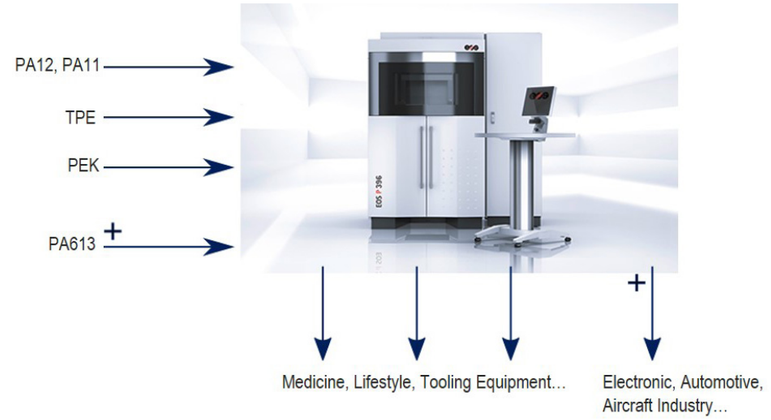

FIGURE 1 Motivation for the laser sintering material PA613

The resulting optimized build parameters were taken to manufacture various specimens. Beside testing tensile, impact, bending and compressive properties at different application relevant temperatures, the material behavior after conditioning was regarded. Conducted tests show that, as known for polyamides, the tensile strength of PA613 is decreasing with increasing temperature but is still above 20 MPa at 120°C. On the other hand, elongation at break is increasing with increasing temperature but also shows more anisotropy for x- and z- build direction.

Material characterization – Long term properties

To extent the comprehensive material data base, the content of the project in 2019 was the determination of long-term properties, especially at high temperatures. As PA613 is a polyamide for high temperature applications, the long term resistance under thermal stress has to be investigated. For this purpose, the temperature index (TI) is determined according to the standard UL 746B for polymeric materials respectively EN ISO 2578. Furthermore, fatigue behavior of PA613 laser sintering parts must be known for dynamical applications like in aircraft, electronic or automotive industry and is therefore also tested within the described project. Hereby, former DMRC Projects about PA613 quasistatic part behavior (Funding cycle 2017 and 2018) and on the other side fatigue behavior of FDM and LS parts made of PA12 (Funding cycle 2015) set the basis for the experimental approach.

The overall aim is to characterize and to identify limits of the laser sintering PA613, to classify the material within the range of engineering plastics and to introduce a new high performance material in industry and therewith to enlarge the field of application of the Additive Manufacturing process Laser Sintering (see Figure 1).