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Material Characterization and Properties regarding a Boeing Design, optimized for Laser Sintering

The aim of the project is a complete investigation of the laser sintering process along the LS Process Quality Chain regarding a real design for the aerospace industry. Influencing parameters are defined reasonable to increase the reproducibility. The investigations of material and quality characteristics are the main focus of this project. One main topic is the development of a characterization method to uniquely define the powder quality of the raw material. The investigation of material properties will be performed regarding the quality of the raw material as well as other influencing factors. Furthermore the construction and design of the given requirements regarding lightweight construction, cost reduction and others round off the project specifications.

Powder Material Characterization

Investigation of a method to characterize the powder material for Laser Sintering

This chapter includes the investigation of diverse methods to characterize the powder quality. As known, the material for laser sinter processes is composed of virgin and used powder, whereas the used powder is a material, which has passed the LS process several times. Because of the temperature influence during the process the material is thermally loaded. State of the art for the raw powder quality is a given powder ratio, but the material age is not defined.

Part of the project is the definition of important methods to get information about the influence on the powder age. Reasonable methods are experimental setups to investigate rheological and thermal properties as well as particle properties. Different amounts of powder with different powder ratios, adjusted using the Melt Volume Rate (MVR), are produced. One main point of the project is the development of an industry-oriented method, so the MVR method is the easiest way to get information about the viscosity of polymer materials, wherefore it is an important parameter for the characterization of powder. Other processes are investigated as well. At first the solution viscosity and a SEC (Size Exclusion Chromatography) are performed to get information about the molecular weight and the molecular weight distribution. The flow curve is detected using a rotational and a capillary rheometer. Information about the flowability as well as the particle size distribution and the particle morphology are important factors and are detected as well.

Material Properties

After getting the information about possible methods for the polymer characterization, the next step includes the determination of important material properties. Next to the standard properties like mechanics, other tests are conducted, such as three point bending and compression tests to enlarge the process understanding. Other experimental setups are performed as well to examine thermal, electrical and physical properties. All tests are accomplished varying layer thickness, temperature and material quality. For the post process an automatical blasting system with a defined distance, blasting pressure and blasting time is used.

It is important to build up a reference job whereby it is possible to compare the influenced parameters. The job height, the exposure strategy as well as the exposure time are three main parameters, but there are lots of other factors which have to be defined at the beginning of the test program. Further on powder boxes are placed at defined locations to compare the material ageing, using the methods developed in the first part of the project, from job to job as well as the packing density regarding the different adjustments. Aspects like hatch conformity or shrinkage are also considered. This part has two focuses: On the one hand a reference job is constructed to detect all influencing parameters, on the other hand the determination of material properties and the influences of the testing methods are investigated as well. The results shall be transferred to chosen machine types as well as a flame retardant material.

Material characterization of different important parameter along the Laser Sintering Process Quality Chain

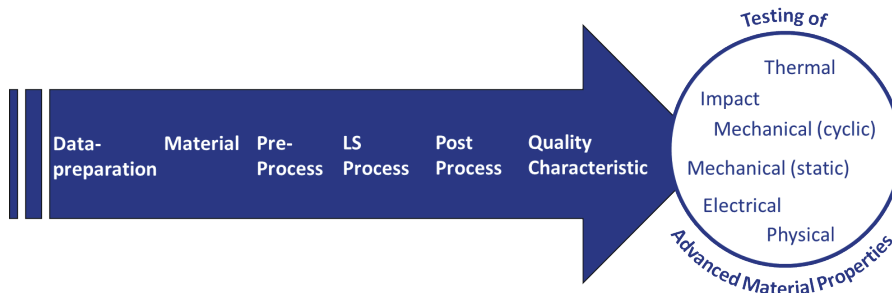


Figure 1: Investigation of material properties along the Laser Sintering Process Quality Chain

Case Study Boeing Design

The last topic of this project is the development of a case study. It is about a real design challenge given by The Boeing Company. By means of a requirements list and a given product environment, a real part is developed for laser sintering. First designs are produced within a student seminar. The following step is an optimization for Laser Sintering and Fused Deposition Modeling, two of the main important AM technologies existing at the DMRC. For a benchmark with conventional manufacturing technologies a product with equal characteristics is designed for injection molding. The different designs are compared regarding costs, weight, functionality and other important parameters. All of these steps are processed interdisciplinary together with other DMRC staffs, who are responsible for the diverse topics.

Design for The Boeing Company optimized for additive and conservative manufacturing technologies

A Finite Element Analysis is performed using the material properties described above. The laser sintered product is designed using the flame retardant material. A load test as well as a test of functionality will be performed as well.