Test Report
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Assessments to Prepare and De-Risk Technology - Powder Characterisation

Powder characterisation of powder batches

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PowderGenetics

a holistic approach for a reliable characterization of powder material to achieve reproducible manufacturing processes and high part quality within additive manufacturing

Executive Summary

The space industry has been developing very rapidly in recent times and is characterized by an increasing international cooperation and interdependencies. With a strong motivation to explore the universe and clarify open aspects, an increasing number of companies were founded to develop and build space systems. Those systems are often distinguished by the propulsion technique of their rockets where new manufacturing methods are considered to produce high complex parts.

In respect to additive manufacturing, the aims of lightweight, complex geometries, hybrid material and integrated functions are realized by the means of powder bed fusion processes. High requirements on a reproducible and stable manufacturing process and on the quality of the created components involve a high grade of knowledge of the process chain with all its influences and uncertainties. Hence, the distinct process steps need to be described precisely.

Being the source of producing parts, the quality of the powder material used in the powder bed fusion processes has a significant effect and therefore it is essential that their properties are adequately defined and understood in the production process.

Conventional methods to characterize powder were derived from other powder metallurgical manufacturing processes as sintering that were developed seventy years ago. Due to the limited possibilities of past investigation techniques that are essentially based on two dimensional considerations the results address cumulative features with rather inaccurate measurements. Many devices are needed for such evaluations where the time and effort for a full characterization is high, while the value of the results is poor and the correlation from powder properties to the production process and part quality is not possible.

A new characterization approach was applied in this project to determine the differences of powder quality that distinguish powder properties from various manufacturers. With PowderGenetics a holistic evaluation of powder material is possible by considering three-dimensional effects to gain with high accuracy relevant information on elemental features. Four investigation steps are undertaken to describe the powder characteristics and to gain results of high value and substance. The macroscopic features of powder samples show serious discrepancies as oxidation, contamination, and humidity. The chemical composition of specified elements is also important in evaluating the condition of powder materials and determining their suitability in various applications. Qualitative information is gained with a scanning electron microscope about the actual shape and topography of a particle sample. As a last step many thousands of particles are separated and enclosed within a capsule for performing computed tomography that acquires the highest possible in depth information of the elemental properties i.e. particle size, size distribution, morphology and the presence of hollow spaces and higher dense particles with the highest possible information depth.

Both, quantitative and qualitative information is used to assess the processability of powder material with respect to the combination of the particle size, the size distribution, the shape, and the topographic appearance of particles. A small variation in size and a high amount of ideal spherical particles with finely structured, dendritic surface lead to a homogenous distribution of powder on the build plate and constant melting during exposure.

A further aspect is the correlation between powder properties and the part quality of produced parts with respect to the surface roughness and the content of pores within the part. A high number of particles that contain hollow spaces will result in higher surface roughness and near surface pores, due to gassing and splashing effects during processing exposure.

Reliable and accurate date are a prerequisite for process monitoring to detect even small deviations, to evaluate the process impact and be able to take fast and cost-efficient decisions.

Numerical analyses supporting virtual product qualification largely depend on the quality of the databases being used that in turn depend on the accuracy of the input data.

To further develop the potential of PowderGenetics it is recommended to apply this powder characterization:

1) On other relevant material types
2) For a batch to batch comparison of one manufacturer
3) For survey and update/completion of specifications both with respect to powder providers and powder users
4) To investigate the success of recycling processes

and in addition, following aspects need to be considered

5) Evaluation of alteration effects due to different container material
6) Investigation of impact of storage due to segregation, temperature, and humidity