# CHANGES OF STAINLESS STEEL POWDER

**In many applications, which can be produced by AM, stainless steel (1.4404) is the most commonly used steel, because it has a well-balanced property profile. For serial production, deep knowledge on the robustness of part properties against variation of powder characteristics is required. The characteristics of the powder material, next to process parameters as well as hard- and software, are important key factors. During the use phase of powder, effects like washing out of fine fractions and the pick-up of nitrogen change the powder characteristics. Therefore, the powder properties permanently change during the manufacturing process. The scope of this project is to investigate the influences of relevant changes of powder characteristics on the material as well as on the part properties.**

## PROJECT OVERVIEW

DURATION

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PARTNER

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## Objectives

The first important step in influencing the powder properties is to create different particle size distributions (PSD) of the stainless steel powder. This is done through systematic manipulation by sieving different size distributions. The second important influencing factor is the possible uptake of nitrogen of the powder during the manufacturing process. The influence of nitrogen on the powder characteristics will be investigated by aging the powder under nitrogen atmosphere at a defined temperature and time. After influencing the powder properties, the next step includes the manufacturing of the test specimen with the aim of studying the impact of different PSDs on mechanical part properties. The specimen production is carried out by using the selective laser melting manufacturing process. The specimen are tested only in one material condition (as built). The last step includes the experimental investigations to determine mechanical and fracture mechanical properties.

## Procedur

The project aim is the investigation of the powder material with its specific influencing factors during the use-phase. Of particular interest thereby is the lot to lot variation of the powder quality inside specified ranges. Because of that, it is necessary to investigate how a shift of the median value x50 affects the material properties. The approach is to shift the median value, through a sieving process, as near as possible to the range limits of the particle size range. The specified particle size range of the standard powder is between 10 µm – 45 µm with an average particle size of d(0.5) = 29µm. The first generated size d istribution is in the range between 25 – 45µm with an median value of d(0.5) = 35µm (upper limit). The second generated size distribution is in the range between 15 – 35µm with an median value of d(0.5) = 24µm (lower limit). The artificial aging process takes place inside a climate chamber under nitrogen atmosphere condition. In this regard a temperature of 200°C is provided, because this temperature is generally present during the building process, when using platform heating. At intervals of about 12 hours, small samples of powder are taken over a period of about one week. The sample of powder which is removed is immediately sealed under vacuum in a glass tube. Based on this, the nitrogen content of the stainless steel powder were determined through thermal extraction with a carrier gas. For a complete powder characterization different test procedures are necessary. In particular, three different material tests are carried out. For all three types of experiments it is necessary to manufacture test specimen. All specimens were built on the SLM 280HL under a nitrogen inert gas atmosphere. For the manipulated powder a smaller building platform is used because it need less powder. Finally, tensile and fatigue tests are carried out to determine the tensile and fatigue strength. Furthermore crack propagation experiments are executed in order to establish crack propagation curves for all different powder states.

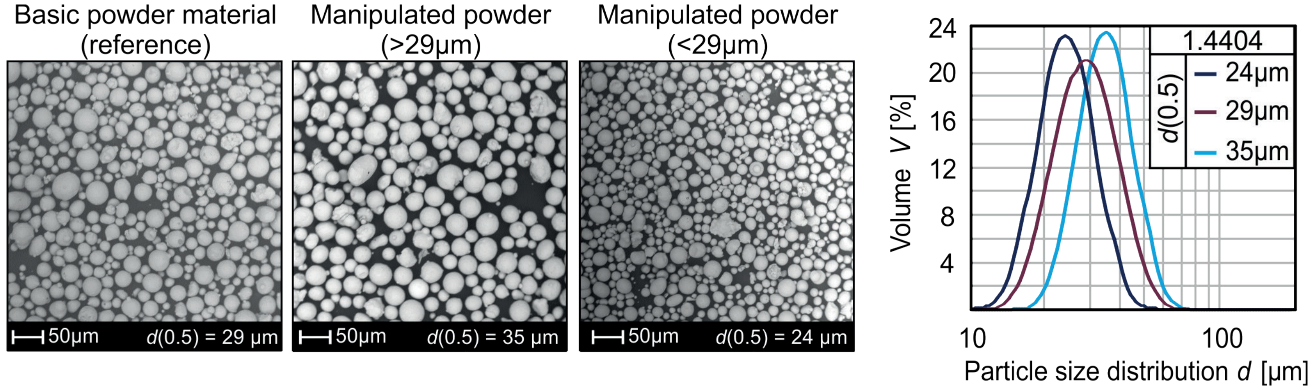


FIGURE 1 SEM-images and PSD of the investigated powder types

## Results

The reference nitrogen content at the beginning of the aging process is 0.085 %. The results of the aging process show an insignificant increase of the nitrogen content of the powder even after long aging time. So it can be concluded, that the selected aging temperature of 200°C does not lead to an increase of the nitrogen content. The next step was to investigate if there is a difference between the nitrogen content of the powder and the nitrogen content of the manufactured specimen. In this regard we measured the nitrogen content of two different specimens from two different previous building jobs. The analysis shows a nitrogen content 0.08 % for both specimens and thus it lies in a similar range with respect to the aged powder material. So in summary it can be concluded, that there is apparently no change in the nitrogen content of the powder as well as of the manufactured parts through the building process.

*Tensile and fatigue tests*

The tensile tests have shown that manipulating the powder particle size distribution has a measurable but not significant effect on the tensile strength, with an increase of 18MPa for a grainsize smaller than 31µm and an increase of 31MPa for a grainsize bigger than 31µm. Furthermore, the elongation at break increased by 11% respectively 18%. Furthermore the results show, that there is no significant influence due to the size of the building platform. The results of the fatigue life tests correlate with these observations, where the small / large fractioned powder conditions withstood an on average 20MPa higher stress level. No significant change can be observed in the slope of the logarithmical regression lines for the finite life graphs.

*Fatigue crack growth experiments*

With regard to the fracture mechanical analysis, the results for the tests with the three different particle size distributions show, that for the examined powders the crack propagation curves have almost the same curve progression, especially in the threshold area and in the middle region. Only in the fracture toughness region some slight differences are observable. The best fracture mechanical results are achieved with the small frationed particle sizes in which we have a slight improvement in the threshold value. But in summary it can be said, that there is obviously no significant influence on the crack propagation curve or the threshold value when using different particle size distributions. Also, identical results were obtained by using different building platform sizes.

## Outlook

Further investigations could be conducted with different material characteristics as the influence of different heat treatments, building direction or the powder humidity. In this way the material can be fully characterize for the additive manufacturing process.