Advanced Additive Manufacturing Material and Part Properties-Reduced Refresh Rates & Cooling Process regarding Laser Sintering (AMP²)

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This project treats two important challenges regarding the Laser Sintering Process. One focus is on an optimized polyamide 12 material (PA 2221), which allows a higher recycling rate of used powder and thereby reduces the material consumption. The impact on part and powder properties is investigated along a production oriented series of build and powder mixture cycles. Another focus is on the cooling process of the part cake, which strongly influences the part and powder properties but is less known yet. Therefore, the temperature history within the part cake is measured experimentally and correlated with part quality characteristics. In a second step, the cooling process is simulated as a basis for optimized process controls.

Reduced powder consumption using PA 2221 material

With the use of PA 2221 material it is possible to use very low refresh rates of about 30% compared to 50% with the standard nylon 12 material PA 2200.

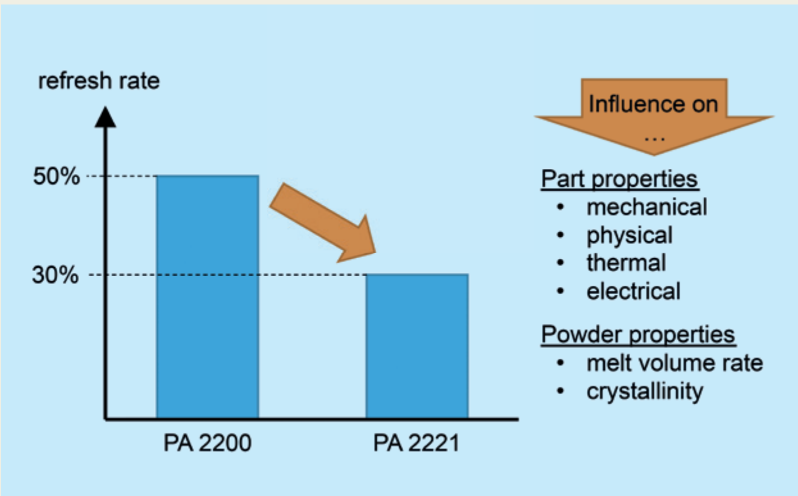


Figure 1: Reduction of the refresh rate and its influence on powder and part properties

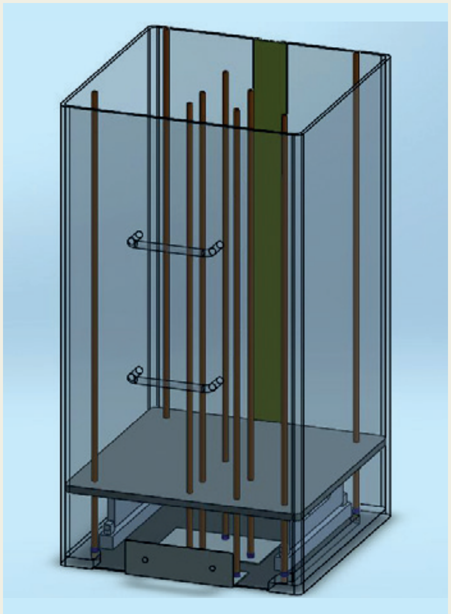
Maintaining similar part quality characteristics, the powder consumption and waste are thus reduced significantly. As a result, the cost efficiency of the laser sintering process can be increased.
The influence of the thermal loading on the powder age is analyzed with various methods, for example the melt volume rate or the crystallinity. Experiments are conducted along a test series with a rising number of build cycles using the refresh rate as well as the MVR value to adjust a used/virgin powder mixture ratio. Thereby, a representative ageing state for circulatory PA 2221 powder is achieved.

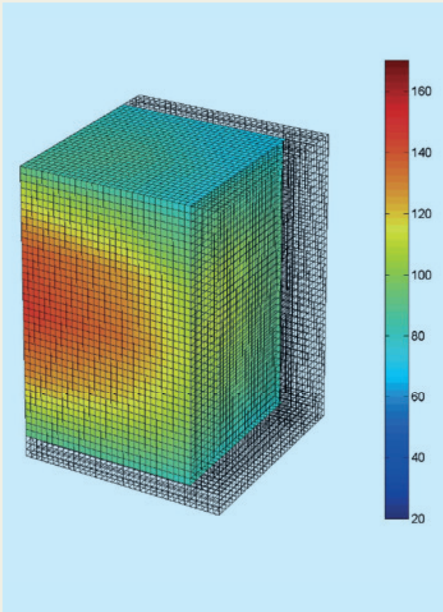
Determination of PA 2221 part properties

Since the ageing behavior of PA 2221 is known and characterized, experiments are performed to determine temperature-dependent material data, for example the mechanical, physical, thermal, electrical or impact part properties, which can be used for part design and FE analyses. These results will be compared to the standard material PA 2200. (Figure 1)

Temperature measurement within laser sintered part cakes

In previous investigations it has been shown that the position of a part within the part cake strongly influences its quality characteristics due to different temperature histories. Next to the part position, important job parameters like the part packing density or the build height influence the cooling rates. Nevertheless, the temperature distribution of the inner part cake during the build process (warm-up, build and cooling





(a) (b)

Figure 2: (a) Construction of the temperature measurement system
(b) Measured inner part cake temperature distribution during cooling (quarter view)

down phase) and its influence on part and powder properties is less known yet.

In a first step, a temperature measurement is installed into an EOSINT P395 laser sintering system. Therefore, the build frame and the lift mechanism of the machine is modified. More than 50 thermocouples are attached to tubes and measure the temperature of the inner part cake during the whole build process. In a second step, the influence of important job parameters like the build height and the used layer thickness is analyzed for part-free build jobs. The third step considers the influence of built parts on the temperature distribution and history. In addition, the different temperature histories are correlated with powder and part properties, for example the part crystallinity (and thereby shrinkage, warpage and mechanics) and the powder age (melt volume rate).

Simulation of the cooling process

The results of the temperature measurements are used to simulate the cooling process using the Finite Element Method (FEM). In this way, important thermal parameters of the bulk powder are analyzed. Different cooling down strategies can be tried out without the need of further experiments. An optimization of the cooling process, which is vital for better and more constant part qualities, may be developed in a follow-up project.