

Efficient and cost-effective optimization methodology for laser powder bed fusion parameters to manufacture dense and mechanically sound parts validated on AlSi12 alloy

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The main drawback of laser powder bed fusion (L-PBF), commonly called selective laser melting (SLM) is the high porosity which may lead to an early failure of the parts. To minimize it, the L-PBF parameters need to be optimized focusing on the laser power, scanning speed and hatching space. Many studies have optimized the L-PBF parameters by analyzing density of samples with different L-PBF parameters, analyzing single scan tracks (SST), etc. However, no standard guideline exists.

In this study, an efficient and cost-effective optimization methodology is developed and validated on AlSi12. This innovative methodology brings together SST and macroscopic properties analysis with design of experiments (DOE). It requires three batches of:

1. SST: for the analysis of the geometrical features of the melt pool
2. Cubes: for density analysis
3. Tensile specimens: for static mechanical properties analysis.

This work shows that nine SST are sufficient to identify a process window that is 85% similar to the one obtained from a full factorial design with 105 SST. This process window based only on 9 SST already reliably leads to high densities (>99.3%). After refinement of the process window based on the cube analysis, the optimized L-PBF parameters lead to better mechanical properties in comparison to the state-of-the-art properties reported in the literature for L-PBF AlSi12.

In conclusion, a methodology using only nine SST, 18 cubes and 12 tensile tests has been validated on AlSi12. It is further envisioned to optimize the L-PBF parameters of any existing alloy leading potentially towards better mechanical properties than that currently in the literature.