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Optimization of SLM process for high density stainless steel 316L

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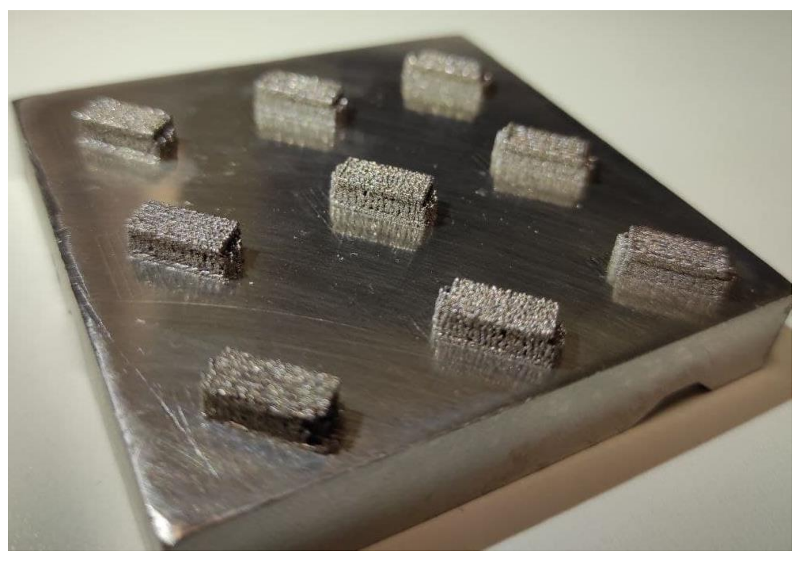
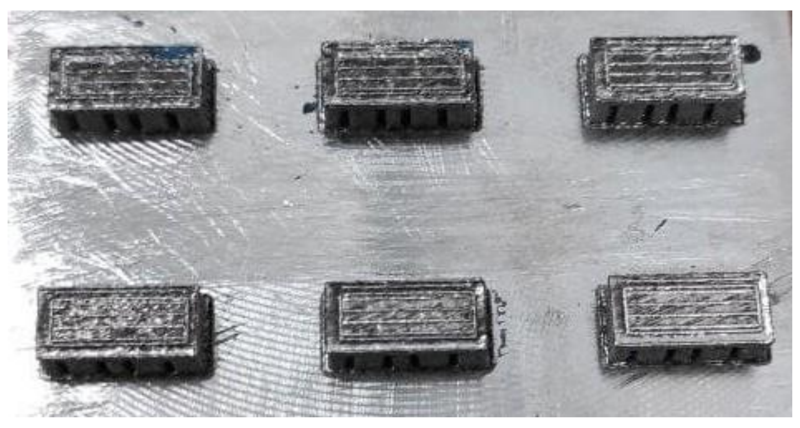
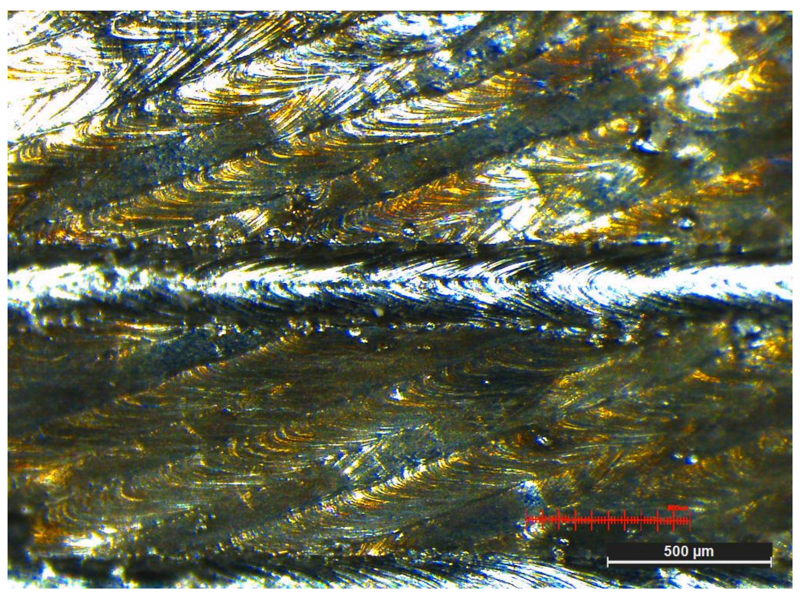
Introduction

Selective laser Melting (SLM) is an Additive Manufacturing (AM) technology, its most significantly benefit compared to conventional manufacturing is the flexibility of the designed part produced. The growing demand for SLM in the industry has increased the need for process development and parameter optimization for new metal powder.
The optimal parameters window is experimentally determined for each metal powder. There are several approaches to find a window of optimal parameters, the most widely used approach is to conduct single track experiment followed by identification of the process parameters which results in suitable melt pool formation. The optimal parameters in terms of density can be determined experimentally by printing parts using different combinations of parameters by mean of a Design of Experiment method and determining the best parameters based on density measurement.
In this study, the optimization of the parameters has been achieved by the DoE approach applied to the single track experiment, in order to build an effective regression model. The regression model has been used to set different combination of process parameters (treatments) to check the relative density, measured with the Archimede's method.



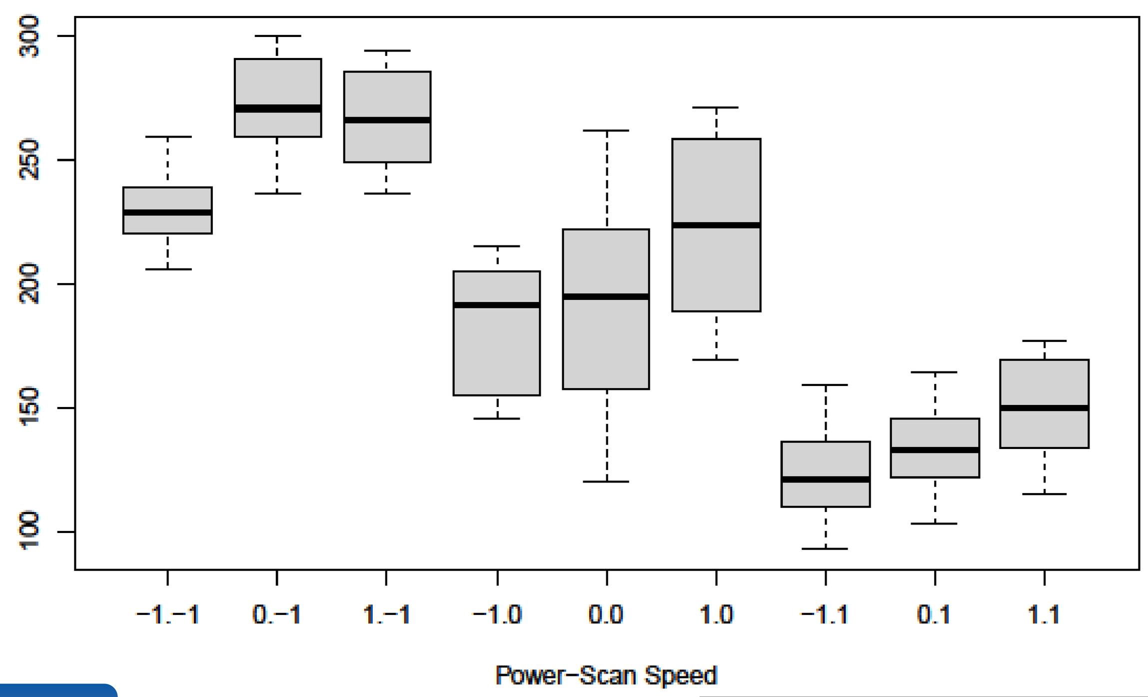


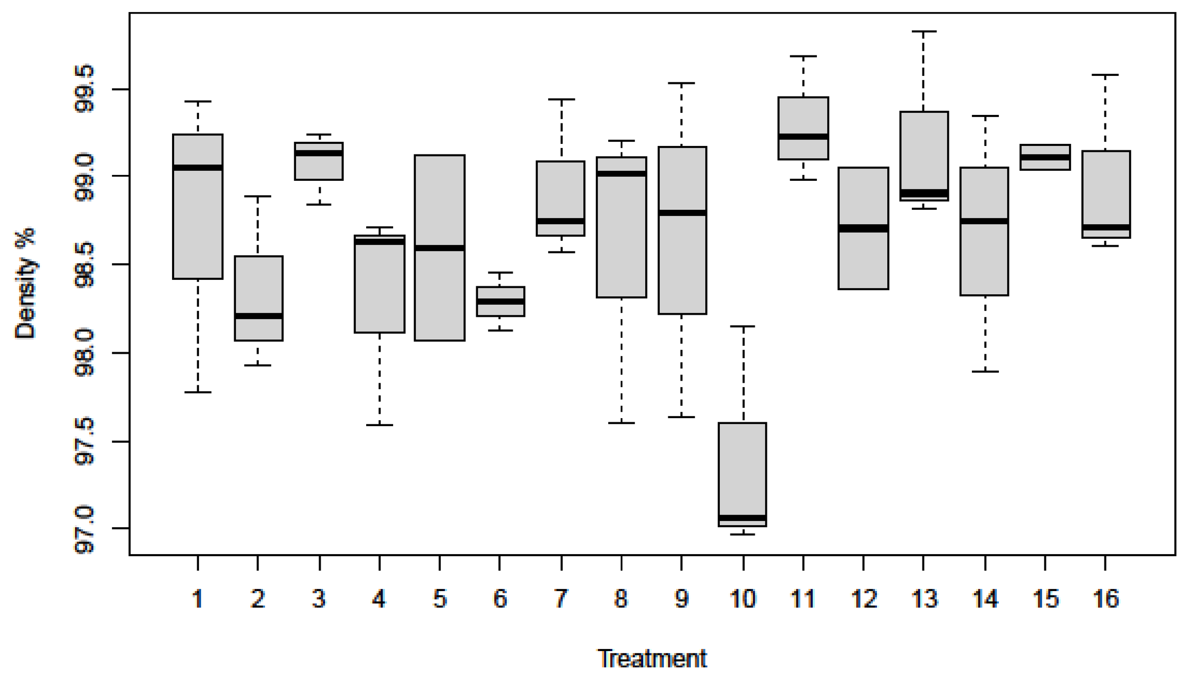


Experimental Methods

In order to get a good quality of single tack the process needs to be stable and free of uncontrollable parameters. The best way to reduce these uncontrollable factors is to print the tracks on a flat structure. In this way, the tracks are printed when the process is stable in terms of temperature and tickness of the layer. This also allow to print the tracks on the same material that avoids some unwanted effects.
The flat structure need to be printed in such a way that permit to identify the traks and get reliable and clear measurements. MetalOne offers the possibility to use a so called «test mode» for a quick Design of Experiment. This modality is used to print the same object with different level of laser power and scan speed.
This study has been relized through the following steps:
- First trial in order to find good process parameters to build the support
- Full factorial matrix 3^2 with 5 repetitions in order to investigate the effect of laser power and scan speed on track width
- Regression model of track width
-A full factorial matrix 2^4 with 3 repetitions in order to investigate the effectivness of the regression model with different combiation of proccess parameters on the relative density measured.

Level	Power [W]	Scan speed [mm/s]
-1	162.5	200
0	200	300
1	237.5	400





Results

The results obtained from the single track experiment clearly show that there is a trend of the track width due to laser power and scan speed parameters. It is shown that increasing the laser power and decreasing the scan speed the track width increase and vice versa.
The results obtained from the second analysis show that the chosen combination of parameters gives in output high relative density of the object. The statistical analysis of the relative density investigation shows a correlation only between laser power and scan speed parameters. It is possible to say that this combination of parameters falls into the operative window.
As a result of this experiment, three groups of parameters have been selected as optimal parameters in terms of density for MetalOne using this powder.

N°	S.S. [mm/s]	Power[W]	Overlap[%]	Wiper speed	Mean density [%]	Variance [%]
1	200	162.5	30	500	98.8	0.74
2	300	162.5	30	500	98.3	0.24
3	200	200	30	500	99.1	0.04
4	300	200	30	500	98.3	0.39
5	200	162.5	40	500	97.9	1.62
6	300	162.5	40	500	98.3	0.02
7	200	200	40	500	98.9	0.21
8	300	200	40	500	98.6	0.76
9	200	162.5	30	750	98.6	0.91
10	300	162.5	30	750	97.4	0.43
11	200	200	30	750	99.3	0.13
12	300	200	30	750	97.2	6.53
13	200	162.5	40	750	99.1	0.31
14	300	162.5	40	750	98.7	0.53
15	200	200	40	750	97.7	5.69
16	300	200	40	750	99.0	0.28

Conclusion

This study shows the effectivness of the single track approach for the optimization of the parameters. Using this approach it is possible to reduce the time required and number of experiment needed to optimize the process parameters. It is hepful to find an operative window for a new metal powder and also to find out different combination of parameters to reduce the production time.