Development of AlSi10Mg based alloys for Additive Manufacturing Processes

Additive manufacturing (AM) technologies are rapidly diffusing in the industrial field thanks to their capability to produce complex-shaped components avoiding/reducing post processing machining steps. The interest in the production of metal components for several fields such as automotive, aerospace and biomedical is significantly increasing. For this reason, developing new alloy compositions suitable for AM production, aiming to enlarge the spectrum of the possible applications, is becoming an important goal for researchers. Special care for every process step is mandatory, from raw material production to the final component built.

This thesis focuses on the AM technology of laser powder bed fusion (LPBF), which requires the feedstock material in a powder state. The process to produce powders suitable for AM, which leads the market, is gas atomization. This thesis aims to describe the entire process of components production via LPBF, starting from the powder production and characterization, passing by the process parameters optimization and bulk production, and ending with the improvement of the characteristics of the as-built components.

The material chosen for this research was the AlSi10Mg, a well-known aluminum alloy in the AM field. The first step was to produce an AlSi10Mg powder with a laboratory-scale gas atomizer and compare it with a commercial-grade counterpart. In this part, the focus was on the advantage in time and cost savings using a laboratory-scale atomization plant to produce powders for research purposes rather than buying the powder from a big supplier. The freedom of design and control of the process of a laboratory-scale gas atomizer is not reachable with an industrial-scale one. In addition, it has been demonstrated that the powders characteristics are strongly comparable with the commercial-grade counterpart, making the laboratory-scale gas atomization an ideal candidate for research purposes.

The next step was to define a combination of process parameters suitable for LPBF production. Several methods are available to achieve this goal, and the present work is focused on the single scan track (SST) method. This choice is due to the SST method main advantages: cost-effectiveness and time-saving. However, the SST method presents some critical points already described in the literature. The aim of this thesis was to overcome the problem related to SST analysis, proposing a new method which also increases the analysis rapidity and precision. After the combination of process parameters was defined, the comparison between self-produced AlSi10Mg and the commercial-grade counterpart powders was extended to the bulk samples properties. Here, different features were evaluated such as densification, microstructure and mechanical properties, confirming that the self-produced powder was suitable for LPBF production.

The last step was to investigate how to improve the as-built characteristics of AlSi10Mg with minor modification of its composition. In this context, the use of modifying elements such as erbium and strontium, added in limited weight percentage in the alloy, could modify the microstructure of the as-built state components with a consequence on the mechanical properties. In the present work, promising results were achieved with erbium regarding hardness modification..