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Study and Fine Characterization of the SS 316L Microstructures Obtained by Laser Beam Melting Process

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Abstract : Laser beam melting (LBM) is an additive manufacturing process that enables complex 3D parts to be designed. This process is now commonly employed for various applications such as chemistry or energy, requiring the use of stainless steel grades. LBM can offer comparable and sometimes superior mechanical properties to those of wrought materials. However, we observed an anisotropic microstructure which results from the process, caused by the very high thermal gradients along the building axis. This microstructure can be harmful depending on the application. For this reason, control and prediction of the microstructure are important to ensure the improvement and reproducibility of the mechanical properties. This study is focused on the 316L SS grade and aims at understanding the solidification and transformation mechanisms during process. Experiments to analyse the nucleation and growth of the microstructure obtained by the LBM process according to several conditions. These samples have been designed on different type of support bulk and lattice. Samples are produced on ProX DMP 200 LBM device. For the two conditions the analysis of microstructures, thanks to SEM and EBSD, revealed a single phase Austenite with preferential crystallite growth along the (100) plane. The microstructure was presented a hierarchical structure consisting columnar grains sizes in the range of 20-100 µm and sub grains structure of size 0.5 µm. These sub-grains were found in different shapes (columnar and cellular). This difference can be explained by a variation of the thermal gradient and cooling rate or element segregation while no sign of element segregation was found at the sub-grain boundaries. A high dislocation concentration was observed at sub-grain boundaries. These sub-grains are separated by very low misorientation walls (< 2°) this causes a lattice of curvature inside large grain. A discussion is proposed on the occurrence of these microstructures formation, in regard of the LBM process conditions.

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