Study of the effect of a superficial nanocrystallization treatment on the fatigue properties of Selective Laser Melted 316L Steel Parts

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Résumé

Selective Laser Melting (SLM) is a metal Additive Manufacturing (AM) process widely used in industry for its extraordinary versatility and minimal waste of material. Mechanical properties of SLM parts strongly depend on the process parameters such as power, scanning speed, hatch space or scanning strategy. Nevertheless, despite the quality of the manufacturing process, SLM leads to two major drawbacks for fatigue life. The surface quality generated is poor and it introduces a tensile residual stress field in the near surface area of the part.
The use of post-treatments can help to overcome these problems. SMAT (Surface Mechanical Attrition Treatment), which is based on ultrasonic attrition technique, is studied in this work as a potential mechanical post-treatment on stainless steel parts processed by AM. Through successive impacts on the surface of selective laser melted samples, SMAT is shown to generate a superficial nanostructured layer as well as compressive residual stresses coupled with strain hardening in the subsurface layers of the treated parts. Two intensity levels of SMAT, , were applied to 2 mm thick pieces of a 316L austenitic stainless steel, fabricated by SLM.
Experimental characterizations of the samples were carried out before and after SMAT through surface roughness measurements, micro-hardness profile evaluation, EBSD analyses and residual stress profile measurements. Fatigue properties were determined in flexural bending in the high cycle fatigue range of 105 to 2x107 cycles. The results show that SMAT can drastically increase the fatigue resistance of SLM parts by means of a high reduction of surface roughness, introduction of compressive residual stresses, increase of micro-hardness and the generation of a nanostructure in the subsurface layers of the treated parts . Characterizations of the failed specimens were performed to understand the origin of this significant mechanical improvement.

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