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ANALYSIS AND MAPPING OF DEFECTS TO PREDICT AND ENHANCE THE PERFORMANCE OF ALSI10MG SAMPLES PRODUCED BY PBF-LB/M

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Summary: Additive Manufacturing (AM) is an emerging technology that has extended its applications in the last decades to a wide range of sectors such as the biomedical, automotive, aerospace and transportation industries. This technology has proven to be a strong candidate compared to other manufacturing techniques, capable of delivering complex and lightweight parts with high densification when employing optimized process parameters. Nonetheless, variations of these parameters can originate process-related defects and, in some cases, more material-related defects, leading to non-optimal parts.

In the present work, the capabilities of Digital Image Correlation (DIC) as a non-destructive testing method for detecting both superficial and internal defects in AlSi10Mg components manufactured through Powder Bed Fusion - Laser Beam based of Metals (PBF-LB/M) are presented, highlighting its sensitivity, accuracy, and potential for ensuring the structural integrity of advanced AM materials. For this purpose, AlSi10Mg uniaxial tensile test using dogbone specimens were produced by PBF-LB/M and three different printing scenarios were chosen from a wide range of processing conditions. The first set of specimens was manufactured using optimized parameters while the other sets were printed with the same laser power and hatch spacing but with different scan speeds, in order to induce keyholing and lack of fusion defects. Additionally, gas pores were also presented in all printed sets, representing a material-dependent defect characteristic of cast aluminium alloys.

Results from tensile testing were obtained by a combination method using two-dimensional (2D) DIC and X-Ray Computed Microtomography (µCT) coupled with a strain gauge extensometer and a clip gauge. The approach evaluated the mechanical properties and the deformation behaviour of specimens while mapping and tracking down surface and internal defects, and their impact on the strain and stress fields of specimens derived from subsequent static loading stages. Such defects were characterized based on their size, shape, orientation, volume fraction, distribution, and concentration. These parameters were used as indicators of porosity and performance and the results from both tensile tests and micro-CT were used to validate the sensitivity and accuracy of DIC. This validation focused on predicting the location and impact of defects related to the material and manufacturing process.

In addition, Young's Modulus, yield strength, ultimate tensile strength, elongation at break and Poisson's ratio were also retrieved from this work to assess the performance of specimens produced in optimal and non-optimal printing conditions.Present results contribute to determining the capacity of DIC as a non-destructive testing technique for identifying and characterizing both surface and internal defects in AlSi10Mg components manufactured via PBF-LB/M.