Investigating the influence of the energy density distribution on the quality of laser sintered polyamide-12 parts by using X-Ray Computed Tomography

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Abstract
Laser sintering of polymers is an additive manufacturing technique used to produce layer by layer 3D polymeric objects. Laser sintered products are progressively used as functional parts in high quality standards sectors like the medical and automotive ones. During the process the melting of the polymeric powder is achieved thanks to the energy delivered by the CO₂ laser on the powder bed, which leads to progressive flow and densification of the material. However, the capabilities of the polymer to reach high densities and meet the dimensional tolerances required, strongly depends on the way the energy is delivered on the surface of the powder bed. In this work X-ray Computed Tomography is used to investigate the influence of the energy density distribution on the quality of laser sintered polyamide-12 parts, intended both as defects present in the microstructure and external dimensions.

Keywords: X-ray Computed Tomography, Laser Sintering, Porosity Analysis, Non-Destructive Testing, Quality Control, Energy Density Mapping, Dimensional Metrology

Introduction
Additive Manufacturing (AM) processes are increasingly being used to produce functional parts instead of prototypes. Laser Sintering (LS) is the most promising polymer processing technique that can aim to meet the quality requirements of the most demanding application sectors (ex. medical and automotive). However, some aspects of the LS process still need to be improved, in order to reduce the spread in part quality [1, 2] and to have a better control on the outcome of the process. The density and the final dimensions of the part depends on the way the energy is delivered on the surface of the powder bed by the CO₂ laser, namely to the process parameters and scanning strategy used. The unique capabilities of CT to inspect both the internal and external structures of workpieces allows to gather information both about the porosity present within the laser sintered object and to verify its dimensions and tolerances in a non-destructive way [3-6]. By correlating the information gathered through the analysis of the CT datasets with the energy distribution is possible to check the influence the process parameters and scanning pattern on the quality of a certain part, in terms of pores present in the microstructure and the dimensions. The use of porosity maps [4-6] allow to spot the area most affected by porosity, allowing to correlate it with the actual energy distribution used to build a part. Dimensional deviations of the parts are also correlated with the local energy distribution. A discussion about the predictability of the deviations from the quality requirements, based on the pre-assessment of the process parameters is also given.

Figure 1 a) Scanning pattern used to build a layer; b) relative CT-slice of the layer laser-scanned using the vector’s pattern in a); c) Cumulative porosity map relative to all the layers printed using the vector’s pattern in a).
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References