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Laser line scanner aptitude for the measurement of Selective Laser Melting parts

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ABSTRACT

When looking for any metrological verification of parts manufactured by metal laser printing with optical equipment, it is necessary to ensure the traceability of the measurements that can be obtained. The difficulty of this process lies in the fact that these measurements are obtained on point clouds captured from surfaces with high form errors and poor surface finishes, even when this type of surface usually undergoes processes to improve the surface finish, such as sandblasting. This research focuses precisely on the analysis of the metrological suitability of a laser line scanner (laser triangulation sensor) on parts manufactured by Selective Laser Melting (SLM).

The study starts from the design of a test part specifically oriented to the printing process with SLM metal powder bed. This test part was printed in 17-4PH stainless steel and then sandblasted. The test part was measured in a Coordinate Measuring Machine (CMM), obtaining reference GD&T values. The measurement was carried out under pre-sandblasting ("as built") and post-sandblasting conditions, thus providing interesting information about the erosion rate of this post process. A state-of-the-art laser sensor was employed for the metrological comparison, mounted on the same available CMM that was used for contact measurements.

In this research three analyses were carried out: the quality of 3D metal printed parts with respect to CAD model, the effect of the sandblasting post-process, and the accuracy of the measurements obtained with the laser line sensor. In addition, this work conducts an in-depth study about the influence of point cloud treatment and filtering procedures, by comparing the filtering methods applied by different reverse engineering software packages. The study leads to the conclusion that filters based on the standard deviation of the point cloud are the best candidates in order to obtain laser measurements closer to the contact measurements.

1. Introduction

Non-contact optical measurement and reverse engineering techniques are increasingly used for the measurement and verification of parts obtained by additive manufacturing techniques. In the case of Selective Laser Melting (SLM), where it is intended to generate functional parts in small batches or even unique, the use of these non-contact inspection techniques is even more interesting, as they allow to capture high-density point clouds of very complex geometries in short time. In addition, the free and usually intricate typology of these parts converts them into evident targets for applying non-contact reverse engineering equipment at the inspection stage. Although the evaluation is only external and performed at the surface level (with the exception of Computerized Tomography), they constitute valid techniques for the dimensional inspection of multiple external geometries, either simple or complex. These optical inspection equipment may become the only suitable techniques due to the high ratio between the number of points captured and the inspection time.

Nevertheless, in order to deploy effectively these techniques, the accuracy that can be reached from the metrological point of view still needs to be determined, beyond the basic application of reverse engineering, i.e., the reconstruction of the geometry [1–5]. Despite the fact that there are already standards [6–9], and specific devices [10–15] designed for assessing optical inspection systems, they are not completely adapted to certain sensors, and the influence of materials, surface finishes, lighting, etc. must be studied [16–20]. The procedures are also diverse depending on the technology used by the sensor, either laser triangulation in CMM [21–25] or laser triangulation in AACMM [26–28] among other equipment (such as structured light, 2D optical CMM, focus variation, etc.), being adapted to the particularities of each technology and its strategies, technological parameters, etc.

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