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Analysis of Modern Optical Inspection Systems for Parts Manufactured by Selective Laser Melting

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Abstract: Metal additive manufacturing (AM) allows obtaining functional parts with the possibility of optimizing them topologically without affecting system performance. This is of great interest for sectors such as aerospace, automotive, and medical–surgical. However, from a metrological point of view, the high requirements applied in these sectors constitute a challenge for inspecting these types of parts. Non-contact inspection has gained great relevance due to the rapid verification of AM parts. Optical measurement systems (OMSs) are being increasingly adopted for geometric dimensioning and tolerancing (GD&T) verification within the context of Industry 4.0. In this paper, the suitability (advantages and limitations) of five different OMSs (based on laser triangulation, conoscopic holography, and structured light techniques) for GD&T verification of parts manufactured by selective laser melting (SLM) is analyzed. For this purpose, a specific testing part was designed and SLM-manufactured in 17-4PH stainless steel. Once the part was measured by contact (obtaining the reference GD&T values), it was optically measured. The scanning results allow comparing the OMSs in terms of their inspection speed as well as dimensional and geometrical accuracy. As a result, two portable systems (handheld laser triangulation and structured blue-light scanners) were identified as the most accurate optical techniques for scanning SLM parts.

Keywords: optical measurement systems (OMSs); dimensional and geometrical accuracy; metrological comparison; non-contact inspection; 3D scanning; additive manufacturing (AM); selective laser melting (SLM)

1. Introduction

Additive manufacturing (AM) is an emerging process to make objects from a 3D CAD model, joining materials layer by layer. AM processes include different techniques, materials, and equipment, and they have greatly evolved in recent years due to the significant advantages compared to subtractive manufacturing processes: complex geometry manufacturing with high precision, material savings, design flexibility, parts customization, and integrating new applications thanks to the continuous development of new materials and additive systems [1]. Advances in AM are generating new design possibilities, products, and production paradigms. The introduction of new business models and the general time-to-market reduction are driving interest in AM technologies [2].

Metal AM allows the manufacturing of final topological optimized parts, improving the performance of the system. It enables designers to create lightweight parts and minimize material usage. These factors offer great benefits in sectors with high requirements, such as automotive,