Investigation on the Accuracy of CT Porosity Analysis of Additive Manufactured Metallic Parts

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Abstract

Additive manufacturing (AM) is emerging as an important manufacturing sector, due to its almost unlimited design freedom, the capability to produce personalized parts and the efficient material use. A reliable knowledge about material porosity of manufactured parts is crucial for optimizing AM process parameters. Indeed, internal pores can be sometimes desirable, e.g. for biomedical implants and thus obtained intentionally by an appropriate selection of such parameters. However, pores are mostly unwanted defects (e.g. in automotive and aerospace sectors) which appear due to process irregularities. X-ray computed tomography (CT) has become a promising method in the field of porosity analysis. Although metrological CT systems are available today and are used as coordinate measuring systems for performing dimensional measurements, their capability of accurately quantifying pores volume and local distribution is still to be proven. The current work aims at investigating the accuracy of CT porosity analysis of AM metallic parts by means of comparisons with other techniques, including Archimedes method and microscopic analysis of cross-sections. Experiments were conducted on Ti6Al4V tensile specimens produced by selective laser melting (SLM), for which the correlation of internal porosity with mechanical properties is of high interest (e.g. for optimizing AM process parameters). In particular, specific cross sections were selected to compare porosity analyses by CT and by microscopic optical measurements after destructive sectioning. Optical measurements were found to provide systematically larger dimensions of pores in comparison to CT measurements. The same samples were CT scanned before and after the cutting procedure: a significant enlargement of pores diameters was confirmed only for pores in the cut section. Possible causes were identified in the cutting procedure itself and the outflow of entrapped powder. Reference measurements for diameters of pores were obtained by means of a high-accuracy CMM equipped with image processing sensor (MPE = (1.8+L/250) µm, with L in mm). In addition, an aluminum reference object with calibrated hemispherical defects was manufactured by micro-milling at the University of Padova and then used for evaluating the accuracy of CT 3D defect detection.

Keywords: defect detection, Dimensional control, Archimedes method, Additive Manufacturing, porosity analysis, X-ray Computed Tomography, micrographic cross-section