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Method Article

Standard method for microCT-based additive manufacturing quality control 1: Porosity analysis

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ABSTRACT

MicroCT is a well-established technique that is used to analyze the interior of objects non-destructively, and it is especially useful for void or porosity analysis. Besides its widespread use, few standards exist and none for additive manufacturing as yet. This is due to the inherent differences in part design, sizes and geometries, which results in different scan resolutions and qualities. This makes direct comparison between different scans of additively manufactured parts almost impossible. In addition, different image analysis methodologies can produce different results. In this method paper, we present a simplified 10 mm cube-shaped coupon sample as a standard size for detailed analysis of porosity using microCT, and a simplified workflow for obtaining porosity information. The aim is to be able to obtain directly comparable porosity information from different samples from the same AM system and even from different AM systems, and to potentially correlate detailed morphologies of the pores or voids with improper process parameters. The method is applied to two examples of different characteristic types of voids in AM: sub-surface lack of fusion due to improper contour scanning, and tree-like pores growing in the build direction. This standardized method demonstrates the capability for microCT to not only quantify porosity, but also identify void types which can be used to improve AM process optimization.

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Introduction

Additive manufacturing (AM) is a fast growing and reliable manufacturing method, with critical metal parts for medical and aerospace applications being produced and processing workflows qualified for the purpose, see for example [1]. Despite huge advances, there are a lack of standards especially for microCT based inspection of AM parts [2]. The microCT-based non-destructive analysis of additive manufactured parts was reviewed recently in [3]. Additive manufactured parts are typically prone to defects such as voids or porosity, which negatively affect their mechanical performance. In the ideal scenario, defects should be minimized in size and extent, which can be achieved through process parameter optimization [4]. Although inspection of the final built part non-destructively is also important, the achievable resolution of X-ray microCT is limited by part size. Typically microCT resolution scales linearly with part size, e.g. 50 mm part results in 50 μm resolution, 20 mm part results in 20 μm, etc. [5] Since some types of additive manufacturing defects may be small and hence missed in a scan of a large complex part, process optimization should ideally be achieved prior to building critical parts. Such process optimization can be done using microCT of small test samples.

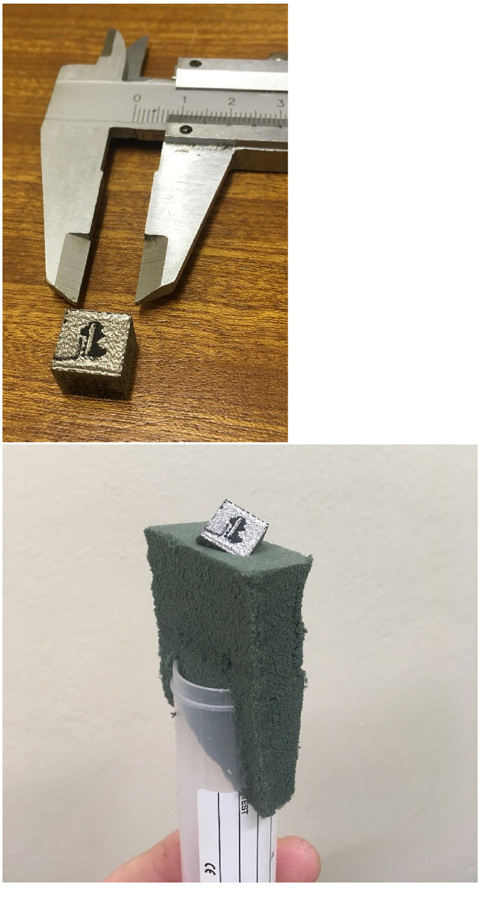
(a)
(b)

Fig. 1. SLM produced Ti-6Al-4V coupon; (a) as-built, (b) sample mounted on foam for a scan.