3D Inspection Of AM Components Using CT: From Defect Detection To Thermal Simulation In COMSOL Multiphysics®

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Abstract

Metal Additive Manufacturing (AM) can be used to create topologically complex designs that would otherwise be difficult or impossible to produce using traditional methods. However, non-destructive inspection and testing of these structures is made difficult by the presence of internal or inaccessible features, leading to defects in built parts being overlooked. For manufacturers, this can mean more time spent on performance testing, and potentially more part failures, scrappage, and resource wastage.
This presentation will discuss a methodology using X-ray Computed Tomography (CT) as part of a non-destructive testing process that includes thermal performance simulation in COMSOL Multiphysics®. The industrial example used is a "hot box" heat exchanger, which was manufactured using AM by HiETA Technologies Ltd., before being CT scanned at the Manufacturing Technology Centre. From the CT scan, an image-based model was generated for processing within Simpleware™ ScanIP software (Synopsys, Inc., Mountain View, USA).
Analysis was carried out to identify defects and deviations from the original design of the "hot box", with the part deemed fit for use if deviations fell within allowed tolerances. If not, further simulation and re-manufacturing using new design parameters or materials was required. By comparing the "as-built" AM surface and the "as-designed" CAD surface in Simpleware software, deviation analysis showed where they differed from the planned design.
To gain more insights into virtual performance, an image-based simulation was conducted of the "real" part, as opposed to the CAD idealisation, in COMSOL Multiphysics®. Simulation was carried out of thermal behaviour in COMSOL Multiphysics®, focusing on coupled heat transfer and laminar flow. Using this method, further comparison was made of the "as-designed" CAD-based simulation and the "as-built" image-based simulation from a full volumetric mesh generated using Simpleware software. With this approach, defects, pores, warping, etc. occurring at the manufacturing stage can be assessed.
The "hot box" heat exchanger example yielded results in terms of structural defects, such as trapped powder in narrow channels, and deviations in the lattice structure of the part. Taken together, the ability to perform dimensional, integrity, and surface inspection within a single workflow was highly beneficial for improving the current production process of the "hot box". The additional results have the potential to reduce inspection time and reliance on additional inspection equipment, thereby reducing costs, cycle times, and freeing up workable floorspace.