Transactions on Additive Manufacturing Meets Medicine
Trans. AMMM, 2025, Vol. 7, No 1, Suppl. 1, Article ID 2053, 1 Page

Infinite Science Publishing

Abstract

X-ray inspection and pore-classification in additive manufacturing: A systematic study on Al-alloys

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In recent years, additive manufacturing (AM) of metals gains more and more interest in the automotive and aerospace industries as well as medicine [1]. Thus, the associated component analysis - especially with focus on safety aspects - has become increasingly important. In this context, the non-destructive evaluation of the porosity within the material and its minimization by optimization of AM-printing parameters are of great interest. In addition to overall porosity and density reduction [2], this study emphasizes the classification of pore types [3,4]. This allows us to categorize the material and accordingly improve the printing processes, where the combined usage of artificial intelligence (AI) opens the door for an efficient way of material development optimization [5].

As part of the publicly funded GeniAl research project, the presented systematic AM study of an $AlSi_{10}Mg$ alloy in laser powder bed fusion (LPBF) uses microfocus computed tomography (µCT) in combination with a subsequent porosity classification to determine optimal 3D printing parameters and identify a methodology for faster parameter determination. In this contribution, we present the current stage of the project with focus on the associated porosity classification. Building on basic properties like the sphericity and pore diameter it also takes into account the bounding box of each pore as well as the edge-distance and the compactness. We extend existing classification methods by introducing new metrics, for example a limiting pore diameter to correlate pore shape and size. For the systematic AM-study we vary the laser power and the scan velocity for a fixed hatch distance. Four eroded slices from center to the edge of the printed cube are investigated by µCT and a subsequent porosity analysis. Performing the pore-classification for each printing parameter leads to parameter landscapes which allow us to find the optimal AM-parameter set by identifying where the number of a specific pore class increases or decreases. The measurements revealed a reduction in irregular pore types of about 14 % at optimal AM settings within the evaluated parameter range. The proposed limiting diameter is used as a supplementary indicator as it shows similar tendencies compared to the classification process. Thus, the systematic study sheds light on the porosity statistics for different printing parameters and allows a good identification of optimal AM-settings for a specific porosity type. Finally, we show that an X-ray µCT based porosity analysis in combination with a tailored pore classification could enable rapid identification of optimal LPBF parameters, reducing material waste and improving reliability in AM production.

Author's statement

Conflict of interest: Authors state no conflict of interest. Acknowledgments: Financial support by the Federal Ministry of Education and Research (BMBF) via the funding project 01LY2301B is gratefully acknowledged. The company Fehrmann Materials GmbH & Co. KG is acknowledged for the cooperation and the fruitful discussions as well as for providing the sample material.

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DOI: 10.18416/AMMM.2025.25062053