EFFECT OF DEFECT

Defects such as porosity are more commonly encountered in as-built Additive Manufacturing (AM) parts than in wrought alloys and some defects, such as trapped powder or lack of fusion etc., are unique to the DMLM process. Process-specific defects that can be produced during the generation need to be characterized using destructive and non-destructive evaluation methods, as there are no established standards. Consequently there is a lack of effect-of-defect data for AM parts, which hinders part acceptance. Developing a catalogue of defects commonly encountered in the L-PBF process, and categorizing the critical defect types, sizes and distributions is critical for establishing acceptance criteria.

PROJECT OVERVIEW

DURATION

01/2019 – 01/2020

PARTNER

Industrial Consortium of DMRC

FUNDED BY

Industrial Consortium of DMRC

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DMRC DIRECT MANUFACTURING RESEARCH CENTER RESEARCH INNOVATION EDUCATION

Aim

The aim is to develop a database of typical defects formed during the DMLM process and to study the effect of these defects on the AM part's performance. Based on the effect-of-defect studies, defects can then be classified into critical and allowable categories, which will help establish limits for part acceptance for specific operational conditions as well as develop methods to prevent or reduce the critical defects.

Procedure

Specific material and process parameter combination and operating conditions will be selected to constrain the range and complexity of the problem. Nevertheless there is a need for a strategy that can reproduce specific defects (e.g. pores) in the building process while ideally not creating any other types of defects (cracks) to allow an independent evaluation of the effects on the mechanical properties. The state of the art machines already generate high density parts without severe imperfections and therefore defects like cracks or large voids usually do not occur in standard materials like INC 718, AlSi10Mg or Ti6Al4V. For this reason it is not possible to just build samples with the standard parameters but with intentionally inadequate conditions as wrong parameters, powder humidity or oxygen content to analyse the influence of these conditions on the process.

After developing the procedure to a specific defect, tensile specimen will be produced and analyzed in a CT-scan, so that the reason of failure might be predicted under real conditions. In addition an investigation of the fracture surface (e.g. SEM, light microscopy) will help to determine the cause of failure. As not only the type and size of a defect is important but also the location in the part. In this case, a catalogue will be filled with these information to allow a precise prediction of the negative effects of defects in AM parts in the future. Additionally to the typical tensile tests, a Charpy impact test will be considered, as defects have a major influence on the notch impact strength, especially with brittle materials.

In a first attempt, density cubes will be printed in order to find a method with which the desired types of defects can be specifically generated. If these preliminary tests are satisfactory, tensile specimens will be produced with the parameters and building conditions found. A further examination will introduce the defects locally, in a few layers or a small volume in the tensile specimen, in order to guarantee a defined failure and to be able to consider the distribution as well as the frequency. The printed samples are then examined in the specified manner.

The results of the tensile tests, fracture surface analysis and CT scans will be evaluated together in order to establish a connection to the defects and to achieve a systematic characterization of these. Based on the results, a classification of the defects is then attempted, which classifies them into permissible and inadmissible, taking into account the position, the material, etc. of the defect.

Conclusion

The performance and quality of AM parts is significantly influenced by the material characteristics and process parameters. Characterizing defects and their effect on mechanical performance would help address gaps related to acceptance criteria for AM parts.

Acknowledgements

The DMRC would like to thank the NMI – Natural and Medical Sciences Institute at the University of Tuebingen for taking the pictures of the different pores.

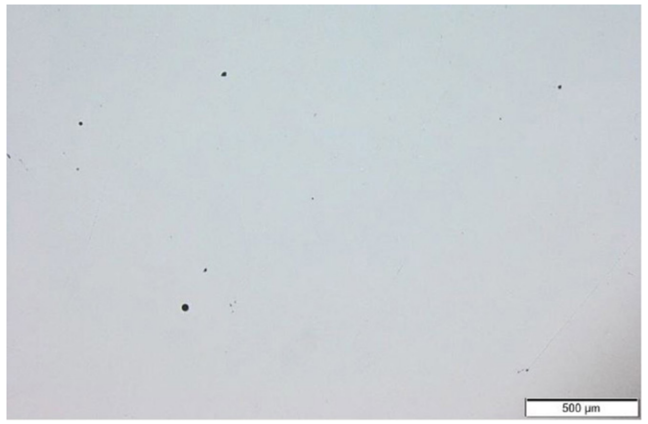

FIGURE 1 Spherical gas porosity

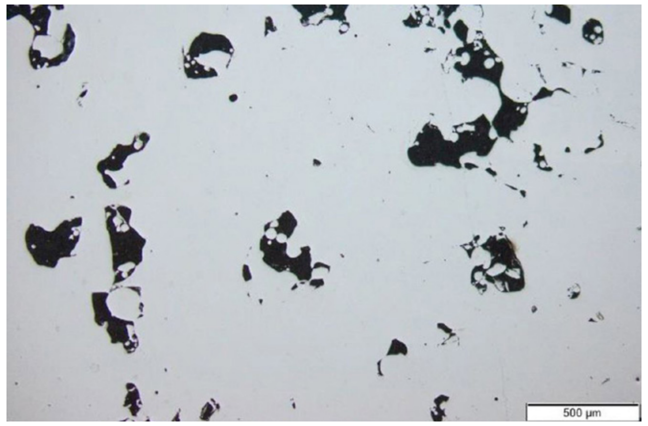

FIGURE 2 Selcetion of demonstrators developed in CaCS

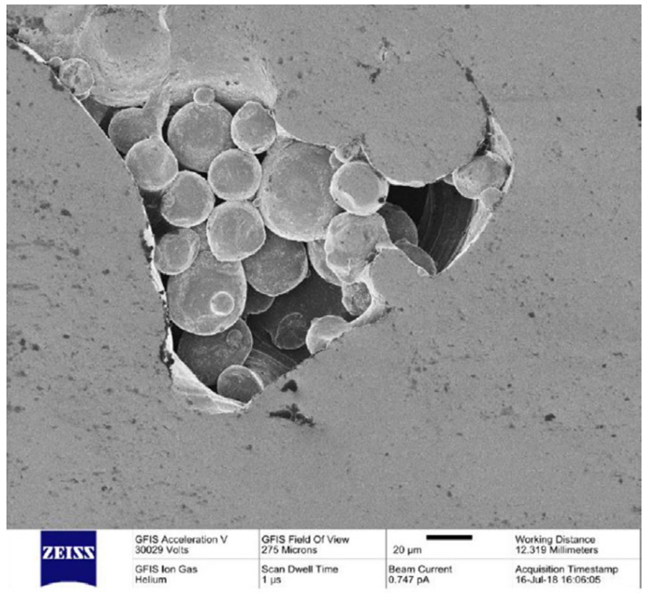

FIGURE 3 Selcetion of demonstrators developed in CaCS