EFFECT OF DEFECT 2.0

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 PBF-LB/M 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 PBF-LB/M process, and categorizing the critical defect types, sizes and distributions is critical for establishing acceptance criteria.

PROJECT OVERVIEW

DURATION

01/2021 – 12/2021

PARTNER

Industrial Consortium of DMRC

FUNDED BY

Industrial Consortium of DMRC

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DMRC DIRECT MANUFACTURING RESEARCH CENTER RESEARCH INNOVATION EDUCATION

Aim

In the 2019 DMRC project “Effect of Defect for SLM” a strategy was successfully developed in which a specific type of defect (gas pores, keyhole pores and lack of fusion) could be locally introduced into samples in a reproductible way. In extensive tests, the effects of these three defect types on static and cyclic mechanical properties of Ti6Al4V were investigated. Based on the defect type, diameter and location, a model for predicting the lifetime of the defect was developed. The current project builds on these results and expands the existing investigations in various areas. The method is to be improved and transferred to other materials. In this case, the material INC718 will be further investigated. Furthermore, a modelling of the results by a computer-aided simulation and component tests are planned.

Experimental Procedure

The strategy developed for Ti6Al4V must be adapted to the new materials through a preliminary study. The aim is to achieve locally introduced defects while maintaining a high density in the rest of the sample. Material-specific parameters for INC718 to create those defects will be evaluated with the powderbed based laser additive manufacturing system from SLM Solutions type 280HL stationed at the DMRC. In case of lack of fusion defects, work will also be carried out on reducing the defect radius to be able to model even smaller bonding defects. Therefore, density cubes will be printed to select the parameters in which the desired types of defects can be specifically generated.
After the required parameters and building conditions are developed, the samples for determining the mechanical parameters (static/cyclic) will be manufactured and the defects will be measured by CT scans. In addition, an investigation of the fracture surface (e.g. SEM, light microcopy) will help to determine the cause of failure. Thus, the defect diameter and the surface can be measured, which are the input variables of the lifetime model. While not only the type and size of the defect are important also the internal location in the part has a significant influence. As in the preceded project, machined tensile specimens will be used. A further examination will introduce the defects locally in a few layers or small volumes in the tensile specimen to account for the distribution as well as the frequency.
The results of the tensile and fatigue tests, fracture surface analyses and CT scans will be evaluated to establish a correlation of the defects and to achieve a systematic evaluation of these. As in the first Effect of Defect project, analogous models will be applied to describe the service life to present the specific results in a transferable way. Since nowadays the lifetime and strength verification is carried out by FEM-Models, the defects should be able to be represented with the relevant influencing factors. Based on this evaluation a classification of the defects will be conducted by taking the position, the material, etc. into account and organize them into permissible and inadmissible defects.

Expected Outcome

The performance and quality of AM parts are significantly influenced by the material characteristics and process parameters. As in the study of Ti6Al4V, local defects were successfully and reproducibly introduced into the samples. It is to be expected that characterizing defects and their effect on mechanical performance for further materials with the already developed strategy is applicable. This would help fill gaps related to the acceptance criteria for AM parts.

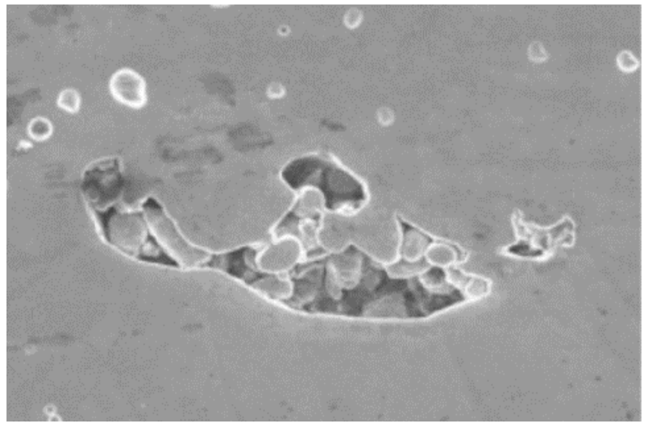

FIGURE 1 Lack of fusion pores

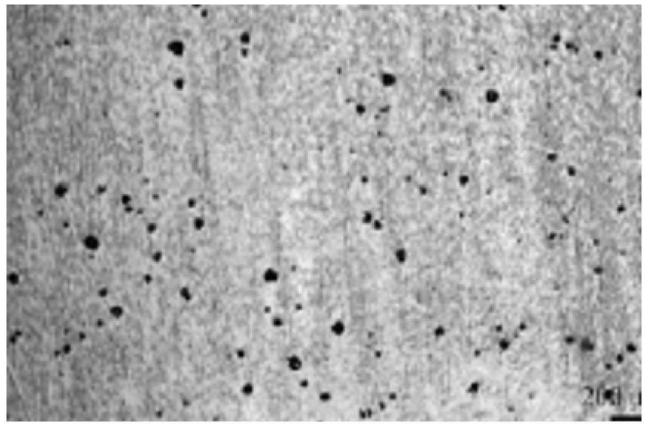

FIGURE 2 Spherical gas pores

FIGURE 3 Computed tomography scan of Ti6Al4V sample