DMLS built Maraging Steel fatigue response investigated for different build orientations and allowance for machining

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Abstract. This work derives its motivations from the increasing interest towards Additive Manufacturing and the lack of studies, mainly in the field of fatigue. The effect of build orientation and of allowance for machining on DMLS produced Maraging Steel MS1 has been assessed. The experimental results, properly set up by tools of Design of Experiment, have been statistically processed and compared. The outcomes were that, probably due to effect of the thermal treatment, machining and material properties, the aforementioned factors do not have a significant impact on the fatigue response. This made it possible to work out a global curve, accounting for all the result. Fracture surfaces have been carefully studied as well.

Keywords: Additive Manufacturing, DMLS, Maraging Steel, rotating bending fatigue.

1 Introduction

A previous study [1] dealt with the effect of build orientation on DMLS produced Maraging steel MS1, following machining and heat treatment, with no significant effect being observed. Conversely, research [2] on Stainless Steel PH1 indicated that the build orientation turns to be effective, when the slanted orientation is introduced in the experiment. Moreover, a higher allowance for machining significantly enhances the fatigue response. The subject of the present study consists in an extension of the outcomes of [1]: it aims at investigating the build orientation effect for incremented allowance and then at deepening the study on the effect of allowance.

2 Experimental and conclusions

Fatigue tests under rotating bending have been performed on DMLS produced heat-treated Maraging steel MS1 samples. The tests aimed at investigating the effect of build

orientation have been arranged, considering three levels of build orientation (horizontal, vertical and slanted) for fixed (3 mm) allowance, thus completing the campaign in [1]. The effect of allowance has been investigated, comparing the fatigue strengths over five levels (allowance of 0.5; 1; 2; 3; 4 mm) for fixed (vertical) build orientation. The results have been statistically processed and compared by an original methodology and the study has then been completed by fractographic and micrographic analyses.

The results indicate that the aforementioned factors do not significantly affect the fatigue response of Maraging steel MS1. Possible reasons may be due to heat treatments and machining removing the possible sources of anisotropy, arising from the different build orientations. Allowance for machining has also a negligible effect unlike for Stainless Steel PH1 [2], due to a more reduced residual stress state, following the stacking process, depending on material properties and on the higher layer thickness. Following the statistical proof of the negligibility of the differences among the results, all the retrieved S-N curves have been merged into a global curve that takes all the fatigue data into account. Based on the fractures surface analysis, it can be emphasized that cracks generally started just beneath the surface (around 80 μm) from porosities having approximately a 40 μm size (Fig. 1).

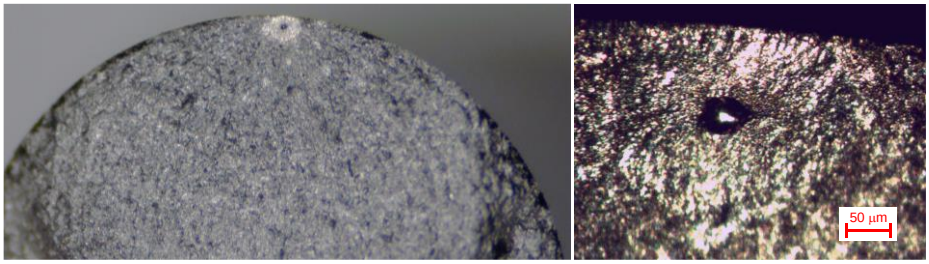

Fig. 1. Crack initiation site (enlarged view on the right).

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