Effects of machining and heat and surface treatments on as built DMLS processed Maraging Steel

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Abstract. The main motivations for this study arise from the need for an assessment of the fatigue performance of DMLS produced Maraging Steel MS1, when it is used in the “as fabricated” state. The literature indicates a lack of knowledge from this point of view, moreover the great potentials of the additive process may be more and more incremented, if an easier and cheaper procedure could be used after the building stage. The topic has been tackled experimentally, investigating the impact of heat treatment, machining and micro-shot-peening on the fatigue strength with respect to the “as built” state. The results indicate that heat treatment significantly enhances the fatigue response, probably due to the relaxation of the post-process tensile residual stresses. Machining can also be effective, but it must be followed (not preceded) by micro-shot-peening, to benefit from the compressive residual stress state generated by the latter.

Keywords: DMLS, Maraging Steel, “as built” state, machining, heat treatment.

1 Introduction

Additive Manufacturing (AM) has great potentials, but also drawbacks, mainly arising from the generation of high tensile residual stresses and from the poor quality of the surfaces of the produced parts. Possible solutions to overcome the mentioned issues are performing an aging heat treatment and making parts undergo machining. It is extremely important to assess the mechanical response of the “as built” components, without further heat treatment and/or machining, to determine if it is affordable to avoid these treatments. Therefore, the subject of this study is tackling this point, investigating also the impact of heat treatment, machining and micro-shot-peening on fatigue.

2 Experimental and conclusions

DMLS Maraging steel parts were tested under rotating bending fatigue. All the samples had vertical orientation with respect to the base plate. The experimental campaign has been arranged as a 2-by-3 factorial plane. In particular, the first two sample sets were in the unmachined untreated and unmachined treated conditions, moreover, both underwent micro-shot-peening just after the building process, as recommended by the material manufacturer. The following two ones, with and without heat treatment, were shot-peened and then machined with 0.5 mm allowance (like in [1]). Finally the last two ones, again with and without heat treatment had shot-peening and machining swapped with respect to the previous case, i.e. micro-shot-peening was performed as the last stage.

The results (some of them are shown in Fig. 1 (a)), in terms of fatigue limits and S-N curves in the finite life domain, were processed and compared by analysis of variance. They indicate that heat treatment, probably due to the relaxation of the post-process tensile residual stresses, has the greatest beneficial impact on the fatigue response. Conversely, operating the micro-shot-peening just after the stacking process seems to have a not positive effect, if followed by machining. Swapping these two treatments is the most proper approach, to benefit of the better surface finishing and of the peening induced compressive residual stress state. Moreover, based on micrographies (an example is provided in Fig. 1 (b)), it can be observed that after the heat treatment the material structure is made more uniform than in the untreated state, however the patterned structure is still undoubtedly present.

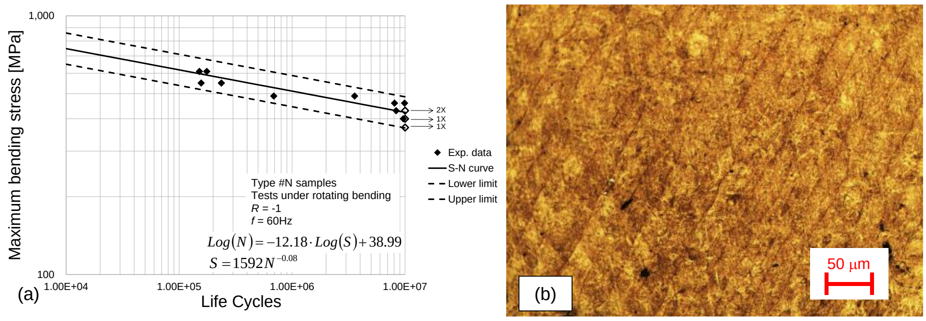

Fig. 1. (a) S-N curve and (b) structure on the build plane for unmachined treated samples.

3 Acknowledgements

The research presented in this paper has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 734455.

References

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