Proceedings IRF2020: 7th International Conference Integrity-Reliability-Failure.
J.F. Silva Gomes and S.A. Meguid (editors), INEGI-FEUP (2020), pp.993-994.
https://paginas.fe.up.pt/~irf/Proceedings_IRF2020/

PAPER REF: 17242

AS FABRICATED DMLS PRODUCED 15-5 PH STAINLESS STEEL: EFFECTS OF POST-MANUFACTURE TREATMENTS

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ABSTRACT

Previous investigations dealt with the effects of build orientation and allowance for machining on the fatigue strength of DMLS produced Stainless Steel 15-5 PH1. Additional studies on Maraging Steel in the "as built" condition, highlighted the heat or surface treatments that are able to enhance the fatigue strength. This work deals with an extensive experimental campaign involving as fabricated 15-5 PH1: the effects of heat treatment, machining and shot-peening after machining have been assessed. The retrieved S-N curves have been compared by statistical methods, highlighting the beneficial effect of the post-machining peening treatment.

Keywords: additive manufacturing, PH stainless steel, heat treatment, machining.

INTRODUCTION

Additive Manufacturing (AM) techniques are capable of producing complexly shaped parts with a short time-to market and high efficiency (Razavi *et al*., 2018). A possible drawback of AM consists in the residual stresses arising from the process. Moreover, AM produced parts may have their fatigue strength, detrimentally affected by internal or surface defects (voids or porosities, due to unmolten particles, entrapped gas bubbles or lack of penetration of the molten pool) (Razavi *et al*., 2018), or poor surface finishing, when left in the "as fabricated" state.

15-5 PH stainless steel is widely applied in aerospace or for parts, such as fasteners or gears, operating in harsh environments and has an improved toughness with respect to 17-4 PH. The present study is focused on this material with regard to DMLS built parts (by DMLS EOS M280 machine). At a previous stage (Croccolo *et al*., 2018) the combined effects of build orientation and of machining and its allowance were studied. A beneficial impact of greater allowance and of slanted orientation upon building were observed. A literature survey indicates that extensive studies dealing with the fatigue response of as built parts and with the effects of heat-treatment, machining or surface treatments like shot-peening are currently missing. This paper tackles this topic with regard to the fatigue response for finite and infinite life. The response of as built parts and the effects of heat, machining and peening treatments are investigated and assessed by statistical methods. Issues of novelty arise from providing useful recommendations to improve the post-manufacture treatments and for design purposes and from the use of advanced methodologies to isolate the effects of the investigated factors.

EXPERIMENTAL PROCEDURE, RESULTS AND CONCLUSIONS

The experimental two-factor design involving 15-5 PH Stainless Steel is resumed in Table 1. Heat treatment (H900 heat treatment: parts kept at the temperature of 482°C for 2 hours after a

ramp increase from the room temperature in 1 hour time.) was regarded as a two-level (on-off) factor. The effect of machining or surface treatment was investigated over three levels: only shot-peening after heat treatment, shot-peening and machining, machining and subsequent peening treatment. The rationale of performing shot-peening after machining derives from the need of keeping the yielded beneficial compressive residual stress state unaltered, as it would then be removed by further processing. Previous studies on a different material (Croccolo *et al.*, 2018) indicated that proceeding this way, unlike the usual recommendations by powder suppliers, may be highly beneficial. The results were processed by Standard ISO 12107 for determining the S-N curves for finite life and by an ANOVA-based methodology for their comparison. The retrieved fatigue curves are plotted together in Figure 1. The statistical assessment indicates that machining is able to yield a beneficial effect on the fatigue strength for finite life, which is furtherly remarkably enhanced by subsequent shot-peening, consistently with (Croccolo *et al.*, 2018). Conversely, heat treatment does not have a significant impact.

Table 1 - Experimental design (involving 15-5 PH stainless steel samples)

		Machining		
		No	Yes	Yes, with subsequent shot-peening
Aging Heat Treatment	No	Set 23	Set 24	Set 27
	Yes	Set 25	Set 26	Set 28

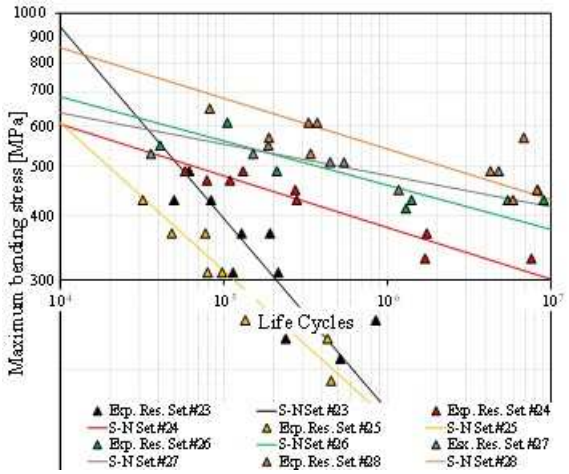

Fig. 1 - S-N curves in the finite life domain for the six investigated combinations

ACKNOWLEDGMENTS

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

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