Probabilistic approach to the fatigue of AM components: formulation, sensitivity analysis and prospective model for 'as-built' surfaces

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ABSTRACT

Despite the disruptive benefits of Additive Manufacturing (AM), the application of this technology for safety-critical structural parts in aerospace is still far from being achieved and standardised. The necessity to comply with very strict reliability requirements is hindering this final step because of the large scatter and low reproducibility always associated with AM, especially in terms of fatigue strength. In this regard, manufacturing defects are the most important and complex issue, but several other sources of variability have an effect as well. The AM community and the main aerospace industries involved are starting to agree that damage-tolerant approaches are necessary and that probabilistic methods are best-suited to obtain reliable but not over-constrained assessments [1].

To address this issue, the authors have developed ProFACE, a fully-probabilistic software that aims to robustly assess the fatigue strength and critical locations of complex components in the presence of defects [2]. This paper presents the underlying concept, its implementation and early validation. The analytical formulation makes this tool ideal to evaluate very low failure probabilities with limited time and effort, which can provide valuable information to significantly improve part design and qualification.

An activity of benchmarking of the software in currently in progress with the support of MTC (Manufacturing Technology Centre) for ESA (European Space Agency). The results of this benchmark will be discussed, especially analysing the effect of the *as-built* surface and their analysis through an *Equivalent Initial Flaw Size* approach [3].

REFERENCES

[1] M. Gorelik. Additive manufacturing in the context of structural integrity. *International Journal of Fatigue*, 94:168–177, 2017.

[2] S. Romano, S. Miccoli, and Beretta S. A new FE post-processor for probabilistic fatigue assessment in the presence of defects and its application to AM parts. *Int. J. Fatigue*, in press, 2019.

[3] D Greitemeier, C Dalle Donne, F Syassen, J Eufinger, and T Melz. Effect of surface roughness on fatigue performance of additive manufactured ti–6al–4v. *Materials Science and Technology*, 32(7):629–634, 2016.