Experimental investigation and numerical simulation of cyclic deformation behavior of SLM-manufactured Aluminum alloys

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ABSTRACT

Selective laser melting process has already been developed for many metallic materials, including steel, aluminum, and titanium. The quasistatic properties of these materials have been found to be comparable or even better than their conventionally-manufactured counterparts; however, for their reliable applications in operational components, their fatigue behavior plays a critical role. This phenomenon is dominated by several process-related features, like surface roughness, remnant porosity, microstructure, and residual stresses, which are controlled by the processing features, like imparted energy density to the material, its corresponding solidification behavior, the cooling rate in the process, as well as post-processing treatments. This study investigates the influence of these parameters on the cyclic deformation behavior of selective laser melted as well as hybrid-manufactured aluminum alloys. The corresponding microstructural features and porosity conditions are evaluated for developing correlations between the process conditions to microstructure, the deformation behavior, and the corresponding fatigue lives. From the numerical point of view, damage development with respect to process-induced cyclic deformation behavior is assessed by the phase-field method, which has been identified as an appropriate method for the determination of fatigue life at the respective applied stress levels [1]. Fatigue strength of SLM-processed parts is found better than their cast counterparts, while hybridization has further increased fatigue strength. No effect of test frequency on the fatigue life could be established.

REFERENCES

[1] Siddique, S., Awd, M., Wiegold, T., Klinge, S. and Walther, F., Simulation of cyclic deformation behavior of selective laser melted and hybrid-manufactured aluminum alloys using the phase-field method. *Appl. Sci.*, (2018) **8 (10), 1948**: 1–18.