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Tools for the probabilistic fatigue assessment of additively manufactured aerospace components

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The application of additive manufacturing in aerospace components is closely connected to the ability of assessing the process anomalies effect on fatigue performance. In this sense, using non-destructive inspections, process induced flaws can be characterized and employed in fatigue life estimates of parts considering their service lives. X-ray computed tomography proves particularly effective for metal powder bed fusion process, especially in recognizing gas porosity and lacks-of-fusion due to sub-optimal local printing parameters. Nonetheless, the accuracy of the inspection is strongly dependent on the achievable voxel size, which usually depends on the size of the analyzed part.

This study proposes a probabilistic fatigue assessment methodology to evaluate the fatigue life of additively manufactured components. This method discusses the reliability of the X-ray computed tomography in terms of probability of flaw detection and of sizing error. The methodology selects a suitable fatigue strength model and considers the various uncertainties to estimate the failure probability of a part depending on the applied stress and on the required life. The relationship between stress, defect and life is based on fracture mechanics concepts and on the characterization of material properties from experimental tests conducted on standard specimens.

The methodology is then applied to benchmark components, manufactured in laser powder bed fused Ti-6Al-4V. The components are brackets sustaining an optical payload for satellite applications. Once manufactured, the parts were inspected through X-ray computed tomography at two voxel sizes, 16 μm and 60 μm. The components were then tested in fatigue on a shaker in a setup that models the original configuration on the satellite; the fatigue load is applied as a sinusoidal excitation at constant frequency and acceleration. The experimental life is hence compared with the predicted, to evaluate the accuracy and bias of the estimates.

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