

The effect of material strength and internal defects on fatigue performance of LPBF metals^{OR?}

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Additive manufacturing (AM), particularly Laser Powder Bed Fusion (LPBF), is increasingly utilized for producing complex metallic components tailored for applications in aerospace, energy, and biomedical fields. Despite the extensive advantages of AM in achieving intricate designs and reduced material waste, the fatigue performance of LPBF-manufactured components remains a critical challenge due to inherent material characteristics such as internal defects, surface irregularities, and residual stresses.

This research investigates the fatigue performance of LPBF-produced AISI 316L, Inconel 718, H13, and Maraging Steel (MS1). Fatigue tests were conducted under both bending and axial loading conditions on samples in as-built and electropolished states, using varied LPBF process parameters. Selected results from an extensive collaborative research project between LUT University, University of Oulu, and Finnish industry are presented to illustrate the relationships among material strength, defect structures, and fatigue behavior.

Findings indicate a direct correlation between alloy strength and achievable fatigue strength, although this relationship diminishes as material hardness increases. Particularly, fatigue strength optimization via process parameter refinement proved most effective in the softer alloy AISI 316L, which achieved an optimal fatigue-to-tensile strength ratio approaching 50%. Conversely, the presence of internal defects, surface roughness, and residual stresses was found to significantly deteriorate fatigue performance, especially in high-cycle fatigue regimes.

These results underscore the necessity of comprehensive process optimization and post-processing treatments, such as electropolishing, when designing LPBF components subjected to fatigue-critical conditions. A holistic approach integrating material selection, process optimization, and post-processing techniques is strongly recommended to enhance fatigue resistance in LPBF-produced components.