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Very-High Cycle Fatigue Life Performance of AlSi10Mg Alloy Additive Manufactured by L-DED and L-PBF Technologies

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Several electrical industry parts are subjected to cyclic loads for extended periods, making their fatigue performance critical. Al-based alloys are widely used in their manufacturing due to their excellent electrical and thermal conductivity. Besides, AlSi10Mg alloy also has good weldability and weight/mechanical strength ratio. Additive manufacturing (AM) may fulfill the demand for electrical sector spare parts manufacturing. When compared to traditional processes, AM requires no tooling, has geometric freedom, and decreases lead-time, benefiting low-scale production. Among the metal AM processes, laser directed energy deposition (L-DED) and laser powder bed fusion (L-PBF) stand out. The first is dedicated to the manufacture of large parts, which require higher deposition rates, while the second allows the manufacture of smaller parts with greater geometric resolution. Despite these advantages, there are challenges in processing AlSi10Mg. Oxygen and moisture atmosphere contents influence processability and built quality, affecting the porosity level. L-DED and L-PBF processes, in turn, present a thermal history at a non-thermodynamic equilibrium. Therefore, to ensure appropriate geometry, the intended microstructure, and the required mechanical properties, both process parameters must be properly parameterized. This is yet more important in the case of very-high cycle fatigue (VHCF) because of the increased sensitivity brought on by cyclic loads delivered at high frequencies. The literature on this research topic is limited, especially when it comes to comparing the effects of L-DED and L-PBF processes on the material's AlSi10Mg performance. This gap is larger concerning the VHCF study. In this context, the present work aims to develop parameters, build strategies, and a heat-treatment route to process AlSi10Mg using the L-DED and L-PBF. The purpose is to compare the performance of these different AM processes and to achieve performance compatible with the casting reference material. Optimized parameters were developed for both technologies, ensuring the defect's absence and high density. From parameters developed for an AlSi10Mg powder alloy, samples were built using L-DED and L-PBF for analysis of Archimedes density, microstructure, hardness, mechanical tensile test, Charpy impact, fracture toughness by J integral, ultrasound Youngs modulus, and VHCF. After manufacturing, samples were subjected to a best-fit heat-treatment. AlSi10Mg casting samples were taken as a reference material. According to early results, processing AlSi10Mg by L-PBF is simpler than L-DED due to the powder bed. The microstructure of both processes was formed by dendrites with Si and Mg-rich precipitates but in L-PBF the grains were more refined. L-PBF samples are anticipated to produce higher yield strength and ultimate tensile strength but lower elongation and impact absorption. The VHCF performance must be affected by microstructure refinement and porosity level.