Low cycle fatigue behavior of Ti-6Al-4V alloy fabricated by high-power laser solid forming additive manufacturing

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The lower cycle fatigue (LCF) property is the main shortcoming for Ti-6Al-4V parts prepared by additive manufacturing (AM) on comparison with the wrought. The strong thermal input in high-power AM with high deposition efficiency induced the strong intermediate heat treatment effect in the deposition process which could improve the microstructure and mechanical properties of the deposit. Here, the LCF properties and failure mechanism of Ti-6Al-4V parts fabricated by high-power (7600 W) laser solid forming (LSF) additive manufacturing after post-fabricated solution treatment and aging (STA) were investigated. Experimental results show that the parts exhibit superior LCF lives than other AM Ti-6Al-4V in previous researches, which are comparable to that of the wrought counterparts at intermediate strain amplitudes (from 0.8% to 1.1%). These results are mainly attributed to the STA LSF Ti-6Al-4V with superior ductility (~18%), which derived from the microstructures consist of relatively coarse columnar prior-□ grains (>500μm) filled with thick α-laths (>5 μm) and fine lamellar (α_s+β) microstructures. Under the strain-controlled loading conditions, cyclic softening behaviors were found at various strain amplitudes (from 0.55% to 1.7%). A microstructure-based multistage fatigue model was used to predict their LCF lives and shows good agreement with experimental data. Finally, a two-step guideline for improvement the LCF lives of LSF Ti-6Al-4V parts was suggested, which may provides an important means to improve the LCF properties of LSF Ti-6Al-4V parts without post-fabricated hot isostatic pressing.