On the low cycle fatigue performance of 7050-T7451 aluminum alloy hybrid laser welded joints

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Abstract

The 2-mm-thick ultra-high-strength aviation 7050-T7451 alloys were welded by a hybrid fiber laser and pulsed arc heat source system with the ER5356 filler. The fatigue fracture of aircraft components is mainly high strain low cycle fatigue (LCF) due to the complex environment. Therefore, in this paper the microstructure, mechanical properties, low cycle fatigue behavior and fracture mechanisms were investigated based on electron backscattered diffraction, mechanical tests, low cycle fatigue, synchrotron radiation X-ray computed micro-tomography. The results indicate that welding process results in the metallurgical heterogeneity in different regions of the joint. Compared with the as-received material and heat-affected zone, the hybrid weld has the lowest hardness value, besides the joint strength coefficient is 0.8. The cyclic strain-stress relationships and the strain-life relationships are obtained through the test results, and related LCF parameters are calculated. It is found that at high stress level, fatigue cracks are preferentially initiated from a breaking pore intersecting with the free surface and then propagate steadily inside the joint with a elliptical shape. The surface behaviors and weld defects are the main controlling factors to deteriorate the low cycle fatigue properties.

Keywords: High strength aluminum alloys; Laser hybrid welding; Low cycle fatigue; Fatigue crack growth; Synchrotron radiation imaging