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Crack Growth Behavior in Dissimilar Welded Ti Based Alloys under Biaxial Fatigue Loading

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Abstract

This study aims at describing fatigue crack growth in dissimilar welding of Ti based alloys under macroscopic multiaxial loading. The proposed methodology involves the experimental analysis of fatigue crack behavior under equibiaxial tension and macroscopic combination of mode I and II for Ti17, Ti6242 and laser welded specimen of both base metals. Based on these experiments, crack path, fatigue crack growth rate and crack interaction with microstructure have been addressed. The 3D finite element analysis of cracks shapes has enabled to derive stress intensity factor (SIF) investigated for opening, in-plane and out-of-plane shear modes based on linear elastic fracture mechanics assumptions. Finally, an equivalent SIF has been proposed to take into account the local mode mixity induced by both macroscopic shear and 3D crack shape. As a conclusion, the dissimilar welding of Ti based alloys increase the fatigue crack growth rate (FCGR) for any macroscopic loading - with or without shear. Moreover, the microstructure of Ti6242 alloy, is well known to inhibit FCGR by multiples local bifurcation of crack path induced by the coarse microstructure of this alloy. This point was confirmed during equibiaxial tension but anomalous and very high FCGR was observed for macroscopic mode I + II loading. For the welded material, the fatigue crack to microstructure interactions have shown that the FCGR was clearly limited by coarse α needles inducing local bifurcation and conversely that in both fusion zone and heat-affected zone, local refinement of α needles could not slow down the crack propagation.

Keywords: laser welding, Ti17 alloy, Ti6242 alloy, macroscopic shear fatigue, crack and microstructure interactions, J-integral, Paris law, In situ observation

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