Modelling of crack coalescence in 2024-T351 Al alloy friction stir welded joints

ABSTRACT

In the present work, FSW of 2024-T351 Al alloy is characterised in terms of weld residual stress and cyclic properties. A fatigue endurance of the FSW joint was also investigated and discussed. Critical areas for natural fatigue crack initiation in FSW are pinpointed. The fatigue mechanism in FSW is identified to follow a multiple crack coalescence nature. The numbers of cracks participate in coalescence and the resulting crack growth rate is governed by the distance between the crack tips from crack initiation to coalescence. The above represents a complex condition for modelling. During fatigue bending tests, surface crack initiation and growth were monitored by means of a plastic replication technique. Detailed analysis revealed that under that the FSW specimen failures in fatigue bending tests are mainly a process of crack growth with initiation from defects and oxide inclusions, causing subsurface crack formation. Multiple crack initiation sites were observed from different microstructural regimes in the non-uniform residual stress distribution across the weld. This indicates that failure is dominated by fatigue crack propagation from defects. Therefore mechanisms that include features such as defect size and residual stress were considered when applying crack growth analyses to lifetime predictions. Based on crack growth and characterisation of FSW joints, a modified version of the Hobson–Brown is adopted. The good correlation achieved between the experimental data and the model predictions is presented in this paper. Satisfactory predictions of FSW lifetimes are derived from the model.

Keyword: Friction stir welding (FSW), Fatigue, Crack coalescence, Fatigue crack growth modelling