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Guoqin Sun, Yajing Chen, Shujun Chen, Deguang Shang

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Guoqin Sun,Yajing Chen, Shujun Chen, Deguang Shang

College of Mechanical Engineering and Applied Electronics Technology, Beijing University of Technology, Beijing, 100124

Abstract: Fatigue properties of friction stir welding (FSW) butt joints for aluminum alloy AA2219 were researched by experimental analysis and numerical simulation. The FSW joint model including the representative volume elements (RVE) was built based on the metallographic morphologies, micro hardness profile and local mechanical properties. The morphology and distribution of the matrix and precipitation strengthening phases were included in the RVE of the joint. The stresses and plastic strains of the precipitation strengthening phases and matrix were estimated with the mixture rules. Stress concentration happens at the strengthening phases and neighboring metal matrix. Plastic strain concentration appears at the interface of the matrix and strengthening phases. The fatigue weak areas in the FSW joint were obtained with the joint model. The results show that the estimated fatigue weak areas are close to the experimental results and the errors of predicted fatigue life are basically within 2 factors based on the FSW joint model.

*Keywords***:** Friction stir welding; Precipitation strengthening phase; Joint model; Fatigue weak area; Crack initiation life