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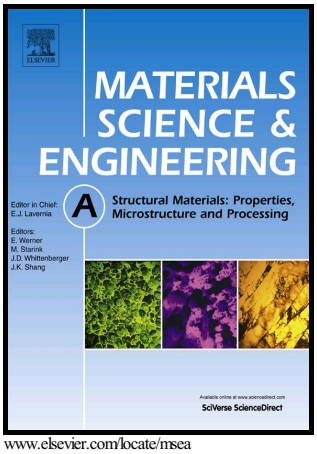

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Study of the effect of microstructural variation on the low cycle fatigue behavior of laser welded DP600 steel: simulation and experimental validation

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Abstract

Non-isothermal heat treatment during welding results in a wide variety of microstructures which strongly affect the fatigue properties of the weldment. To improve the durability of weldments, the effect of microstructural heterogeneity on the fatigue behavior of welded joints should be thoroughly understood. In this paper, the role of microstructure features on the low cycle fatigue behavior of laser welded dual-phase 600 steel was studied by both experimental analysis and simulation. In-situ cyclic tests combined with scanning electron microscopy (SEM) imaging and electron backscattered diffraction (EBSD) were performed to identify microstructural deformations in different laser welded regions during cyclic loading. Microstructural characterization revealed that the microcracks caused by fatigue mostly occurred in the ferrite phase and close to the interface boundaries of ferrite/martensite. In the numerical part, the hierarchical micromechanical modeling using a representative volume element (RVE) was employed to study the regional mechanical properties of welded joints. 2D RVE calculations for different parts of the welded joints were based on the metallographic morphologies. The cyclic behavior of constituent phases (ferrite, martensite) in the microstructure of different regions was quantified based on the dislocation-density-based model and Ramberg-Osgood model. The laser weld joint model containing the RVEs of different weld regions could accurately predict the fatigue weak area of the laser welded joint. The hysteresis stress-strain loop of the welded joint with a heterogeneous multiphase microstructure was simulated and was in line with the experimental data.

Keywords: Laser welding, Micromechanical modeling, Microstructure characterization, Stabilized hysteresis loop, Fatigue failure location

1. Introduction

The ongoing demand to reduce the weight of steel structures while increasing the safety leads to the need to employ advanced joining methods and advanced high strength low alloy steels in the manufacturing process. Among the different joining processes, laser welding has become very popular for the joining of t thin plates due to the method´s high productivity, lower distortion,

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