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Localized Strain and Associated Failure of Structural Materials

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ABSTRACT

Aircraft are made primarily out of strong and lightweight aluminum alloys, which are relatively low cost, easy to produce, and have allowed for several innovations in the airplane industry. Even though these alloys are highly corrosion resistant, they are susceptible to failure since airplanes experience some of the harshest fatigue and corrosion conditions. Predicting the location of crack initiation on these corroded materials could lead to preventative safety of aluminum components on an aircraft. To study the mechanisms leading to cracking, pre-corroded AA7050 samples were fatigue loaded to failure, virtually reconstructed form post-mortem characterizations, and modeled accordingly to obtain the micromechanical state of the material. Fatigue indicator parameters were calculated from the resulting stresses and strains. The initial corrosion front was then analyzed at the reconstructed crack plane, using a metric that identifies the most active slip planes per grain. The reconstructed data is masked over onto planes that have the same orientation as the [111] slip planes. Then, the data is analyzed quantitatively for each slip plane, looking for the highest median fatigue indicator parameter value. The slip plane on the grain closest to the crack initiation site was found to have a slip plane roughly parallel to the crack plane. On this plane, many significantly larger fatigue indicator parameter values were found, with the highest value pinpointing the region where crack initiation was experimentally observed.

KEYWORDS

Strain Localization, Corrosion, Aluminum Alloy, Data Analysis, Crack Initiation