Mechanical Engineering Thesis Defense

Time-based Subcycle Fatigue Life Prediction Model Considering Surface Roughness

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Abstract

Fatigue fracture is one of the most common types of mechanical failures seen in structures. Considering that fatigue failures usually initiate on surfaces, it is accepted that surface roughness has a detrimental effect on the fatigue life of components. Irregularities on the surface cause stress concentrations and form nucleation sites for cracks. As surface conditions are not always satisfactory, particularly for additively manufactured components, it is necessary to develop a reliable model for fatigue life estimation considering surface roughness effects and assure structural integrity. This research study focuses on extending a previously developed subcycle fatigue crack growth model to include the effects of surface roughness. Unlike other models that consider surface irregularities as series of cracks, the proposed model is unique in the way that it treats the peaks and valleys of surface texture as a single equivalent notch. First, an equivalent stress concentration factor for the roughness was estimated and introduced into an asymptotic interpolation method for notches. Later, a concept called equivalent initial flaw size was incorporated along with linear elastic fracture mechanics to predict the fatigue life of Ti-6Al-4V alloy with different levels of roughness under uniaxial and multiaxial loading conditions. The predicted results were validated using the available literature data. The developed model can also handle variable amplitude loading conditions, which is suggested for future work.

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