A CONTINUUM MECHANICS MODEL FOR FATIGUE LIFE PREDICTION WITH PRE-CORROSION AND SEQUENTIAL CORROSION FATIGUE

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We present a continuum model to predict pre-corrosion fatigue which is a prevalent damage mechanism in aerospace structures under operational conditions. It is assumed that the process of corrosion and fatigue sometimes exist separately to a large extent. In this scenario, it is assumed that when an aircraft is in fight at high altitude, cyclic loading due to engine vibration and flutter is at its maximum, whereas the corrosive processes due to moisture or temperature are minimal. And when the aircraft is on the ground the corrosive process is at its maximum, whereas vibration loading is non-existent. For demonstration purposes, we study the effect of prior corrosion on fatigue life of aluminum alloy 7075-T6. In this work, we employ Continuum Damage Mechanics (CDM) as the modeling platform to study the fatigue crack initiation and growth from a pre-existing corrosion pit. In the CDM approach, a crack is assumed to initiate when damage variable, D, attains a critical value D_c. We use the corrosion-free fatigue data to calibrate D_{c0} for 7075-T6. This value for critical damage signifies the failure of a representative value element (RVE) when corrosion is non-existent, see Fig. 1. In other words, the corrosion exposure time is zero, $t = 0$. The corrosion RVE starts to corrode as time elapses. The effect of corrosion is shown by increased in surface roughness. At initial times of exposure, damage occurs as corrosion pits and increased surface roughness. As time passes, pits grow in size and spread over the entire surface of RVE. After long time of exposure, the RVE will corrode in a self-similar manner, meaning that we assume that surface roughness reaches a limit value while uniform surface recession continues. We refer to this model as the concept of corroded RVE as shown in Fig. 1. We used this model to predict the fatigue life of 7075-T6 exposed for 0, 96, 768 and 1536 hrs in the prehesion spray. The predicted results are in a reasonable agreement with experimental data. We further tested the model for life prediction of sequential corrosion-fatigue scenarios where corrosion and fatigue occur in sequence. For maximum stress of σ_{max} = 340 MPa, load ratio of $R = 0.1$ and exposure time of t_{exp} = 100 hrs, the model predicts 17% increase in fatigue life for sequential corrosion-fatigue than the pre-corrosion fatigue. This result is interesting since it shows the interaction between corrosion and fatigue cycles. The result infers that if the corrosion time is spread over the fatigue cycles the life may increase.

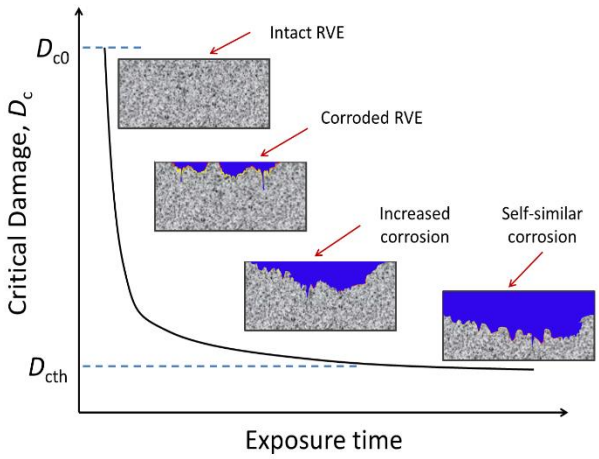

Figure 1 – A schematic that shows the concept of corroded RVE. The critical damage changes from D_{c0} for un-corroded RVE to D_{cth} for self-similar corroded RVE.