ELECTROCHEMICAL STRESS INTENSITY APPROACH TO MODELING GALVANIC COUPLING AND LOCALIZED DAMAGE INITIATION IN STRUCTURES

William Nickerson, Office of Naval Research, Arlington, VA USA
william.nickerson@navy.mil
Keith Legg, Corrdesa, LLC, Libertyville, IL USA
Nagaraja Iyyer, Technical Data Analysis, Falls Church, VA USA

Keywords: Aircraft Structures; Corrosion; Fatigue; Stress Corrosion Cracking

Traditionally, airframe structures are designed for immediate mechanical performance and loads-only structural response; the lifetime of aircraft structures is predicted on these analyses and environmental degradation of properties over the life cycle and during operations is often an afterthought. Although the maintenance of aircraft structures is primarily determined by material degradation, galvanic management of airframe designs and corrosion resistant material selection has never been done systematically. From end of life tear-down inspections, we know that, predominantly, structural failures are initiated from corrosion features, especially those accelerated by dissimilar material coupling. In its most simplistic form, this environmental exposure, “loading”, creates corrosion features, such as pitting, that produce crack initiation morphologies, cracks nucleate from these features and then grow under the combined influence of mechanical stress and corrosion, eventually leading to structural failure. There is clearly a strong correlation between corrosion and structural damage, which we think of as corrosion fatigue and stress corrosion cracking. We propose that it is possible to treat “electrochemical stress” mathematically in a similar way to mechanical stress, with numerically equivalent approaches. Using such a model, the combined influence of electrochemistry and stress can, in principle, be treated as the sum of these two stresses, allowing us to develop models to predict the risk of environmentally assisted fatigue and stress corrosion cracking damage.

ONR’s Sea-Based Aviation program is developing computational approaches to corrosion activity prediction, crack initiation, and crack growth, with the ultimate aim of predicting service life in terms of the combination of mechanical and chemical stress. This approach is intended to be the basis for design of durable aircraft structures, using design principles that will take into account both stress and corrosion in the design phase, rather than designing for stress and then maintaining for corrosion.