Towards A Versatile, Fully-integrated Corrosion Model Using A Combined FEM-experimental Approach

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Abstract

Corrosion control of aluminum alloys in the aerospace industry is of high importance to prolongate the service life of aircraft structures. Commonly used high-strength aerospace aluminum alloys such as AA2024 are susceptible to localized corrosion (e.g. pitting corrosion) due to the presence of copper-rich intermetallic particles in the alloy matrix. Therefore, a complex coating system consisting of several (organic) coating layers is usually applied to provide barrier corrosion protection. Dedicated evaluation of these corrosion protective layers is strictly necessary. While laboratory trial procedures and outdoor test programs are personnel and time intensive and accelerated corrosion tests can lead to limited service performance information, predictive modeling of the durability and lifetime of (organic) coated aerospace aluminum alloys under long-term environmental corrosion can provide a promising alternative.
Predictive modeling of (organic) coated aerospace aluminum alloys aims to develop a deterministic modeling and simulation concept that allows to forecast the onset of corrosion on relevant micro-defects of a simplified corrosion protection scheme. Furthermore, it allows to generate fundamental understanding of corrosion processes, of important parameters and boundary conditions and constitutes an important first step towards more complex and accurate predictive deterministic and/or hybrid models.
In this work, a finite element modeling (FEM) approach is employed to develop a versatile, fully-integrated corrosion modeling tool, by subsystem approach. Four different subsystems are considered: the corrosion of metals, the transport of species through organic coatings, the dynamic electrolyte film model and the delamination of coatings. The key aspect is the generation of experimental input parameters, experimental understanding and evidence of the governing physics, and experimental validation at all stages. As such, the importance of suitable, well-defined experiments must not be underestimated in the development of physical based models and is highlighted for the different sub-systems throughout different research projects.

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