Numerical simulation of cracking in anodic films

PARTNERS

Key words : fracture mechanics; cracking; finite element method

Department: DMSM

Master's level internship offer

JOB DESCRIPTION:

Aluminum alloys in the 2000 series are very commonly used in the aerospace industry due to their excellent specific mechanical properties. In addition to the mechanical stresses associated with their use, aerospace structures are also subjected to environments that can compromise their integrity. Anodizing surface treatments allow a thin protective film to grow, thereby improving the corrosion resistance of these alloys. However, cracking or crazing phenomena—resulting from thermal stresses—can occur and significantly reduce their corrosion resistance in harsh environments. Understanding these phenomena of anodic film degradation and identifying and taking into account the influencing parameters will make it possible to improve the thermal behavior of anodized components.

In this context, the present study, conducted in collaboration with the CIRIMAT laboratory, which works on anodization issues, aims to perform numerical simulations to understand the creation and propagation of cracks in an anodic film on a 2024-T3 aluminum alloy substrate when subjected to a rise in temperature. The first step will be to create a finite element model that can be configured in terms of anodic layer thickness. The mechanical properties (modulus of elasticity, toughness, coefficient of thermal expansion, Poisson's ratio, tensile strength) used for the anodic

film will either be provided by CIRIMAT once they have been determined experimentally, or taken from the literature. The load applied will be a constant and uniform thermal load, with temperature levels chosen to be representative of the stresses encountered by the parts in service or during assembly. Only the effect of thermal stresses will be studied. Cracks of varying width and length will then be incorporated into the anodic film. Analysis of the stress fields in the film and the stress intensity factors at the crack tips will provide a better understanding of crack formation and propagation in correlation with the thermal load and the properties of the anodic layer.

The study comprises the following steps:

• Creation of a 2D/3D model and mesh adapted to take into account the gradient of properties of the anodic layer

• Parametric analysis: calculations for different temperatures and different values of elastic modulus and thermal expansion coefficient. The stress results will be compared with the breaking strength => comparison with the experimental observation of the temperature at which cracks appear.

• Introduction of a crack: geometries chosen according to the first cracks observed experimentally – analysis of the stress field to estimate the size of the crazing islands => comparison with the experimental observation

• Introduction of multiple cracks: their geometry and density will be based on experimental observations – analysis of the stress intensity factor at the crack tip to be compared with toughness to predict the cracking phenomenon => comparison with experimental observation of crack width.

REQUIRED PROFILE:
Mechanical engineering or materials science student at M2/Bac +5 level – finite element calculations – ABAQUS

DURATION: 5-6 months starting in February-March 2026

LOCATION: Institut Clément Ader, 3 rue Caroline Aigle, 31400 Toulouse / ISAE-SUPAERO, 10 avenue Edouard Belin, 31500 Toulouse

RESPONSIBLE OF THE SUBJECT:

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APPLICATION PROCESS: CV and cover letter to be sent by email to C. MABRU