A reverse identification of the friction coefficient operating within crack lips through a complete elastoplastic simulation of 3D fretting fatigue cracks

Pierre Arnaud*[1], Vincent Maurel[2], Siegfried Fouvry[1], Julien Said[3], Christine Yang[4], and Fikri Hafid[4]

[1]Mines Paris - PSL (École nationale supérieure des mines de Paris) – Centre des Matériaux (CMAT), CNRS UMR 7633, BP 87 F-91003 Evry Cedex – France
[2]Mines Paris - PSL (École nationale supérieure des mines de Paris) – Centre des Matériaux (CMAT), CNRS UMR 7633, BP 87 F-91003 Evry Cedex – France
[3]RTE – Direction de la RD – Pôle Smartlab, 92073 Paris la Defense Cedex, France – RTE – Direction de la RD – Pôle Smartlab, 92073 Paris la Defense Cedex, France – France
[4]RTE – Direction de la RD – Pôle Smartlab, 92073 Paris la Defense Cedex, France – RTE – Direction de la RD – Pôle Smartlab, 92073 Paris la Defense Cedex, France – France

Abstract

Fretting fatigue involves mechanical loading characterized by oscillating friction and displacement, often leading to crack nucleation or wear depending on displacement amplitude. In industrial applications, such as overhead conductors for high-power transmission, fretting fatigue plays a critical role in determining component lifespan. These conductors consist of helically stranded aluminum wires, where misaligned contacts under external forces create elliptical contact areas. Low aluminum yield stress induces significant plasticity, enlarging the contact area and modifying local stress distributions. This cyclic loading can lead to crack growth and eventual failure, with lifetime reductions widely reported in the literature. This study builds upon experimental and numerical strategies developed to assess crack growth and arrest in aluminum wires under fretting fatigue. Using three-dimensional finite element analysis (FEA) incorporating 3D cracks, the investigation evaluates elastic and elastoplastic behaviors to replicate experimental results. It was found that purely elastic assumptions fail to capture the critical conditions for crack arrest. Incorporating elastoplastic behavior revealed stress intensity factor (SIF) evolution consistent with experimental observations, enabling a more robust numerical framework for studying crack propagation. Particular attention is given to the friction between crack lips. A reverse analysis method allows for the estimation of the coefficient of friction (COF), yielding values consistent with COF obtained by fretting experiments. These insights clarify the interplay between crack closure, local plasticity, and friction in determining whether cracks arrest or propagate to failure. This work highlights the necessity of considering plasticity and friction effects to predict fretting fatigue damage accurately. By combining numerical modeling with experimental results, the study provides a robust framework for understanding and mitigating crack propagation in critical applications, improving the predictive assessment of the mechanical behavior of aluminum wires.

---

[*] Speaker

sciencesconf.org:esmc2025:593599