Numerical study of the initiation and propagation of fretting-fatigue cracks in a TA6V polycrystal

H. Proudhon[1*], C. Nigro[1], L. Sun[1]

[1)] Centre des Matériaux, Mines-ParisTech, CNRS UMR 7633, BP 87, 91 003 EVRY

[*]Corresponding author for tribo-lyon2013@sciencesconf.org

1. Introduction

In order to assess the lifetime of compressor discs in plane engines, several mechanical and chemical problems have been identified. In particular, the fretting-fatigue contact problem has been the subject of many studies but remains partly misunderstood. Different phenomena are involved in this problem such as Hertz contact problem, the initiation and the growth of cracks in the material (TA6V titanium alloy). The existing crack initiation criteria are not effective enough since a stress averaging procedure must be applied to attenuate the strong stress gradient under the contact. Besides, in a fretting contact, the growth of cracks in the very first grains of the microstructure consumes an important part of the lifetime of the structure and is generally not taken into account in the life time models.

2. Cracks initiation

First, this study aims at determining how much the initiation of cracks is dependant of the microstructure (size and orientation of grains) and the geometries in contact. In this context, the Crossland criterion is applied in the contact area of several finite elements calculations using a variety of Voronoi microstructures.

3. Cracking propagation

A numerical model of fretting-fatigue contact based on the finite elements method is developed to simulate and reproduce the crack growth within a titanium alloy microstructure (cf. Figure 1). Electron Back Scattered Diffraction (EBSD) mappings are used to produce a mesh to account for realistic TA6V two-phase microstructures in the simulations. The numerical model, using constitutive relations including crystal plasticity, is able to assess the cracking speed or the number of cycles corresponding to the growth of a crack from 0 to 300 microns.

4. Summary

This study brings up a new scale in the fretting life time description taking into account the microstructure of a complex metallic material. Setting up numerical models of fretting contact incorporating microstructural effects is a way forward to reduce the cost of experimental tests in the industrial context.

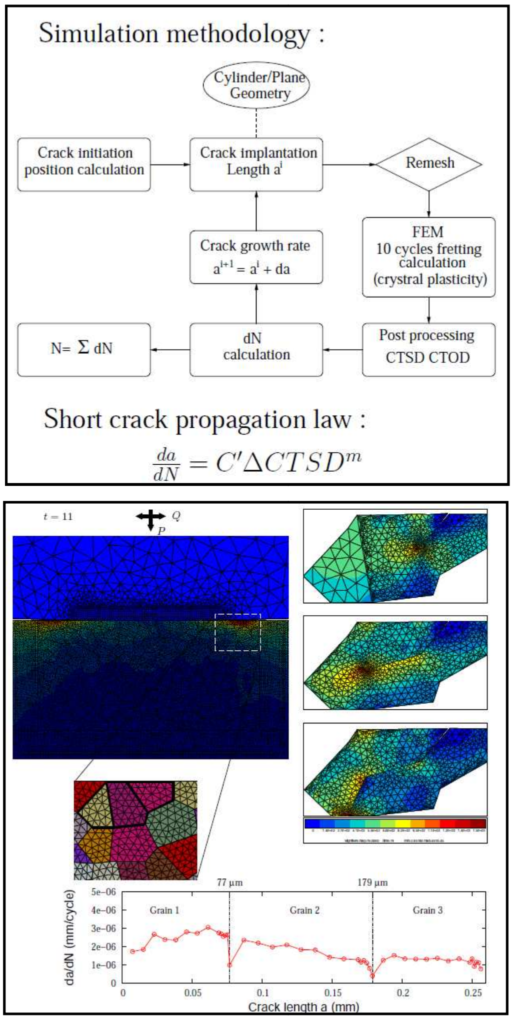

Figure 1 : Simulation process for the cracking propagation

5. References

[1] D.A. Hills and D.Nowell, “Mechanics of fretting fatigue”, 1993.

[2] L. Sun, “Etude numérique de l’amorçage et de la propagation de fissures de fretting”, Thesis, 2012.

[3] J. Mériaux, “Etude expérimentale et modélisation de l’endommagement d’un contact aube-disque de soufflante soumis à des chargements de fretting fatigue”, Thesis, 2010.

[4] H. Proudhon, “Identification des mécanismes de fissuration dans un alliage d’aluminium sollicité en fretting et en fatigue”, Thesis, 2005.

[5] S. Fouvry, K. Elleuch and G. Simeon, “Prediction of crack nucleation under partial slip fretting conditions”, Journal of strain analysis, Vol. 37, N°6, 2002.