Modeling contact oxygenation and adhesive wear extension in linear flat fretting interfaces

Soha Baydoun[1)]*, Pierre Arnaud[2)], Siegfried Fouvry[1)]

[1)] Ecole Centrale de Lyon, LTDS Laboratory, 36 av Guy de Collongue, 69130 Ecully, France
[2)] MINES ParisTech, Centre des matériaux, 63-65 rue Henri-Auguste Desbruères, 91100 Corbeil-Essonnes, France

*Corresponding author: soha.baydoun@ec-lyon.fr

In this study, adhesive wear extension in linear fretting contacts is simulated by applying the Contact Oxygenation Concept (COC) which illustrates the influence of fretting loadings on oxygen transport within the interface. Di-oxygen flow is modeled using an Advection-Dispersion-Reaction (ADR) approach which was formerly proposed assuming third-body as a porous medium crossed by atmospheric gases. Then, ADR model is coupled with an existing finite-element code (Wear-Box) in order to predict the composite abrasive-adhesive scar of fretting contact. Moreover, a simplified analytical solution is proposed for ADR equation which is proven to be highly correlated with the numerical and experimental results.

Keywords: abrasive-adhesive fretting wear, linear flat contact, contact oxygenation concept, Advection-Dispersion-Reaction model (ADR)

1. Introduction

Micro-displacement oscillatory motion, referred to as fretting, is encountered in a wide range of industrial assemblies submitted to vibrations. Adhesive wear is one of the most severe forms of wear as it leads to welding of materials which might ultimately block the sliding of the mechanical systems inducing seizure and cracking phenomena. So, the current work aims at predicting adhesive wear extension in linear flat contacts such as long rectangular flat-on-flat interfaces.

2. Methods

The transition from abrasive to adhesive wear in gross-slip fretting is dependent on different loading conditions (sliding frequency, contact pressure, etc…) [1]. This dependency can be clarified by the "Contact Oxygenation Concept (COC)" suggesting that adhesion appears in the contact center if the O_2 partial pressure (P_{O_2}) is below a threshold value ($P_{O_2,th}$) (Figure 1). In the lateral sides, where O_2 concentration is sufficient, oxidation and abrasion occur.

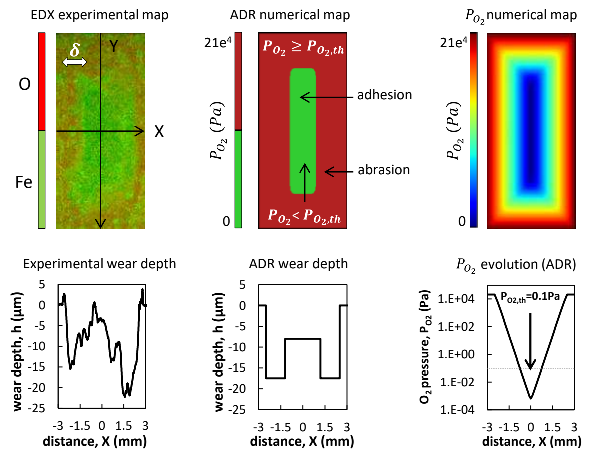

Figure 1: Illustration of the ADR model to predict adhesive/abrasive wear distribution within a steel fretting interface for linear flat-on-flat fretting contacts.

COC is recently simulated by modelling oxygen transport within fretting interface using an advection-dispersion-reaction approach (ADR) [1] by considering debris bed as a compact porous medium traversed by atmospheric gases. However, the previous model was performed for square and circular flat-on-flat contacts without taking into account the wear kinetics.

Hence, the current work aims at extending this ADR approach to linear flat contacts such as long rectangular flat contact where wear kinetics will be considered using a combined ADR-COC-Wear approach. Besides, a simplified analytical solution is proposed which allows the assessment of the loading conditions as well as debris wear extension in fretting interfaces.

3. Results and Discussion

Fretting wear experimental results of a crossed rectangular flat contact reveals that adhesion zone extends with the augmentation of the contact pressure and the sliding frequency. This evolution was predicted by the analytical and the numerical solutions of the ADR approach which expected the partition of abrasion and adhesion as well as the transition of wear-mechanisms from pure abrasive to mixed abrasive-adhesive wear. Additionally, by coupling this ADR-COC with finite element simulations (Wear-Box), the W-shaped composite adhesive-abrasive wear scar was equally predicted for different loading combinations. This method, though predictive, still needs to be ameliorated in many aspects like introducing the material reactivity effect along with evolution of contact area and the debris porosity with fretting loadings.

4. References

[1] S. Baydoun et al., "Modelling adhesive wear extension in fretting interfaces: An advection-dispersion-reaction contact oxygenation approach", Tribol. Int., 106490, 2020, 1-20.