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# Material Response to Fretting Action - A Thermoelastic Fracture Mechanics Perspective

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## Abstract

Fretting damage is produced by relatively low amplitude oscillatory motion between two contacting surfaces under static or dynamic load. The mechanical and chemical components of the fretting action may cause wear and/or fatigue damage. Fretting damage can have major economical and safety impact, especially in the nuclear and aerospace industries. Modelling of the fretting process is essential for damage prediction, control and risk management assessment.

It is established that both fretting wear and fatigue are governed by subsurface or surface crack nucleation and propagation processes. In the present study, the linear elastic fracture mechanics (LEFM) approach is extended to incorporate the *thermal constriction phenomenon,* which is responsible of establishing very steep temperature gradient in the subsurface layer due to the friction-induced heat generated on the contacting surface asperities.

Another interrelated aspect of this complex is the *formation of surface oxides*, which is generally characterized by its higher hardness and a lower thermal conductivity compared to the substrate. This raises the contact temperature further, and in turn affects the oxide kinetics, the material properties and residual thermal stresses. Consequently, it can affect significantly affect the subsurface crack nucleation and propagation processes and the fretting wear rate.

Using a finite element thermomechanical model, the effect of the frictional heat on the wear debris formation by delamination is presented. It is shown that the frictional heat creates a competition between two opposing deformation streams which puts the subsurface deformation zone under a state of higher hydrostatic compressive stress. Consequently, there is a formation of shallower (thinner) wear debris through the reduction of the depth at which cracks initiate. Once a crack is initiated, the opposing streams of deformation lead to an increase in the shear plastic strain, and consequently, an increase in shear stress. This shear mechanism causes an increase in the in-plane crack growth, and consequently, in the crack tip sliding displacement (CTSD). Thus, frictional heat causes quicker crack propagation. The paper is concluded with recommendations for future research work.