Fretting Corrosion Degradation, Threshold Behavior and Contact Instability

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Abstract

During the last three decades many authors have conducted empirical studies on the impact fretting corrosion has on base metal contacts. Generally the goals of these studies were to evaluate the performance of various material systems such as tin and tin alloy contacts. In some cases, contact stability and thermal effects were studied to shed light on the performance of various contact configurations in specific applications. Consequently, a body of data has accumulated in the literature covering various aspects of this degradation mechanism. Most of these studies were conducted by artificially causing micro-motions at a contact interface using various laboratory fixtures. Moreover, most of these studies were not aimed at evaluating fundamental fretting parameters but rather to reveal the performance of specific material systems.

Over the past several years, in an effort to shed light on connector performance and develop meaningful accelerated tests, the present author has pursued a number of efforts to understand the fundamentals of fretting corrosion and how they relate to real world field conditions. Moreover, the impact of fretting degradation on contact stability was studied to understand how this mechanism might impact electronic systems. These studies were intended to extend the present data base and our understanding of fretting corrosion as a serious degradation mechanism in the field. To this end, the present author has investigated the effects of fretting amplitude, contact force, temperature and vibration to model fretting behavior and subsequently provide a basis for understanding this mechanism. This work was done using two separate approaches. The first employed controlled laboratory experiments where artificially induced fretting was used to investigate basic fretting parameters. The second used various environmental tests on actual connector products to evaluate acceleration factors. The initial goals were to study the effects of these variables and the nature of the oxide films as they accumulate in the contact region. Subsequently, an empirical model was developed to aid in designing accelerated laboratory tests that utilize thermal cycling and vibration as major stress factors. During the course of these studies, a number of characteristics such as oxide film build up and electrical stability were revealed as fretting progressed. Moreover, threshold behavior was observed with respect to fretting amplitude, which is believed related to field stresses. Factors such as vibration g-levels and temperature-swings, which characterize field stresses, were subsequently used to interpret laboratory tests.

This paper addresses the electrical behavior of contacts as fretting corrosion progresses. To this end, the results developed over the last several years are summarized and used to provide an understanding of fretting corrosion phenomena and accelerated testing. The oxide build up and associated impact on film characteristics and contact stability are considered. In addition, the nature of the fretting degradation process is analyzed in the context of chaotic processes. Analyses of phase space parameters and non-linear dynamic behavior are conducted to reveal chaotic behavior as contact degradation progresses towards higher and unstable resistance. The overall objective is to reveal the nature of the degradation mechanism and provide a basis for understanding how test parameters and failure criteria relate to threshold behavior and contact stability.