Fretting fatigue: recent developments

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Abstract

Fretting Fatigue (FF) is one of the most difficult areas of fatigue, and require a multidisciplinary effort in the areas of contact mechanics, tribology, fatigue and fracture mechanics. It is clear that two aspects contribute to the fatigue detrimental effect, and these are stress concentration and frictional surface damage due to microslip, which result in the typical fretting scars, but it is not clear what the influence of the combined presence is. FF is presently receiving a large effort from many academic and industrial groups in Europe and USA. Attacks to FF over the years have been various and conceptually very different, and all of them significantly oversimplified and/or highly empirical. However, most of them have recognized the presence of pronounced and distinct "thresholds" and "regimes". We attempt here to collect few ideas on connecting the two concepts with the obvious conterparts of fatigue (endurance) limit and crack propagation thresholds, trying to elucidate what would most likely happen in limiting conditions.

A recent important contribution has been Suresh's "crack analogue" model, which focus on the stress concentration, rather than surface damage — the idea itself of considering contact areas as cracks is not innovative, as Johnson and Maugis have used it for long, but Suresh's use in the context of contact fatigue is certainly innovative. In particular, he has introduced first a flat punch case, where no microslip is considered, and then a smooth punch where the mode I singularity is reintroduced via adhesive forces. In his case mode I loading is constant, whereas fatigue loading comes from mode II and mode III cycles. In this latter case, he also allows for microslip, which alleviates mode II stress intensities. However, it is here recognized that a more general approach is possible and perhaps needed,

considering frictional energy as localized plasticity like in BCS cracks (mode II), and mode I is not necessarily to be included. This permits to recognize the important innovation of Suresh's approach, but also its limits. In particular, frictional microslip cannot be taken into account with stress intensity factors alone, as with large "plasticity" (frictional damage), EPFM is needed. Also, there may be conditions where real plasticity occurs at "crack tip" which needs to be considered separately, although this may be negligible for HCF conditions. Therefore, suggestions are given for a more general framework in which to attack fretting fatigue crack propagation thresholds, depending on the *regime*, loading and geometrical conditions, with appropriate tools. Most of these tools involve the detailed solution of the underlying frictional contact problem, which is where the author have concentrated their effort over the last few years. Some comparisons are outlined in order to interpret recent experiments. A set of relevant references is given.

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