The static friction peak in frictional hysteresis loops

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Introduction

Frictional hysteresis loops have been widely studied in the literature to examine the resistance of materials to wear and to investigate their fretting and fatigue behaviour. It has been noticed that the hysteresis loops reported in the literature [1-3] usually do not exhibit a clear static friction peak (i.e. a static friction level higher than the kinetic friction level). The aim of this study was to investigate the presence of the static peak in the loops by performing reciprocating sliding on highly flat silicon samples with nanoscale roughness. Studying frictional behaviour of materials via reciprocating sliding is a significant aspect of assessing materials resistance to damage. The damage (or wear) occurs due to repeated sliding over the same area. Investigation on friction hysteresis loops in the literature has been crucial in terms of helping to find techniques to increase lifetime of materials, particularly those used in severe environments. The scope of such studies has usually been directed towards wear and fretting phenomenon. The lack of a static friction peak in reported hysteresis loops is interesting and not fully understood. On the other hand, the static friction peak is often observed in unidirectional sliding friction tests [4]. A cursory look might attribute it to a number of reasons such as the minimal sticking time owing to the rapid change of sliding direction or indeed the evolving surface roughness influenced by wear. However, it requires investigation.

Experimental and modelling approaches

This study investigates static peak appearance in frictional hysteresis loops by performing reciprocating sliding via a customised friction rig on smooth silicon samples. The friction tests were performed on flat-on-flat silicon samples with nanoscale roughness. The samples experienced reciprocating sliding for 100 cycles under 10 N normal load. Sliding parameters were 0.05 mm/s and 1 mm for the sliding velocity and total displacement per cycle, respectively. The experiment is accompanied by comparison to a friction model developed by Xu *et al.* [5]. This model is developed to predict the evolution of the interfacial friction, F, normal load, F_z, and real contact area, A_r, as an elastic nominally flat rough surface slides on a rigid flat. The model friction test parameters are mainly dictated by roughness-related parameters of the tested silicon samples in order to inspect their effect on the static peak. These parameters were extracted from AFM scans that were performed before and after testing.

Summary

Interestingly, the current study showed a clear static peak in the first cycles which later decayed away after a number of cycles. The highest peak was observed in the first cycles, where static friction was much higher than the sliding friction. The experimental results were combined with a statistical model of adhesive contact. The model was implemented to help explain the appearance and subsequent disappearance of the static peak as the cycle number increased. Results of the model were governed mainly by the change in roughness data during the tests. The model follows the experimental static friction peak decay behaviour indicating that a change in roughness governed by surface wear may explain the decay of the static friction peak magnitude.

References

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