M. F. Ashby[2]

A point under a sliding contact suffers contact stresses. Superimposed on these, when sliding is fast, are thermoelastic stresses caused by frictional heating. If the combined stresses exceed the yield strength of either surface, the repeated loading will ultimately cause wear. The criterion for wear by this mechanism is that the von-Mises stress exceeds a critical value.

This paper extends the analysis of contact-plus-thermal loading to ceramics. Such materials are brittle at low temperatures and ductile at high. The authors use a maximum principal tensile stress criterion in the brittle regime, and a von-Mises criterion in the ductile one. The results are presented as maps with axes of normalized contact pressure and normalized sliding velocity, showing three regimes: an immediate wear regime in which the contact stress alone exceeds the yield or failure stress; a no wear regime in which the combined stresses never exceed the yield or failure stress; and a regime in between where the combined stresses cause failure, though either one, taken alone, would not.

All this is very persuasive. Clarification of the following questions might help to relate this mechanism to others with which it (presumably) competes.

(*a*) Wear does occur in the "no wear" regime. What other mechanisms can the authors envisage which might be responsible?

(*b*) Can the authors describe the microscopic evidence for the thermo mechanical wear mechanism? What does it predict about the nature of the wear debris? The appearance of the worn surface?

(*c*) Is the "immediate wear" regime that of seizure, in which the macroscopic contact pressure exceeds yield? If so, why does not the coefficient of friction influence the critical value of the normalized stress for the onset of "immediate wear"? Are the calculations based on a static contact stress, rather than the contact stress beneath a sliding contact with friction?

Authors' Closure

The authors would like to thank both Drs. M. F. Ashby and A. W. J. de Gee for their discussions.

With respect to Dr. Ashby's comments; Thermomechanical wear criterion is based on the plastic deformation of materails due to mechanical and thermal stress. It is assumed that wear occurs when the surface of materials yields. The"no wear" region means no thermomechanical wear occurs. All other wear mechanisms are possible in this region, such as, corrosive, abrasive or fatigue mechanisms of wear.

The microscopic evidence for the thermomechanical wear model can be shown by the observation of hot spots and associated asperity deformation and by the measurement of the contact temperature during wear (Quinn and Winer, 1985). We did not try to predict the nature of the wear debris and appearance of the worn surface, however we believe that the surface worn by the heat checking or scuffing as well as plastic deformation are examples of themomechanical wear.

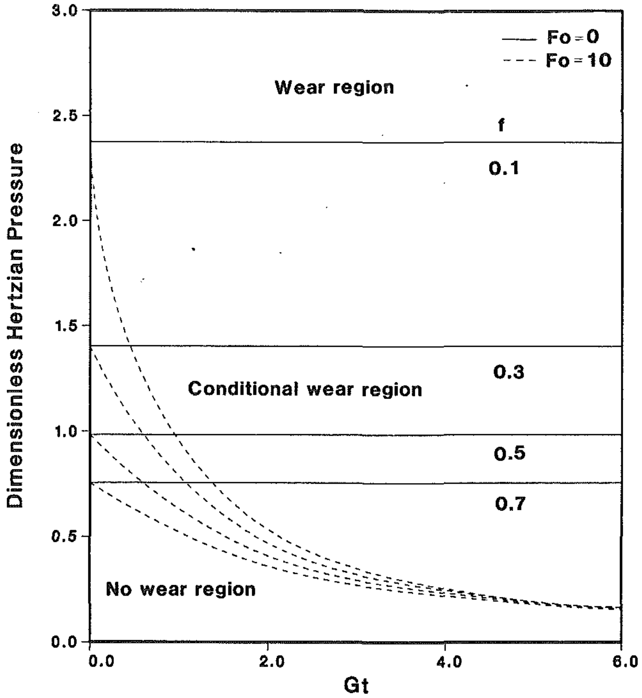

Fig. 13 Wear map of AISI 52100 steel for different fraction coefficients with $F_0 = 0$ and 10

The immediate wear region is that of yielding or seizure if the load is above the critical stress corresponding to the $F_0 = 0$ value. This critical stress does vary according to the friction coefficients, because the stress calculations are based on the sliding contact with friction, and the friction coefficient influences the value of the critical stress. Figure 13 shows the effects of friction coefficient on the critical stress for AISI 52100 steel. In Fig. 13 the curves are for different friction coefficients of 0.1, 0.3, 0.5 and 0.7 at $F_0 = 0$ and $F_0 = 10$. As expected, the larger the friction coefficient is, the lower the critical stress.

The discussion of Dr. de Gee deals with additional comparison between his experiments and our calculation for the transition load as a function of friction coefficient. The agreement for these new comparisons is very satisfying. This is a useful result and we agree completely with his comments.

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