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LETTER TO THE EDITOR

Comments on "The delamination theory of wear"*

While the newly proposed delamination theory[1] of wear has raised some interesting points it appears to be in need of further development in several regards. First, it seems reasonable to assume that microcracks form at or near inclusions or hard particles. However, it is unreasonable to assume that they form below the "low dislocation density zone" at a uniform depth, h, given by equating the image shear stress with the drag stress:

$$h = \frac{Gb}{4\pi(1-\nu)\sigma_f}$$

In fact, a previous study[2] has shown that microcracks can form an order of magnitude deeper than predicted by delamination. It is apparent, therefore, that microcracks can form anywhere in the severely deformed zone. This leads to another contradiction with the delamination theory concerning the particle shape and the mechanism of particle formation. Because microcracks exist at various depths, as shown previously[2], it is clear that coalescence occurs not necessarily in a plane (as delamination suggests), but more likely over a random path determined by local slip and locally high inclusion density. Thus, failure (particle formation) occurs along a "surface" that is weakest relative to the system of applied stresses. Therefore a wear particle can form by a combination of shear and tensile failures along a path of microcrack induced weakness. The tensile failures would generally occur at nearly a 45 degree angle to the applied shear in a manner analogous to the formation of a shear lip on a ductile cleavage failure during purely tensile loading. The shear failures would naturally be parallel to the applied shear. It is expected, therefore, that particles would be generated in various shapes and sizes, which is more consistent with the findings of other authors[3–8]. It is unclear in Dr. Suh's delamination article[1] why he uses wear particles of undetermined origin and past history (from the lubrication oil of gun mounts) rather than those from his carefully controlled pin-on-disk laboratory experiments. It is also unclear why he chose to use dry sliding to show the existence of subsurface cracks and lubricated sliding to demonstrate the shape of his wear debris. These inconsistencies could have some bearing on the peculiar and previously unreported finding of almost exclusively platelike wear particles.

A topic that needs discussion is the usefulness, meaning, and validity of the proposed wear equation:

$$W = \frac{b}{4\pi}\left[\frac{K_1 G_1}{\sigma_{f_1} S_{0_1}(1-\nu_1)} + \frac{K_2 G_2}{\sigma_{f_2} S_{0_1}(1-\nu_2)}\right] \cdot LS$$

* See *Wear*, 25 (1) (1973) 111.

If the term S_0 is a "critical sliding distance required for removal of a complete layer" of plates (and no method is given for calculating S_0), it must be assumed that this method is at least semi-empirical. Certainly an empirical equation is limited in scope of application. The author further postulated that "K_1 and K_2 are constants which depend primarily on the surface topography." This is, again, confusing because the relationship to surface topography is not defined nor was any experimental work to define the role of surface topography alluded to by Dr. Suh. In addition, it is suggested from the above remarks on depth of microcracks that the depth term

$$h = \frac{Gb}{4\pi(1-\nu)\sigma_f}$$

used in the equation is incorrect. A test of the validity of the equation would be to show (at least qualitatively) where it ranks certain materials in wear resistance and how that ranking correlates to the existing data. No attempt to make such a correlation was mentioned.

Conclusion

Although the delamination theory is still in rough form it offers two plausible explanations of wear phenomena:

(1) Subsurface microcracks, particularly near inclusions, and their subsequent coalescence play a major role in the generation of wear particles, and

(2) Adhesive wear, fretting wear, and fatigue wear can be caused by the same mechanisms.

However, the delamination arguments on particle shape, microcrack depth and the associated wear equation are not convincing.

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