CC/NUMBER 18
MAY 4, 1981

This Week's Citation Classic

Suh N P. The delamination theory of wear. *Wear* **25**:111-24, 1973.
[Massachusetts Institute of Technology, Cambridge, MA]

A new theory for wear of metals is presented. The theory is based on the behavior of dislocations at the surface, subsurface crack and void formation due to plastic deformation of the surface layer, and subsequent joining of cracks by shear deformation of the surface and by crack propagation. The proposed theory predicts qualitatively that the wear particle shape is likely to be thin flake-like sheets and that the surface layer can undergo large plastic deformation. [The *SCI*® indicates that this paper has been cited over 110 times since 1973.]

Nam P. Suh
Laboratory for Manufacturing
and Productivity
School of Engineering
Massachusetts Institute of Technology
Cambridge, MA 02139

April 13, 1981

"Beginning in 1968 I was investigating the physics of the elastoplastic transition in metals and the delayed yielding behavior of annealed low carbon steel. Based on the results of this work I began friction and wear experiments in 1971 so as to utilize the delayed yielding phenomenon in minimizing wear. Since the classic adhesion theory (which dominated the tribology field since the 1940s) stated that friction and wear are consequences *of* the adhesion between asperity junctions, it seemed that if the duration of loading could be made very small at these asperity junctions, the deformation of the steel could be minimized, prolonging wear life. However, the experimentally determined wear rates were significantly different from expected based on the hypothesis, raising questions about the validity of the adhesion theory. At about the same time, I began to write a textbook on mechanical behavior of solids with Arthur Turner. I agreed to write the chapter on surface phenomena which dealt primarily with tribology. My first draft was based on the classical work of Bowden and Tabor[1] and Rabinowicz,[2] which emphasized the adhesion theory of wear. I became very uncomfortable with the draft since the postulates and predictions of the adhesion theory were not consistent with the basic laws of nature and what I knew about the mechanical behavior of solids. This feeling was further intensified when I saw, in the fall of 1972, the micrographs of wear particles taken by V. Westocott. Many of the wear particles were not equiaxial in shape which was postulated by the adhesion theory.

"One evening in the late fall of 1972 I was explaining some aspects of the mechanical behavior of solids to a new graduate student. All of a sudden (like many other new ideas generated by me) it occurred to me that the wear of sliding surfaces must be due to plastic deformation, subsurface crack and void nucleation, and joining of these defects by shear deformation and crack propagation, all of which are dictated by surface traction. I called this process the delamination process for lack *of* better words to describe the postulated wear process.

"This concept was so different from the adhesion theory which had a very wide following throughout the world at the time that I wrote it up (in three pages) and solicited the comments of six of my colleagues at MIT and elsewhere. Only three of these people responded, two with encouraging remarks and one with rather discouraging comments. These responses made it clear that a few critical experimental results were needed to support the theory. So I had a few existing specimens sectioned and examined under SEM for the first time. The very first specimen showed that the basic postulates of the delamination theory of wear were sound. Therefore, I decided to publish the essence of the delamination theory *of* wear, although I did not have sufficient experimental data and analytical results to verify all aspects of the theory. Since the publication of the original paper we undertook extensive research work by having a number of students look into various aspects of the theory experimentally and analytically. These results were published in a special edition of *Wear* in 1977.[3] We are still conducting research to understand some of the details of the wear process.

"The reason this paper is often cited might be due to the fact that it introduced a radically different concept to the tribophysics field to explain the sliding wear mechanism. The 1976 Gustus L. Larson Memorial Award of the American Society of Mechanical Engineers, which I received, cited this work as being one of the reasons for the award."

1. **Bowden F P & Tabor D.** *The friction and lubrication of solids.* Oxford: Clarendon Press, 1954-1964. Parts I & II.
2. **Rabinowicz** E. *Friction and wear of materials.* New York: Wiley, 1965.
3. **Scott D,** ed. The delamination theory of wear. *Wear* **44**:1-162, 1977.