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Validation of Proposed Metrics for Two-Body Abrasion Scratch Test Analysis Standards: In Principle, Any Scratch Can Be Analyzed by This Method

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Abrasion of mechanical components and fabrics by soil on Earth is typically minimized by the effects of atmosphere and water. Potentially abrasive particles lose sharp and pointed geometrical features through erosion. In environments where such erosion does not exist, such as the vacuum of the Moon, particles retain sharp geometries associated with fracturing of their parent particles by micrometeorite impacts. The relationship between hardness of the abrasive and that of the material being abraded is well understood, such that the abrasive ability of a material can be estimated as a function of the ratio of the hardness of the two interacting materials. Knowing the abrasive nature of an environment (abrasive)/construction material is crucial to designing durable equipment for use in such surroundings.

The objective of this work was to evaluate a set of standardized metrics proposed for characterizing a surface that has been scratched from a two-body abrasion test. This is achieved by defining a new abrasion region termed "Zone of Interaction" (ZOI). The ZOI describes the full surface profile of all peaks and valleys, rather than just measuring a scratch width. The ZOI

has been found to be at least twice the size of a standard width measurement; in some cases, considerably greater, indicating that at least half of the disturbed surface area would be neglected without this insight. The ZOI is used to calculate a more robust data set of volume measurements that can be used to computationally reconstruct a resultant profile for detailed analysis. Documenting additional changes to various surface roughness parameters also allows key material attributes of importance to ultimate design applications to be quantified, such as depth of penetration and final abraded surface roughness. Furthermore, by investigating the use of custom scratch tips for specific needs, the usefulness of having an abrasion metric that can measure the displaced volume in this standardized manner, and not just by scratch width alone, is reinforced. This benefit is made apparent when a tip creates an intricate contour having multiple peaks and valleys within a single scratch.

The current innovation consists of a software-driven method of quantitatively evaluating a scratch profile. The profile consists of measuring the topographical features of a scratch along the length of the scratch instead of the width at one location. The digitized profile data is then fed into software code, which evaluates enough metrics of the scratch to reproduce the scratch from the evaluated metrics.

There are three key differences between the current art and this innovation. First, scratch width does not quantify how far from the center of the scratch damage occurs (ZOI). Second, scratch width does not discern between material displacement and material removal from the scratch. Finally, several scratches may have the same width but different zones of interactions, different displacements, and different material removals. The current innovation allows quantitative assessment of all three.

This work was done by Kenneth W. Street, Jr. of Glenn Research Center, Ryan L. Kobrick of MIT, and David M. Klaus of the University of Colorado at Boulder. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18780-1.