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Finite element analysis of the influence of the sharpness of the abrasive particle in micro-abrasive wear tests

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In micro-abrasive wear tests, the abrasive can either roll or slide in the contact region. In this work, these phenomena were studied based on a series of ABAQUS/FEM analyses. The objective was to analyze how the wear modes are affected by the sharpness of the abrasive, which was defined based on the ratio between the minor and the major axes of an elliptical particle. Sharpness values of 0.3, 0.5, 0.7, 0.83, 0.9 and 1 were considered. Results have indicated that different abrasive wear modes were obtained for different values of sharpness and normal load, allowing a discussion with the literature.

Keywords: sharpness of abrasive, micro abrasive wear, finite element analysis, particle movement

1. Introduction

In micro abrasion, material can be removed in two ways: (i) abrasion by sliding - when the abrasives are fixed and scratch the worn surface or (ii) abrasion by rolling - when the particles are free to rotate in the contact, causing multiple indentations. The literature [1,2,3] presents models to predict such behaviors and the mode of material removal. However, in tests with multiple abrasive particles, it is usually difficult to describe the isolated influence of particle parameters, such as shape. Numerical approaches can be beneficial in these studies.

This work aims to develop a numerical model using the Finite Element Method (FEM) for the analysis of the behavior of abrasive particles with different sharpness in situations typical of micro abrasion tests, including the effect of normal load on particle movement.

2. Methods

Two-dimensional (2D) FEM models were developed to reproduce phenomena typical of micro-abrasive wear tests with fixed-ball configuration. ABAQUS/Explicit® was used to simulate the behavior of rigid particles in the contact between two AISI H13 tool steel surfaces (Figure 1). The elastic-plastic properties of H13 tool steel have been taken from the literature. For the study of the abrasive particle morphology, rigid particles with different sharpness were simulated, which was defined as the ratio between the minor and major axes of an ellipse. Sharpness values of 0.3, 0.5, 0.7, 0.83, 0.9 and 1 were considered. In addition, two different loads per particle were selected, 9.7×10^{-06} N and 5.0×10^{-05} N. In the simulations, the counter-body - upper surface - was moved in the direction shown in Figure 1 and the sample - bottom surface - was fixed.

3. Results

For the lowest load, the particles with sharpness of 0.3, 0.5, 0.7, 0.83, 0.9 showed sliding movement with an initial rotation moment until a steady state was reached. For sharpness of 1, corresponding to a circular particle, only rolling was observed.

In general, more spherical particles can favor rolling, while more sharp particles can favor sliding. The increase in load also influences the transition between mechanisms, with higher loads favoring sliding.

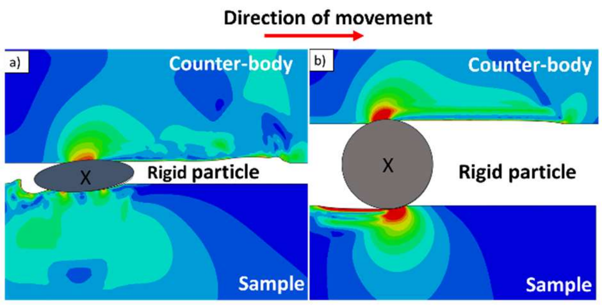

Figure 1: Von Mises stress fields generated by sharpness particles: a) 0.3 and b) 1.

4. Discussion

Results were analyzed in terms of apparent coefficient of friction (COF), stress fields, and particle movement (dynamics of the tribosystem). In the contact, there is a balance between the frictional force, generated by the movement of the upper surface, and the normal applied force. The moment generated by: (i) this balance and (ii) the capacity of the body and counter-body surfaces to deform define the particle behavior and the ability of material removal.

5. References

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