Short Communication

Third abrasive wear mode: is it possible?

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A R T I C L E  I N F O

Article history:
Received 29 January 2014
Accepted 17 March 2014

Keywords:
Abrasion
Rolling abrasion
Grooving abrasion

A B S T R A C T

The objective of this paper is to propose an initial discussion on the characterization of a third abrasive wear mode. The results obtained in a previous work [1] under different test conditions revealed the occurrence of the superposition of the “rolling” and “grooving” abrasive wear modes. This phenomenon was denoted “micro-rolling abrasion” due to the observation that “rolling abrasion” was found to act on “grooving abrasion”.

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1. Introduction

In abrasive wear, two abrasive wear modes are observed on worn surfaces: “grooving abrasion” results when abrasive particles slide on the specimen, whereas “rolling abrasion” is observed when abrasive particles roll on the specimen [2]. Depending on the test conditions, there is a predominance of “grooving abrasion”, “rolling abrasion”, or the simultaneous occurrence of both modes [3–5].

The purpose of this initial study is to discuss the possibility of the existence of a third abrasive wear mode, which is characterized by the superposition of the “rolling” and “grooving” wear modes. Further detailed information on equipment configuration, materials and experimental procedure can be found in Refs. [1,6–9].

This subject began during the Ph.D. program of R.C. Cozza [7], and the first results were published in Refs. [1,7–9]. However, this is the first time that R.C. Cozza suggests the classification of a third abrasive wear mode and proposes a discussion with the scientific community.

2. An initial discussion on a third abrasive wear mode

In the studies of Refs. [1,7–9], an optical microscopy analysis was performed on worn areas, and in all cases, the abrasive wear mode was grooving abrasion. However, when a more detailed analysis was conducted with a scanning electron microscope (SEM), the occurrence of rolling abrasion was observed in addition to grooving abrasion, i.e., the SEM revealed the occurrence of rolling abrasion along the grooves. In this case, the $A_0/A_t$ relationship defined by Cozza et al. [6,7,10,11] is no longer valid; $A_0$ is the projected area fraction with grooving abrasion, and $A_t$ is the total projected area of the wear crater.
In the discussions in Refs. [1,7–9], the phenomenon of rolling abrasion at the surface of or between the grooves was referred to as “micro-rolling abrasion”. Fig. 1 [9] presents the occurrence of micro-rolling abrasion for a normal force of 1.25 N, for a sliding distance of 100 m.

Fig. 4 of Ref. [10] (Fig. 3c in this work) exemplifies the simultaneous action of rolling abrasion and grooving abrasion, which is a situation that indicates a transition condition between these abrasive wear modes and a possible distinct qualification of the areas $A_t$ and $A_g$ in Eq. (1); $A_t$ is the projected area fraction in rolling abrasion.

$$A_t = A_s - A_g$$ (1)

The difference between the example shown in Fig. 4 of Ref. [10] and “micro-rolling abrasion” (Refs. [1,7–9]) is that both the rolling and grooving wear modes act together and are superimposed in the same area of micro-rolling abrasion.

Differences in the conditions of the abrasive particles can result in grooving abrasion or rolling abrasion, e.g., if abrasive particles are incrusted on the surface of the counter-body or are free, respectively. For micro-rolling abrasion to occur, there must be both abrasive particles incrusted on the surface of the counter-body that are responsible for generating grooving abrasion and abrasive particles that are free to roll.

Another possible explanation for this phenomenon is related with the abrasive particle size: the marks of rolling abrasion are derived from abrasive particles that roll along grooves that were produced by other larger abrasive particles.

The larger abrasive particles, which adhere to the counter-body, are subjected to relatively higher normal forces; therefore, these particles acquire only “translation” motion and thus generate “grooving abrasion”. In contrast, the smaller abrasive particles, which are subjected to reduced normal forces, exhibit motions of “translation + rotation”. Then, the translation motion of the larger abrasive particles and the “translation + rotation” motions of the smaller abrasive particles produce “micro-rolling abrasion”, as suggested in Fig. 2.

3. Preliminary conclusions

Three points can be highlighted in this initial discussion:

(1) Fig. 3a–c [1,3,7,8,10] exemplify the classic actions of “grooving abrasion” and “rolling abrasion” wear modes. In
addition, a third abrasive wear mode, denoted “micro-rolling abrasion”, has been suggested (Fig. 3d [1,7,8]).

(2) The conceptualisation of a third abrasive wear mode, called “micro-rolling abrasion” in this work, is important by the synergy between “grooving abrasion” and “rolling abrasion”, which is not possible if the abrasive wear modes are considered independent.

(3) Further studies, discussions and a joint effort of the scientific community are necessary regarding this subject to acquire knowledge and to determine whether there is a third abrasive wear mode.

**Conflicts of interest**

The authors declare no conflicts of interest.

**REFERENCES**


