Ball-on-flat linear reciprocating tests: Critical assessment of wear volume determination methods

Alaitz Zabala[1)*], Iñigo Llavori[1)], Andrea Aginagalde[1)], Dirk Spaltmann[2)], Jörn Bonse[2)], Liam Blunt[3)]

[1)] Mechanical and Industrial Production department, Mondragon University, Spain
[2)] Bundesanstalt für Materialforschung und -prüfung (BAM), Unter den Eichen 87, 12205 Berlin, Germany
[3)] EPSRC Future Metrology Hub, University of Huddersfield, UK
*Corresponding author: azabalae@mondragon.edu

This work presents a critical assessment of wear volume determination methods for ball-on-flat linear reciprocating sliding tribological tests. A mass literature review in tribology journals was carried out to identify the prevalence of the existing methods and wear tracks of different size and morphology were generated for a critical assessment of the methodologies. Following a sensitivity study, improvements are suggested for a better implementation of ASTM D7755-11 standard and guidelines for the most used method, 3D profilometry are developed.
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Keywords (from 3 to 5 max): Wear, ASTM, 3D profilometry, D7755-11

1. Introduction

Notwithstanding that the quantification of the wear volume is key in tribological testing, current methods for volume calculation in contacting triboelements have several limitations, as extensively discussed by Blau [1]. Whereas gravimetric methods cannot be used for determining small wear volumes, characterising the wear track with 2D profiling techniques can be applied only to flat specimens, and, finally, 3D profilometry may be time-consuming, especially for the wear volume calculation of large testing campaigns. Simple and fast methodologies are desirable, however, robustness and accuracy of the measured data are fundamental in conducting valid tribological research. This study presents a critical analysis on the wear track volume calculation methods for wear volume computation in ball-on-flat linear reciprocating sliding tribological tests (RSTT), and provides recommendations on improving such techniques.

2. Methods

2.1. Mass literature review

A systematic literature search was carried out on the ScienceDirect database by entering the keywords reciprocating sliding and wear volume. The search was limited to a set time frame (2014–2018) and to relevant tribology journals (Wear and Tribology International). A total of 271 papers were divided between four reviewers and examined independently to identify the applied wear volume calculation method. Finally, the reliability of the results was validated using a cross-check of 10% of the results of each evaluator.

2.2. Tribological analysis

Diverse wear-track typologies (of different sizes and morphologies, see Fig 1) were produced for the critical analysis. An in-house-built tribometer was used and operated in ball-on-flat linear reciprocating test conditions with a stroke of ~1 mm at a reversing frequency of ~1 Hz. Plane polished titanium alloy (Ti6Al4V) samples were used along with 10 mm diameter counterbodies (hardened 100Cr6 steel or Si_3N_4 ceramic) in dry or oil-lubricated conditions at a normal load of 1 N. Each wear track was analysed and characterized by three different users to reveal differences and determine the robustness of each method.

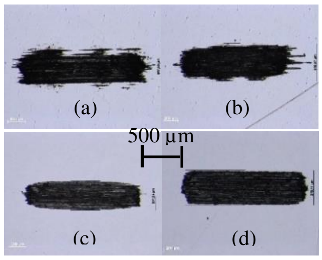

Figure 1: Wear tracks generated for the critical assessment of the wear volume determination methods.

3. Discussion

The mass review disclosed the prevalence of the wear volume characterization method for RSTT (see Table1).

Table 1: Results of the Mass literature review

Wear volume characterization method	[%]
3D profilometry	46
Other calculation methods	6
Gravimetry	7
Standard (ASTM D7755-11 or G133-05)	3
Not reported	8

The existing standards for wear volume computation are rarely reported and the preferred method is the 3D profilometry, although the methodology is ambiguously reported. Experimental comparison between the identified methods disclosed that the ASTM D7755-11 standard reported the highest relative errors. Improvements are suggested for a better implementation of ASTM D7755-11 standard (which decreased the error from 106% to 17% for irregular tracks) and guidelines are provided for the most used method, 3D profilometry.

4. References

[1] P.J. Blau, Needs and Challenges in Precision Wear Measurement, ASTM J. Test. Eval. 25, 216–225, 1996.