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Influence of relative humidity on wear of self-mated 100Cr6 steel

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The understanding of physicochemical phenomena affecting tribology is hampered by poor reproducibility, large numbers of variables, and difficulties in the detection of tribochemical processes and products. Hence, statistical analysis with big datasets are necessary. In this study, 686 tests were analysed under wide variation of the relative humidity on 5 tribometers. Aim of this work is to determine the dependence of the wear coefficient on the relative humidity, to understand the underlying physicochemical phenomena and to build three dimensional maps of the wear coefficient as a function of both humidity and the product of normal force and sliding distance.

Keywords: wear coefficient, humidity, 100Cr6 steel, big dataset, reproducibility

1. Introduction

The role of relative humidity (RH) in unlubricated tribological processes has been subject of discussion since decades [1]. It is known that the influence of the relative humidity, depending on the chemistry of the solid surfaces, can significantly change the wear coefficient.
Yet, previous conclusions must be verified through the analysis of big datasets and the variation of several operating parameters, in particular the product of sliding distance and normal force sF_N. The final aim of this analysis is building a map of the wear coefficient as a function of both relative humidity and sF_N.

2. Methods

Big datasets are indispensable for meaningful statistical analysis. Results of 51 own tests and 635 data collected in a databank (TRIDAS) of the Federal Institute for Material Research and Testing have been analysed in the present study. All reciprocating sliding tests were unlubricated with 100Cr6 balls on 100Cr6 planes. The temperature was 23 ±6 °C. Operating parameters were varied in large intervals.

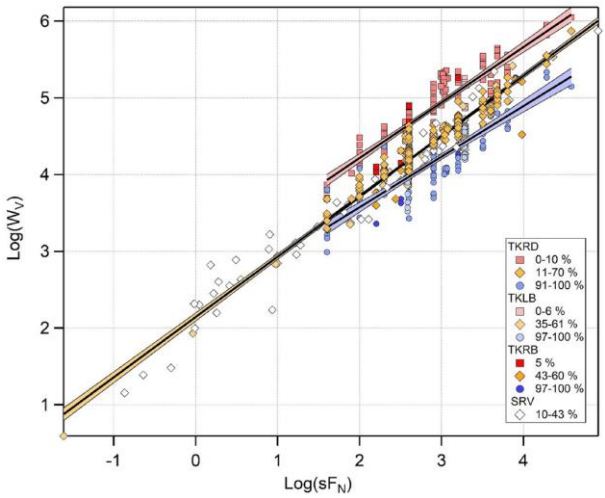

Figure 1: Wear volume vs sF_N for tests performed on 4 tribometers in 3 different ranges of relative humidity, as shown in the legend. Fits for each range of RH are shown together with confidence bands. [Reproduced from Ref. 2]

2.1. Results

- Volumetric wear data are repeatable and reproducible in the whole range of RH.
- Fits in 3 ranges of RH (Fig. 1) with $W_v = c\ (sF_N)^m$ and $m < 1$ show that the wear coefficient k depends on sF_N and Archard's law cannot be applied.
- The dependence of the wear coefficient on RH can be related to a BET type-II adsorption isotherm.
- A procedure enables to build a map of k vs the relative humidity and the logarithm of sF_N, shown in Fig. 2.

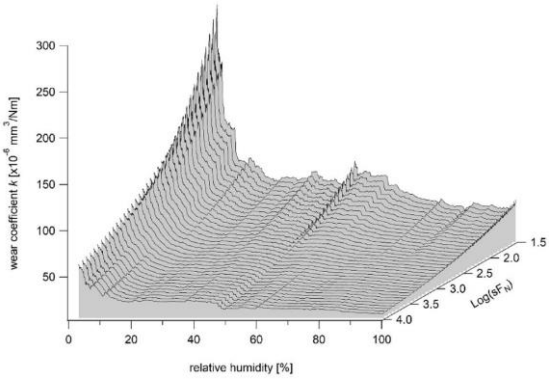

Figure 2: Map of the wear coefficient vs the relative humidity and the logarithm of sF_N. The black curves connect values corresponding to the same sF_N. [Reproduced from Ref. 2]

3. Discussion

The large number of data permitted to characterize comprehensively the dependence of the wear coefficient k on the humidity and on sF_N. In particular, k depends on sF_N and Archard's law cannot be applied. Rather, the effect of the humidity and of sF_N must be considered concurrently. These experimental results enable to predict the wear of the studied system and can serve as input for simulations and theoretical studies.

4. References

[1] Barthel, A. J., et al., "Effects of gas or vapor adsorption on adhesion, friction, and wear of solid interfaces", Langmuir, 30, 2014, 2977–2992.
[2] Reichelt, M., Cappella, B., "Influence of relative humidity on wear of self-mated 100Cr6 steel", Wear, 450–451, 2020, article # 203239.