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Effect of Normal Load and Rotational Rate on the Coefficient of Friction of CoCr Alloy in Hyaluronic Acid as Lubricant

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Synopsis

The effect of normal load and rotational rate on the coefficient of friction (COF) of CoCr sliding against alumina was evaluated using a pin on disk tribometer. Tribological tests were carried out by using CoCr disks of 38 mm diameter and alumina balls of 6 mm diameter as counterpart (pin). An aqueous solution containing 3g/L of HA, concentration equivalent of that found in the synovial fluid, was used as lubricant and it was in continuous recirculation throughout the test. The COF values for two normal loads, 1N and 5N, and two rotational rates, 60 rpm and 120 rpm, have been obtained for a constant sliding distance of 500 m. The tribological tests were performed in duplicate in order to verify the reproducibility of the results. The results show that the COF varies with the load and with the rotational rate, so that, for the same load, the COF increases as the rotational rate decreases. This effect is more significant at lower loads. Meanwhile, the COF values are higher for loads of 1N than for 5N regardless of the rotational rate. The wear tracks were observed by optical microscopy and the images revealed the widest tracks at 5N and 60 rpm.

Introduction

Cobalt-chrome alloys (CoCr) are commonly used for the MoM hip joints, due to their substantially low corrosion and wear rates. Nevertheless, it is unavoidable that the continuous sliding between the contact areas shorten prosthesis durability.

The friction between two surfaces depends on multiple factors such as lubrication, type of material, surface cleanliness, etc., but perhaps the ones that play a more important role in the variation of the friction are the normal load and the sliding rate [1]. Therefore, in this research an attempt is made to study the effect of both factors on frictional behavior of CoCr sliding against alumina in a hyaluronic acid (HA) solution as a lubricant.

Results and Discussion

- Effect of rotational rate on the coefficient of friction

Figure 1 (a, b) shows the COF versus distance for CoCr/alumina in HA solution: (a) for load of 1N and (b) for load of 5N. This figure reveals the increase in COF with the decrease in rotational rate from the beginning to the end of the test. In the case of 5N the effect of rotational rate is less significant exhibiting a less stable COF along the test.

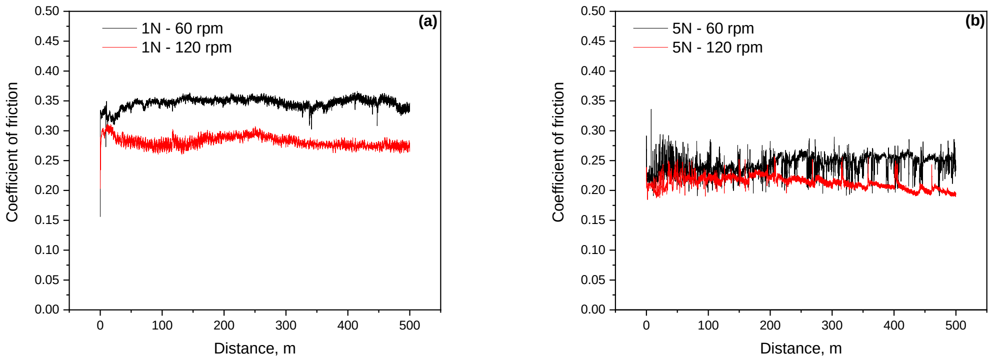

Figure 1. COF versus distance for CoCr/alumina in HA for 60 rpm and 120 rpm rotational rates. Normal load: (a) 1N and (b) 5 N.

- Effect of normal load on the coefficient of friction

The COF data obtained for each condition and replicate were represented in a box-whisker type graph (Figure 2), which shows the statistical data as separate box that indicates the middle 50% of the data (box) and with markings that indicate the 25 (bottom line), 50 (horizontal line in the box) and 75 (top line) percentiles. The lines that go from the box correspond to the standard deviation and the black and red dot correspond to the mean. This figure shows that the COF increases with the decrease in normal load at both 60 and 120 rpm. Optical microscopy images revealed wider tracks at 5N than at 1N.

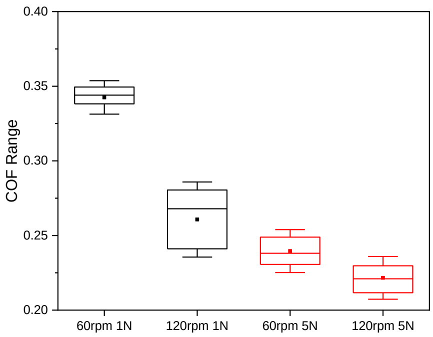

Figure 2. Variation in the COF values with the normal load and rotational rate.

Conclusions

The COF values of CoCr alloy sliding against alumina in HA vary with the load and with the rotational rate, increasing as the rotational rate decreases and normal load decreases.

References

[1] D.M. Nuruzzaman and M.A. Chowdhury, Effect of Normal Load and Sliding Velocity on Friction Coefficient of Aluminium Sliding Against Different Pin Materials, American Journal of Materials Science, 2 (2012) 26.