Friction and wear behaviour of ceramic materials under unidirectional sliding with saline lubrication

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1. ABSTRACT

Ceramic materials, with their biocompatibility and wear resistance, are widely used in biomedical bearing applications such as artificial replacement joints [1], in implantable devices and as dental implants [2]. As such, knowledge of the friction and wear performance of commonly used ceramic materials is of interest to the bio-tribology community.

In this paper, three commonly-used material combinations were tested to assess their wear performance for use in biomedical applications. Testing was performed in a pin-on-disk tribometer constructed by the Cardiff Tribology Group. The material combinations tested were (A) zirconia pin on alumina disk, (B) zirconia pin on zirconia-toughened alumina (ZTA) disk, and (C) ruby pin on ZTA disk. The contact geometry was a 1mm radius spherical pin sliding on a flat disk, with an applied load of 5 N and a nominal sliding speed of 57 mm/s. The contact was lubricated with 2 ml of phosphate-buffered saline in a reservoir surrounding the disk. Each test was conducted for a nominal duration of 8 hours, which represents a total sliding distance of 1642 m. During the tests, friction was continuously monitored using a load cell, to allow the calculation of mean coefficient of friction. Following each test, the pin and disk components were measured using a surface profilometer, and the vast majority of wear in all cases was found to occur on the pin.

Figure 1 shows the mean coefficient of friction and wear rate for the three tested material combinations. It can be seen clearly that material pair C offers the lowest coefficient of friction, of 0.35. However, the wear rate of ruby on ZTA is significantly higher than that of the other two material combinations.

Figure 2 shows a typical microscope image of the wear scar on a ZTA disk, taken from a test using combination B, where surface modification was generally limited to polishing or light abrasive wear caused by entrapped wear debris particles, with the deepest original finishing marks remaining visible.

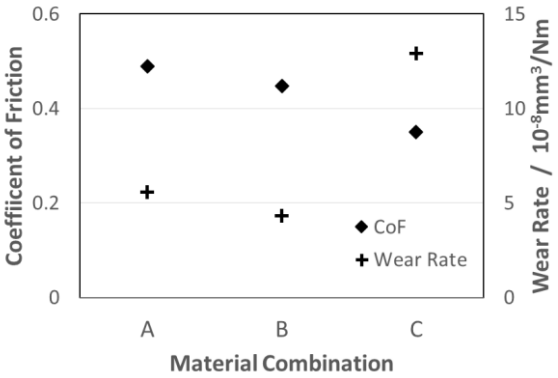

Figure 1: Mean coefficient of friction and pin wear rate for three pin / disk material combinations – (A) Zirconia / Alumina (B) Zirconia / ZTA (C) Ruby / ZTA.

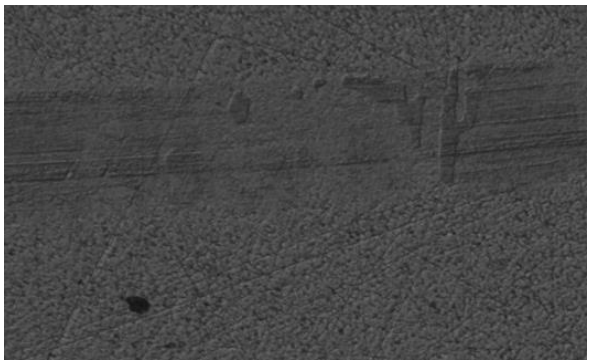

Figure 2: Wear scar on ZTA disk

It is therefore demonstrated that when assessing the performance of ceramic materials, consideration must be given to both the frictional and wear behaviour.

References

[1] McEntire, B.J. *et al.*, Journal of the European Ceramic Society, 35(16), 4327-4369, 2015.
[2] Kwon, M-S, *et al.*, Journal of the Mechanical Behavior of Biomedical Materials, 47, 21-28, 2015.