BIOTRIBOLOGICAL BEHAVIOR OF BORONIZED TUNGSTEN

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ABSTRACT

Boronized tungsten is one of the potential biomaterials due to its high corrosion resistance, and high strength. Present investigation encompasses the wear behavior of this material in dry condition as well as in simulated body fluid (SBF). The pin-on-disc reciprocating tribometer was utilized to conduct the wear tests. The worn surfaces were analyzed using an atomic force microscope (AFM). Results showed that not only the SBF reduces the friction, but also shortens the initial break-in period. This presentation discusses the wear mechanisms of boronized tungsten affected by SBF.

INTRODUCTION

Metal surfaces have been boronized to improve their corrosion resistance, electrochemical properties, tribological performance, and to prolong service life. Efforts have been made in studying material properties of boronized steels [1, 2, 3, and 4]. Boronizing is a thermo-chemical diffusion surface treatment in which boron atoms diffuse into the surface of the target material to form hard borides with the base materials [5]. The layer-lattice structures formed on the surface of the boronized steels gave ultra-low friction [6, 7, 8, 9, and 10]. Martini [11] studied the sliding and abrasive wear of boronized coating on steel. He found that there was difference in values of surface height in different regions of the coatings. The difference was due to various crystallographic orders of iron borides. The wear resistance was initially poor when there was a thin, friable layer constituting disordered crystals. The wear resistance increased to a maximum value in regions with ordered Fe₃B crystals.

The bio compatibility of refractory metals has been studied [12]. Boronized refractory metals are potential bio materials. The study of their friction and wear properties is important in order to find their feasibility as bio materials.

MATERIALS AND METHODS

In the present study, tungsten with purity of 99.99% was boronized in presence of Ekabor powder at 940°C for 2, 4 and 8 hours respectively. Tribological studied were performed for boronized tungsten for 4 hours. Friction and wear test were conducted using reciprocating pin-on-disc tribometer in dry and using SBF. The counter pin used was steel bearing ball (52100). The dry test was conducted with applied load of 5N for 3600 seconds whereas wet test was conducted for 1800 seconds. The worn surfaces were studied using an AFM to evaluate the wear mechanisms. Detailed test procedure is motioned elsewhere [13, 14].

RESULTS AND DISCUSSIONS

In case of dry test, the curve of coefficient of friction with time shown in Fig. 1 can be divided into three distinct regions (i.e. region I, II, III). The change in the coefficient of friction in the first 200 seconds was fast (i.e. region I). This change was very slow from 200 seconds to 2000 seconds (i.e. region II) and thereafter it stabilized (i.e. region III). The stabilized coefficient of friction was 0.75.

The coefficient of friction plotted against time for wet test using SBF is shown in Fig. 2. The coefficient of friction between boronized tungsten and steel ball in presence of SBF was found to be 0.14. The initial break-in period lasts for 150 seconds in the initial period until the friction is stabilized. This period is shorter than the break-in period for dry test. In wet test, the lower coefficient of friction was observed between boronized tungsten and the steel ball. Most likely, this is due to the surface modification induced by SBF.

The observation of the boronized tungsten wear track (dry test) at micron level indicated that the wear is abrasive in nature. The morphology of the surface in Fig. 3 shows the abrasive grooves on the worn surface. The single phase
tungsten boride present on the surface is hard and brittle intermetallic compound. Upon detaching from the surface, the hard debris particles are involved in the third body action. These hard particles further involved in abrasion of mating surfaces and failed themselves by fracture. The morphology image of the wear track (formed in wet test) in Fig. 4 shows that the failure of the surface is mainly abrasive wear that occurs at the micrometer length scale level. Lots of debris was observed on the wear track. As there was different break-in period, the nano scale wear might be different. Apparently, the SBF works as a vehicle carrying the debris out of wear track during sliding. Furthermore, it can be seen that shear forces on the surface are reduced by the presence of SBF fluid so that less materials are removed.

CONCLUSION

The wear mechanisms of the boronized tungsten in dry and wet conditions are the same at micro level, i.e. abrasive wear. However, the friction behaviors are different in both cases. The initial break-in period was reduced in wet test and the friction was reduced as well.

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REFERENCES