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WEAR SIMULATION OF EXPERIMENTAL ALLOY Ti-7.5Mo

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Abstract. *In the last years, titanium has been used for biomedical applications due their excellent properties such as biocompatibility and corrosion resistance. However, some studies on friction of this material have shown poor wear properties. This behavior has been associated to the oxide layer and low shear strength hcp materials. New titanium alloys with different structures and oxide layer have been proposed. In this work, wear resistance of Ti-7.5Mo experimental alloy was evaluated. Wear tests were realized in a pin-on-disc device. One tribological pair was used Ti-7.5Mo experimental alloy - UHMWPE (Ultra High Molecular Weight Polyethylene). Sliding wear and lo of the polymer to the metallic surface was evaluated by determining the weight loss of the pin and disc.*

Keywords*: titanium alloys, wear, UHMWPE, pin-on-disc*

1. INTRODUCTION

Titanium and Ti-6Al-4V alloy have been used for biomedical applications due excellent properties such as biocompatibility and corrosion resistance (Gerber et al., 2005; Chanine et al., 2008; Bornstein et al., 2005). However, wear strength of these materials is inferior when compared with Co-Cr alloys and this property has been improved by using of composition adjustment, heat treatment and surface modification (Majumdar et al., 2008).Titanium based alloys with different compositions such as Ti-10Mo (Ho et al. 1999, Alves Rezende, 2007; Alves et al., 2004), Ti-29Nb-13Ta-4.6Zr (Li et al., 2004) and Ti-13Nb-13Zr (Niemeyer, 2008) have been studied for these applications. Lin et al. (2005) developed binary alloy Ti-7.5Mo with low elastic modulus and high-strength/modulus ratio.

Wear of C.P. titanium and titanium alloys have been studied for several researches. Gispert et al. (2006) realized pin-on-disk tribological test in materials commony used joint materials for substitution of hip joints: UHMWPE (Ultra high molecular weight polyethylene) for cup and alumina, stainless steel, Co-Cr for head. The authors concluded that wear was particularly intense on steel surface. Recently, Wilches et al.(2008) evaluated wear of pairs stainless steel/UHMWPE and titanium alloy/UHMWPE. The lower values of friction coefficient were measured when a thin film of polymer was transferred to the metallic surface.

In the present work, it was evaluated tribological behavior of pair UHMWPE against Ti-7.5Mo experimental alloy. Values obtained were compared with pairs UHMWPE against Ti-6Äl-4V and UHMWPE against Ti-13Zr-13Nb.

2. MATERIALS AND METHODS

The dry sliding wear tests were realized in a pin-on-disc type test rig machine (Fig.1). The pins (15mm in length and 3 mm in diameter) were machined from commercial alloy Ti-6Al-4V (Multialloy, Brazil) and experimental alloys (Ti-13Nb-13Zr and Ti-7.5Mo) (Fig.2a). These experimental alloys were produced from sheets of commercially pure titanium (99.9%), zirconium, niobium and molybdenum (99.9%). Melting was realized in arc melting furnace in an argon atmosphere. Ingots were homogenized in a vacuum at 1100ºC for 86.4 ks to eliminate segregation chemical and cold worked by swaging producing a final 13 mm rod. After machining pins were heat treated using water quenching 1100ºC and 900ºC for Ti-7.5Mo and Ti-13Nb-13Zr, respectively.

The wear test was realized against medical grade UHMWPE (ultra high molecular weight polyethylene) which exhibited properties listed in Tab. 1 (according manufacturer). Pin was polished with emery papers and surface

finishing of disc was obtained with machining. Schematic diagram of shape of pin and disc used in tests is shown in Figure 2.

The microstructural analyses of the Ti-7.5Mo alloy were made by optical microscopy. The specimens were prepared using this technique: wet grinding up to 2400 grit with SiC (using water plus paraffin). Chemical polishing was done with a colloidal silica. Microhardness experiments were carried out using a Vickers microhardness tester.

Figure 1 – Pin-on-disc wear testing machine

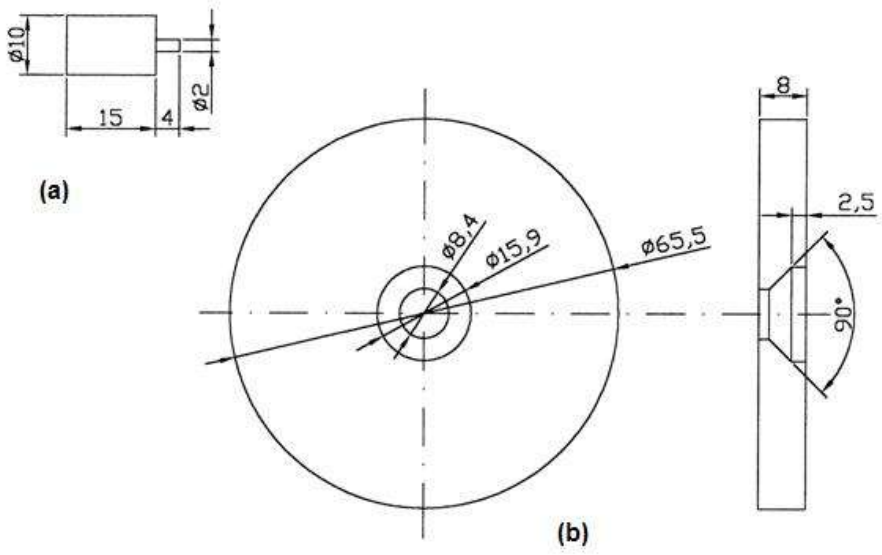

Figure 2 – Schematic diagram of (a) shape of pin and (b) disc used in tests

Table 1 – Properties of *UHMWPE (Ultra High Molecular Weight Polyethylene)according manufacturer*

Properties	
Mechanical strength (MPa)	40
Yield strength (MPa)	17
Elastic modulus (MPa)	650
Density (g/cm^3)	0.932

During wear test, the surface of pin was rubbed against the rotating disc of UHMWPE. Sliding speed and distance was 0.5m/s and 12,000 m, respectively. After each wear test, samples were carefully cleaned in an ultrasonic bath with alcohol for 12 min to remove any bulk material and dried in hot air. Followed, they were weighted on analytical balance. The wear was evaluated by determining the weight loss of the pin and disc.

3. RESULTS AND DISCUSSION

The optical micrograph of Ti-7.5Mo alloy after heat treatment (QW) is shown in Fig. 3. This alloy exhibited acicular martensitic structure, similar to verified by other authors (Ho et al (1999); Lin et al (2005)). The average value of microhardness obtained was 256 HV which is greater than commercially pure titanium (160HV) , less thanTi-6Al-4V (294HV) and equal to Ti-13Nb-13Zr (256HV).

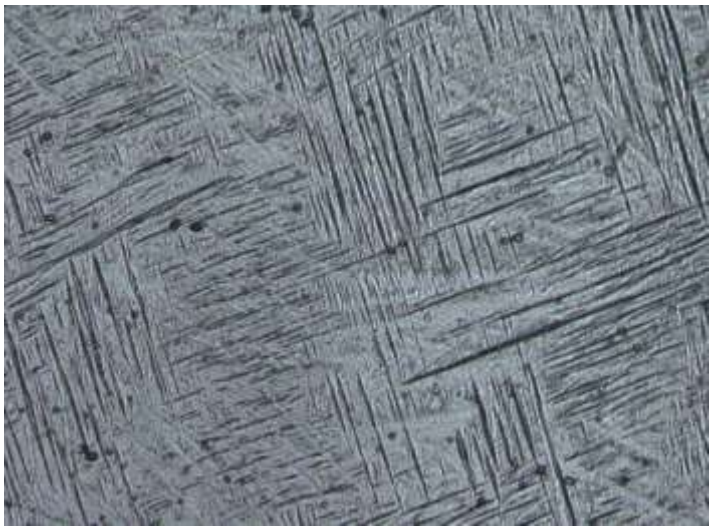

Figure 3 - Micrograph after heat treatment of Ti-7.5Mo alloy (QW, 1100ºC)

Figure 4 shows loss weight of pin of Ti-7.5Mo alloy against UHMWPE with sliding distance (km) compared Ti-13Nb-13Zr and Ti-6Al-4V. Initially, loss weight of the Ti-7.5Mo alloy varied between Ti-6Al-4V and Ti-13Nb-13Zr and decreased subsequent with gain weight. It can be seen that Ti-7.5Mo exhibit the lowest loss weight.

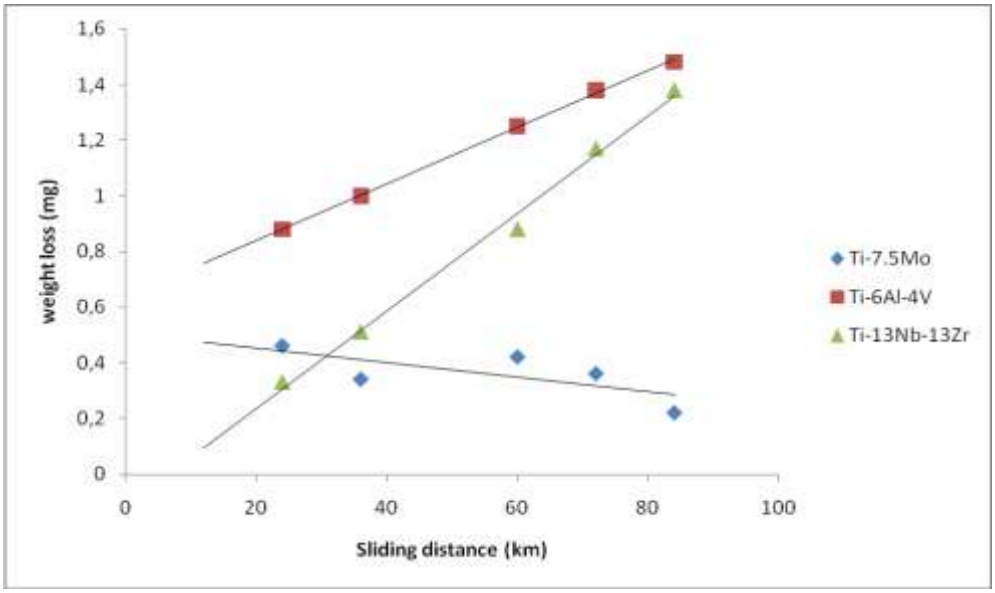

Figure 4 – Weigth loss of pin – Ti-7.5Mo, Ti-6Al-4V and Ti-13Nb-13Zr

The loss weight of disc of UHMWPE with sliding distance compared with Ti-7.5Mo is shown in Figure 5.

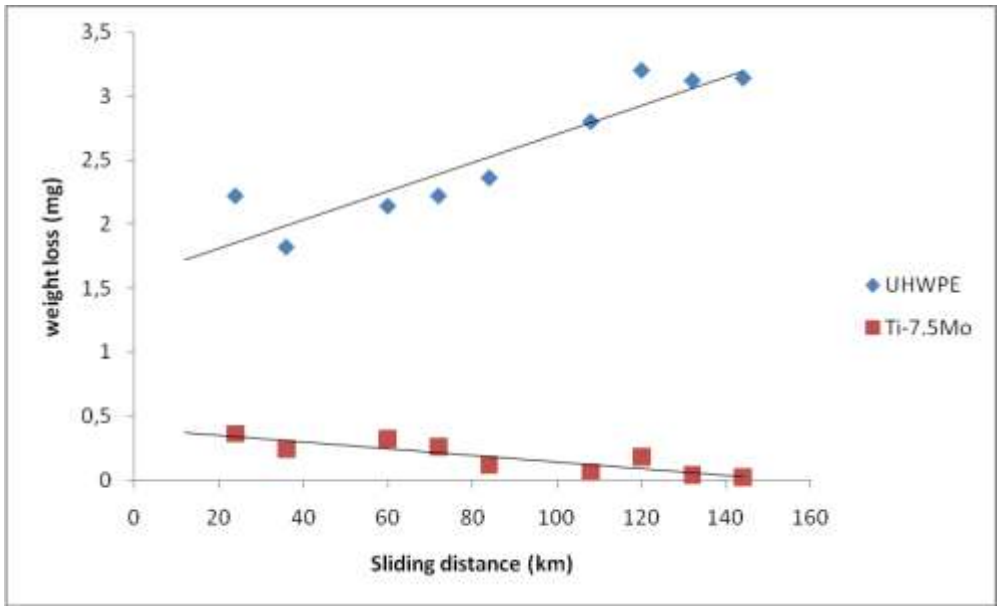

Figure 5 – Weigth loss of UHWPE and pin – Ti-7.5mo experimental alloy

It was found that the initial loss weight was higher for UHMWPE (2.2 mg) rather than Ti-7.5Mo alloy (0.5mg) for 12,000 m. Followed, weight loss decreased with sliding distance (24,000m) and increased again but with values lower. It was concluded that polymer adhered to the surface of Ti-7.5Mo alloy disc tends to increases the mass of disc. According Kim et al. (2008), occurrence can be associated with test time period and elevation of temperature in dry tests.

4. CONCLUSIONS

In this study, we also concluded that the wear of disc of Ti-7.5Mo alloy/UHMWPE pair was lower than Ti-6Al-4V/UHMWPE and Ti-13Nb-13Zr/UHMWPE. The first exhibited better tribological properties. In order to understand the dominant mechanism that governing sliding wear new researches using microstructural investigation using optical microscopy and surface treatments in UHMWPE surface are been realized.

5. ACKNOWLEDGEMENTS

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