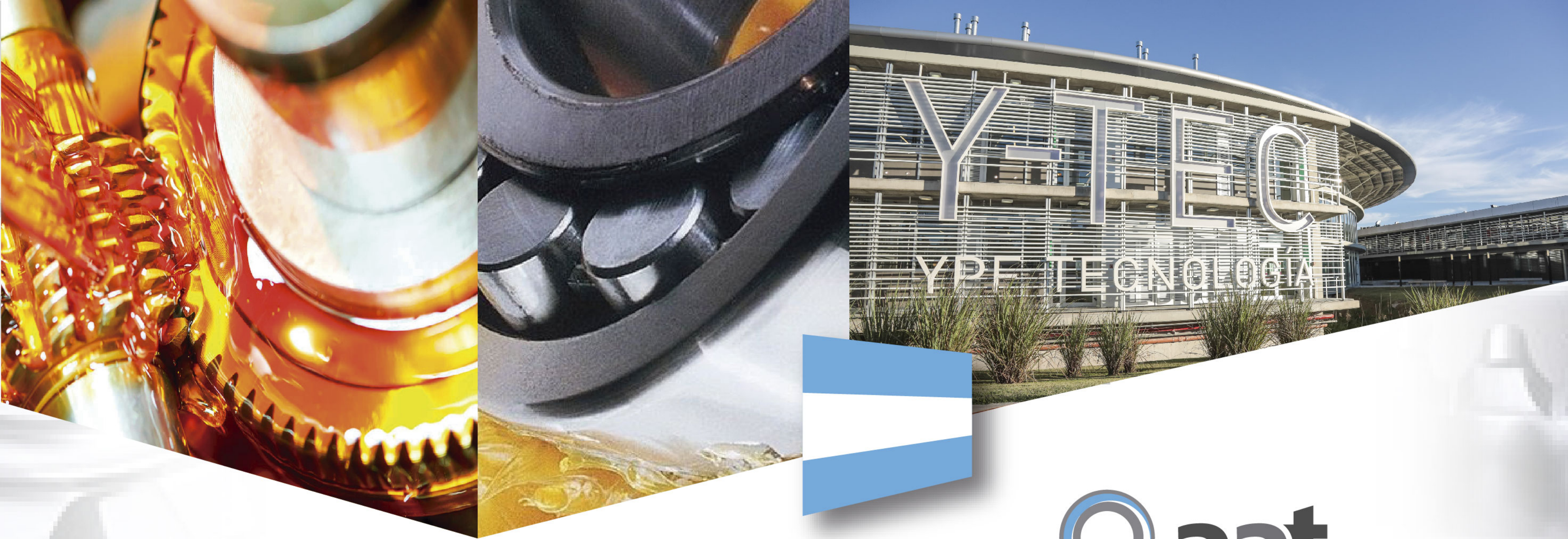

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DEVELOPMENT AND EVALUATION OF HOME-MADE BALL-ON-RING AND BALL-ON-DISK DEVICES

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INTRODUCTION

The electrochemical deposition of metals and alloys has been used for over 100 years, mainly with decorative purposes. However, this technique has lately been employed to obtain functional coatings with excellent mechanical and tribological properties [1,2]. As a result, determination of wear resistance and coefficient of friction (CoF) of has become of great interest for the both academic and industrial researchers in the field of electroplating. Nevertheless, no measuring devices were available in La Plata's region making evaluation of large numbers of samples difficult or time consuming. For this reason, both a ball-on-disk and a ball-on-ring measuring setup were designed and constructed together with the data recording and processing device. The present manuscript presents the details of the equipment developed together with some preliminary results performed on well-characterized materials to assess the reliability of these home-made systems.

MATERIALS AND METHODS

The ball-on-disk device consists of a free-standing structure with a flat plate/platform onto which samples are placed (Fig. 1). The latter can be rotated at speeds between 80-500 rpm, while a static 6 mm AISI 52100 ball counter body is placed over the rotating surface under evaluation, applying a fixed normal force. As shown in Fig. 1, the steel counterbody is held in place by an adjustable arm (height and position along radius of the sample (r) can be changed. A small secondary arm is attached perpendicularly to the main one, so its axis is parallel to the tangential speed. This arm will contact a load cell (0.2 g precision) during the wear test in order to measure the friction force.

A similar setup was used for the ball-on-ring device (Fig. 2). In this case, the arm with the counterbody and the load cell are mounted on the carriage of a lathe while cylindrical samples are placed on the chuck and rotated against a static steel ball (same as in ball-on-disk).

In both systems a home-made data recording software and device was employed. The latter registers the applied force on the load cell as well as the time of test, and calculates the CoF according to the ASTM G115-04 [3] standard. The results are written on an Excel spreadsheet in real time.

Fig. 1. Photograph of the ball-on-ring device

Fig. 2. Photograph of ball-on-disk device

RESULTS AND DISCUSSION

Table 1 summarizes the CoF of various materials measured either with the ball-on-ring or the ball-on-disk configuration. The values obtained are in good agreement with previously reported results. Using the ball-on-ring configuration, several runs were performed on a SAE 1020 rod at various normal loads and rotation speeds to evaluate the consistency of our measurements on different conditions, obtaining satisfactory results. Moreover, some experiments were performed after applying a thin layer of a lubricating oil between both surfaces. Under these conditions, the force on the load cell was significantly low which as expected in the presence of a lubricating oil. Similar tests were performed on the ball-on-disk configuration obtaining comparable CoF values in both cases (Table 1).

Table 1 – CoF values obtained with homemade

devices

Material	Ball-on-ring	Ball-on-disk
AISI 1020	0.32±0.03	0.31±0.03
AISI 1020 lubricated	0.07±0.005	0.08±0.005
Cu	0.22±0.02[1]	0.19±0.02
Al		0.56±0.03
Anodized Al		0.32±0.01
Ti		0.37±0.030
Ag coating on Ti		0.11±0.01
MDF-biopolymer		0.45±0.04

[1]Avarage value of Cu coatings obtained in different conditions

Once the capability of the mechanical setup and acquisition device had been proved, tribological characterization of different types of materials was carried out as part of our investigations. In this regard, the CoF Cu coatings electrodeposited from an alkaline ecofriendly copper electrolyte developed in our laboratory [4]. It was found that this parameter strongly depended on the deposition parameters (current density and time) and bath composition (pH and presence of additives). CoF values between 0.15-0.30 were measured, which are around the previously obtained CoF of copper coatings deposited from a traditional acid sulfate electrolyte[5].

Furthermore, the tribological behavior of Al (1000 series) before and after its electrochemical anodization was assessed. The results that the alumina film that forms during the anodization process not only increases the wear resistance of the surface (probably due to an increase in surface hardness) but also reduces de CoF from 0.56 to 0.32.

Silver coated titanium samples were also tested. This material is expected to be a good option for hip implants fabrication as a result of silver's biocidal properties. However, this coating has to be able to withstand repeated fretting and hence its tribological properties must be determined. The results demonstrated the ability of this material to resist severe friction for several minutes, with a CoF of 0.11.

Our latest investigation, in collaboration with a biopolymer development group, was focused on the characterization of the wear resistance and friction properties of MDF materials using starch-based biopolymers as binders. The preliminary data shows that this material have similar CoF values to those of regular MDF (Table 1) suggesting that it could be possible to replace the latter with a more environment-friendly alternative as the one proposed.

CONCLUSIONS

Two devices for tribological characterization of samples with two rather different geometries have been designed and built. Both have been proved to provide reliable and reproducible results based on measurements carried out on steel samples. These devices have also been used to study novel electrochemical (Cu) and PVD (Ag) coatings, as well as anodized aluminum and polymeric materials. Since this is the only equipment in La Plata's region for this kind of characterization, their existence is relevant for the entire academic and industrial community interested in tribological studies.

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