WEARING TESTS ON COPPER COATED WITH DIAMOND BY TRIBOADHESION

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Abstract:-In this work are shown the results obtained from subjecting copper coated with diamond by triboadhesion to a wearing process with a plane rider. Here it is shown the ratio of the normal to shearing forces, called friction factor, as an indication of the resistance of the surface. Micro-Vickers tests shown a 23.2 % increase of hardness of the coated probes compare to non coated probes. Although similar behaviour on the friction factor was found between the coated a non coated probes, micrographs taken from them shown less weare on the coated ones.

Keywords:- Friction, surface, triboadhesion and wear.

1 Introduction

Friction and wear as mentioned in [1], are functions of the built up and destruction of the surface layers of materials. Because of that, surface treatments and coating process are among the main subjects of study in tribology for decreasing these phenomena. Amongst the methods more used nowadays are PVD and CVD. The later more frequently employed because of the temperatures reached, which are between 700-1000°C. This promotes diffusion and because of that, the enhancement of the adhesion of the film coating to the surface.
Q. H. Fan [2], by using CVD to deposit diamond on copper found out that, when the copper surface is polished with diamond paste, the nucleation of diamond in the copper surface is increased. He considered that this was caused by tiny particles of diamond trapped during the polishing process. He also observed, that the diamond exhibits a weak adhesion to the copper for film depths lower than 15µm, causing the formation of cracks.

Later J.M. Rodriguez L., et. al. [3], based on the work of Ernts Nagy [4], showed the potential of surface coating by triboadhesion. They showed that films up to thirty microns could be achieved. These films, as shown in Plate 1, are a composite material formed by the coating and base materials. Then, it is believed that the surface characteristics are function of the amount of each component present in the film.

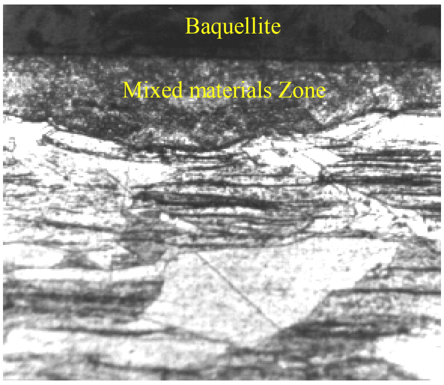


Plate 1. Micrograph of copper with diamond coating at 200X.

Following the described process copper plates were coated with diamond with the purpose of find out the resistance of this coating to wear. In this work, a machine was designed and built to subject the copper to the action of a plane rider. Here a parameter called friction factor, defined as the ratio of the shearing forces to the normal forces, was used as an indication of the resistance to wear of the coating.

2 The Deposition Process

The device employed for the deposition process is shown in Plate 2. This is composed by: (1) a rotating wheel or mop made of cotton; (2) a force measurement and (3) a feeding system. The deposition process consists of passing the coating material through the wheel and the plate to be coated.

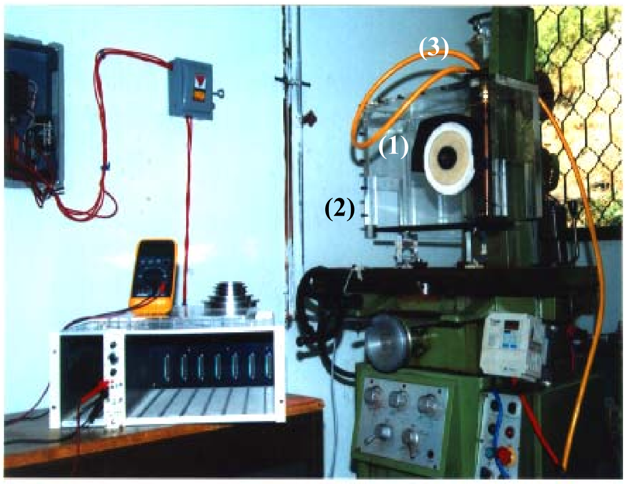


Plate 2. Deposition arrangement: (1) Deposition mop; (2) Force measuring device; (3) Feeding system.

3 The Wearing Device

In Fig. 1, it is shown the wearing device designed and built to evaluate the probes obtained from triboadhesion. This device is formed by: (a) a rotation system for the rider; (b) a force measurement system and (c) a acquisition data system.

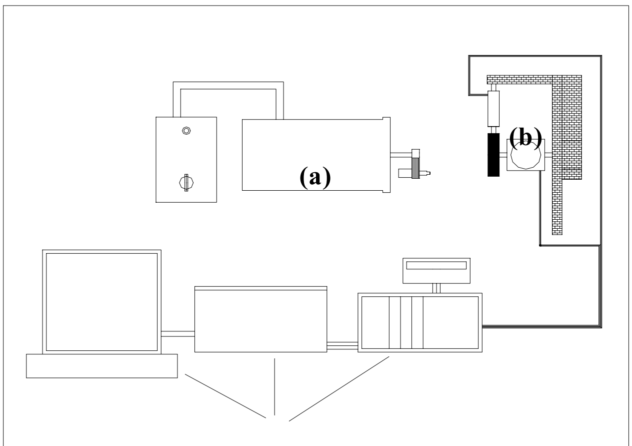


Figure 1 The wearing device.

The force measurement system (b) it is shown in Figure 2. This system is composed of three load sensors of ring type. Rings (1) and (2) measure shearing forces F_x y F_y which are caused by the circular movement of the rider. Ring (3), measures the normal force cause by the pressure of the rider on the base material. From here the shearing resultant force is:

$$\overline{(F_x)^2 + (F_y)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

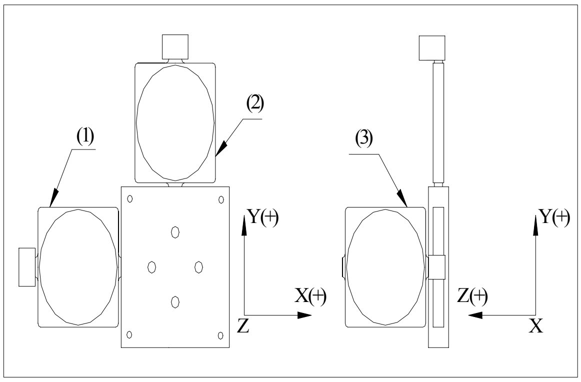


Figure 2 Force measurement system.

4 Results

4.1 Micro-hardness Vickers Test

Table 1 shows the micro-hardness test for copper without coating. Here six measurements were carried out and compared with literature . The average value obtained was HV_{25}77.77.

Test No.	Vickers HV_{25}
1	74.17
2	78.83
3	75.68
4	78.83
5	80.48
6	78.83
Average	77.77

Table 1 Micro-hardness for aluminium without coating.

Table 2 shows the micro-hardness tests carried out in copper with diamond coating. It may be seen that there is not uniformity on the values of hardness measured. The results show a maximum of HV_{25}95.78 and a minimum of HV_{25}83.94. It may also be seen from this results that the coating is not a continuous coating rather a mix of materials randomly located. Finally the average value obtained is HV_{25}89.96 which is 23.2 % larger than the case with no coating.

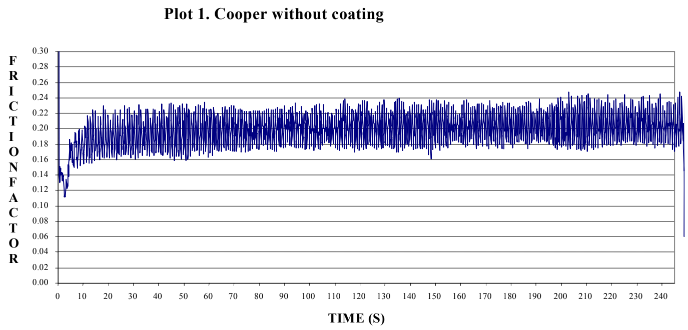
Test No.	Vickers HV_{25}
	87.63
	93.64
	95.78
	93.64
	93.64
	85.76
	89.57
	83.94
	87.63
	89.57
e	89.96

Table 2 Micro-hardness for aluminium with diamond coating.

4.2 Wearing tests

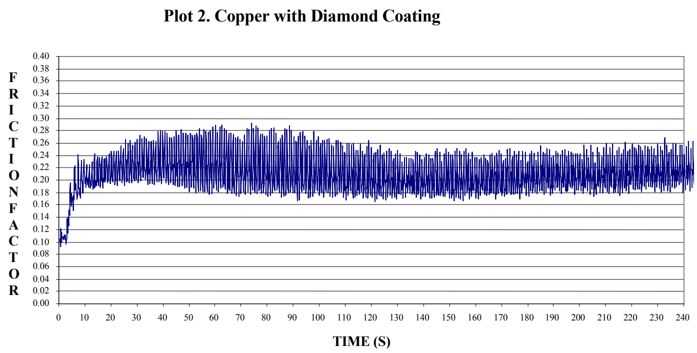
To carry out these tests the normal force applied to the copper plate with out coating varied from 1.5 to 1.8 N, and for the test with diamond coating varied from 1.5 to 2.0 N. The rotational velocity in both cases was 70 r.p.m. No material loss was detected during the tests in both cases. The test were carried during 245 seconds.

Here the ratio of the resultant of the shearing forces F to the normal force measured, called friction factor is taken as an indication of the wear behaviour. It may be seen in Plot 1 the test for copper without coating. Although, it should be considered that this contained a oxide film caused by its exposure to the environment. Here, the friction factor starts 0.14 and raises almost immediately to 0.20 where nearly remains constant. The test was stopped after 240 seconds when the friction factor reached a value onear to 0.21. After the rider was separated from the plate there were not found traces of copper on the raider. Since there was no change either on the weight, it was assumed that the material was drag since the early 5 seconds and moved apart by the raider.



Plot 1 Friction factor for copper without coating..

A similar test was carried out for the probe with coating. This is shown in Plot 2. The path followed for the friction factor is similar to Plot 1. However in this particular test, the friction factor starts at 0.1 and after 10 seconds takes a value of 0.2 and at 30 seconds reaches a maximum of 0.24. From this point forward decreases to a value near 0.21 and then follows the behaviour of the test without coating. From this behaviour it may be considered that the raider took the first 30 second to remove a very thin film of diamond and copper mix, which is three times the one observed in the test with no coating..



Plot 2. Friction factor for copper with diamond coating.

In Figures 3 and 4 are shown the micrographs of the test above mentioned. It may be seen that the print on the copper with diamond coating isles deep than in the case with no coating. It may also be noted that appears to be removed a layer that is not present on figure 3.

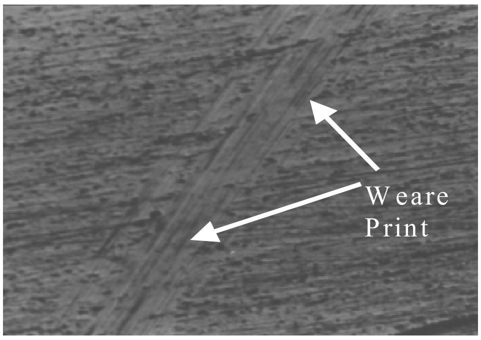


Figure 3. Wear print on cooper without coating (100X)

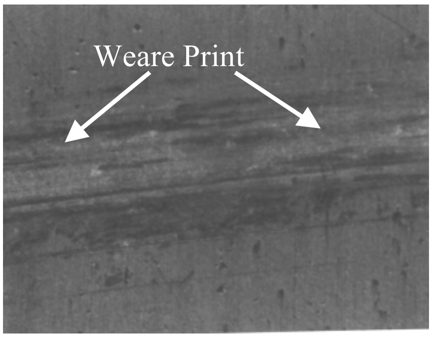


Figure 4. Wear Print on copper with coating (200X)

4 Conclusion

From the micro-hardness test it may be seen that the surface film is not a continuous film but rather a mix of coating and base materials.

It may be considered that the oxide film present in the copper lasted three times less than in the copper with coating.

No loss of material was detected in either cases, and this might be attributed to the softness of the copper employed.

References:

[1] Haduch, Z., 1986, "*Significado tecnológico y económico de las investigaciones tribológicas en procesos de fricción y desgaste*", Gestión tecnológica, vol. 1, no. 3, pp. 7-12.

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[4] Ernst Nagy. Private communication.