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MICROHARDNESS BEHAIVOR FOR TISIN/ALCRN AFTER HIGHT TEMPERATURE TRIBOLIGICAL TEST

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Abstract. *Coated tools are largely used at metallurgical industry, for they can improve the productivity of the machining process. During the machine process, the temperature at tool can raise up to 1000°C in some points, because that is important to know how the material works at this temperature. The goal of this research was to evaluate temperature and tribological effect on coating hardness behavior of TiSiN/AlCrN coating. To accomplish this work, samples are produced with coating WC-Co disks with TiSiN/AlCrN by CAE/PVD processes to obtain a commercial coating used on cutting tools. The coating has micro hardness, adhesion tested before and after the tribological test, to be sure no issue regarding adhesion can modify the tribological result. The wear test was done using a Pin-on-disk test where the sample was tested at 20°C, 500°C and 800°C. The microhardness was measured by Knop technique, with different loads from 25 gr to 1000 gr and penetration at each sample. After that, they were submitted to a tribological test. Measurement was done at the surface of the coating and in the wear track to analyze if there are any changes in the coating's microhardness, due to the temperature and the load applied on coating during tribological test. The results show there are no changes in the microhardness profile when compared to the original microhardness coating, though there was an oxidation of the coating tested at 800ºC.*

Keywords: *Microhardness, TiSiN/AlCrN; Helica*

1. INTRODUCTION

During the machining process, part of the applied power is used for plastic deformation of machining material to make machining chips. A large quantity of the applied energy is converted in heat near to the cutting edge, what raises the temperature at this region, having an influence on tool wear and in the friction coefficient between machining chip and the tool. (Grzesik, 2008)

The material with good wear resistance for different mechanisms like abrasion, erosion, corrosion are perceived by the metalwork industry, which have improved the research for new materials and/or coatings on last years, with the objective to promote the compounds' surface resistance.

To increase the tools' characteristics, a lot of research was done with coated tolls where ceramic coating is applied on the tools. (Stappen, Stals, et al., 1995)

This coating promoted other kind of gains when applied at cutting tools like: low friction coefficient, reduction of cutting forces, thermal protection, low oxidative wear, high surface hardness, and better wear resistance. (Paiva Jr., Amorim, et al., 2013)

Coated tools have superior performance if compared to non-coated tools. That condition possibility uses such tools at more several conditions like high cutting speed and feed during machining process, which makes possible the more efficient use of all modern cutting machines' potential. (Balzers, 2015)

The most used coating material for cutting tolls have been the Nitrides and their variations, like: TiN, TiAlN, and AlCrN. (Bourhis, Goudeau, et al., 2009) (Kutschej, Mayrhofer, et al., 2004)

Variations of these coatings at deposition process and chemical composition have been developed with the objective of increasing their performance. One of these variations is the coating TiSiN/AlCrN, produced by Oerlikon Balzer, with the commercial name of HELICA. (Balzers, 2014)

2. OBJECTIVE

This research's goal was to evaluate the microhardness behavior of TiSiN/AlCrN coating when submitted at room temperature (20°C), 500°C and 800°C on the tribological test.

3. METHODOLOGY

3.1 Sample Production

For this research, Hard Metal (WC/Co) samples were produced with 18,4 mm diameter and 5 mm thickness. These samples have their surface milling and grinding. After that, the surface was polished with 6 µm diamond paste to remove all scratch done on process before. No roughness measurement was done, but the surface was free of any marks from the process before.

These samples were shipped to Oerlikon Balzer Company, at São José dos Pinhais – PR, for coating deposition of TiSiN/AlCrN, identified commercially as Balinit Helica®, being produced by Phisical Vapor Deposition (CAE-PVD). During the deposition, the same process parameters were applied for the tools' coating.

The sample's coating shows a multilayer of TiSiN and AlCrN, with thickness of about 3 µm over hard metal, as informed by supplier.

3.2 Micorhardness

The microhardness was evaluated with Shimadzu Microhardness model HMV-2T at coating. For this task, a Knoop indenter with pyramidal geometry with 172,5° and 130° angles was used. The measurement was made with the following loads: 980,7 mN (100 gr), 1961 mN (200 gr), 2942 mN (300 gr), 4903 mN (500 gr), e 9807 mN (1000 gr). The increasing load was used as a mean to analyze how the hardness changes along with the depth. Once the depth increases, the hardness decreases, for the coating suffers influence from the substrate. (Oliver e Pharr, 2004)

3.3 Tribologycal Test

The tribological tests of the coating were carried out in the CSM High Temperature Tribometer. The methodology used was the pin-on-disk, and a 6 mm diameter alumina sphere was used as the material in the counter-body

During the test the sample was submitted to ambient temperature and the temperatures of 500 °C and 800 °C to evaluate the changes in the wear mechanisms presented. The parameters used in the test were linear velocity of 5 m/min (8.33 cm/s), distance of 100 m and normal load applied in the sphere of 5 N.

4. DISCUTION AND RESULTS:

The microscopy images of the cross-section of the coating, produced with a magnification of 20,000x and the BSE mode, are possible identified in the cross-sectional electron microscopy images of the layers of the coatings, produced by the intercalated deposition of the different TiSiN and AlCrN materials constituting the TiSiN / AlCrN coating (multilayer). Samples were submitted to temperatures of 25ºC, 500ºC and 800ºC during the tribological test and it did not present a significant change in the different layers of the coating, since the separation lines of the different deposited layers were clearly identified. The total thickness of the coating is approximately 3.5 µm and the thickness of each coating layer is approximately 0.2 µm or 200 nm, as show in Figure 1, Figure 2 and Figure 3.

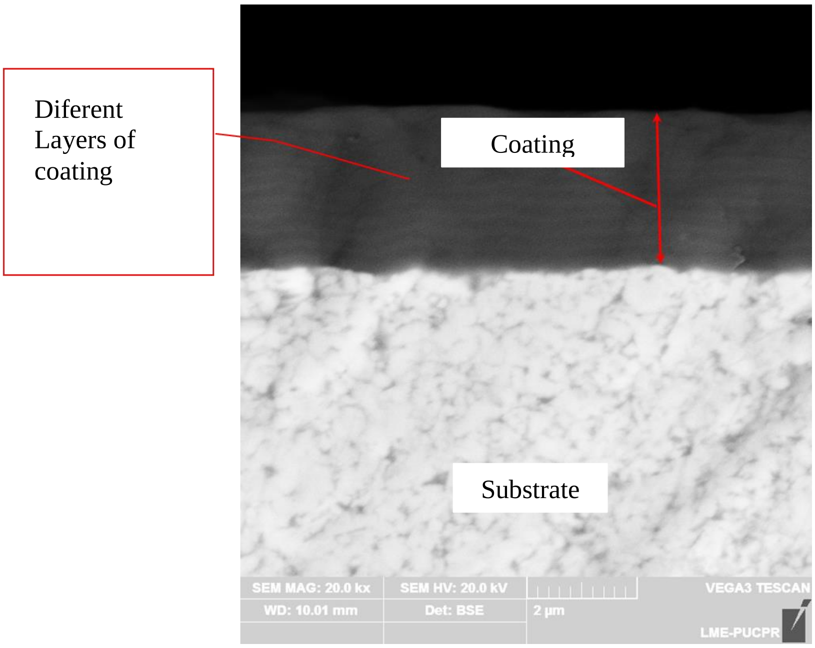

Figure 1 - SEM image of the cross section of the coating for sample tested at room temperature (25 ° C).

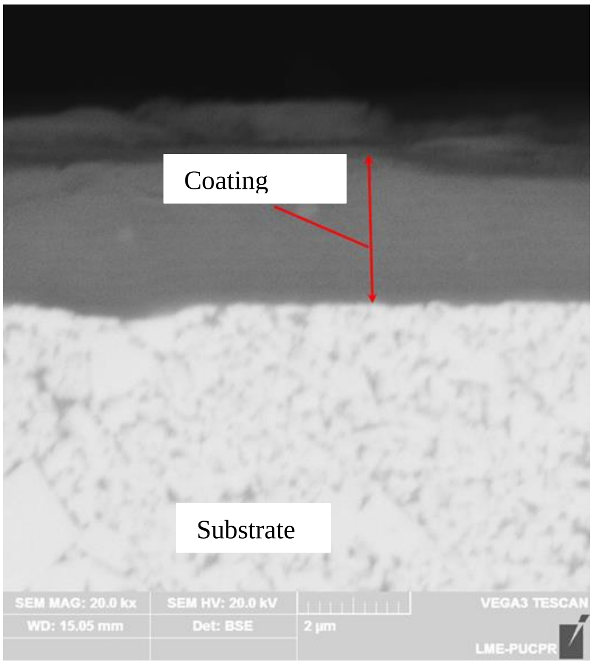

Figure 2 - SEM image of the cross section of the coating for sample tested at a temperature of 500 ° C.

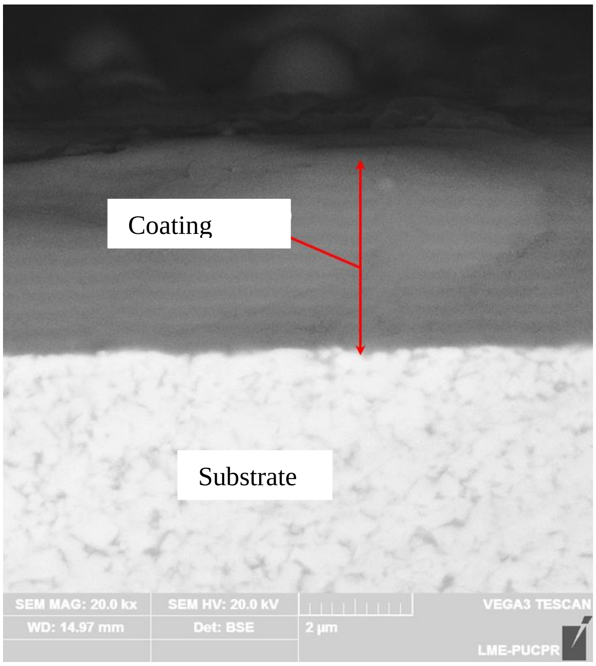

Figure 3 - SEM image of the cross section of the coating for sample tested at a temperature of 800 ° C.

The microhardness research made on the samples show a similar behavior to all samples, as shown in Figure 4. There is a reduction of harness due to the indentation's depth, what's expected, for the substrate begins to have each time more influence in the coating's hardness (Bourhis, et al., 2009). The medium values of the hardness in the coating's depth of a micrometer are approximately of 25 GPa, and the hardness of the substrate in the same depth is around 13 GPa. However, for the samples they were subjected to, and the elevated temperature, the oxidation of the coating – especially of the Ti –, with the formation of TiO2 (Rutile), results an increasing of the coating's hardness. This value is attenuated as the substrate begins to have bigger influence over the hardness of the coating.

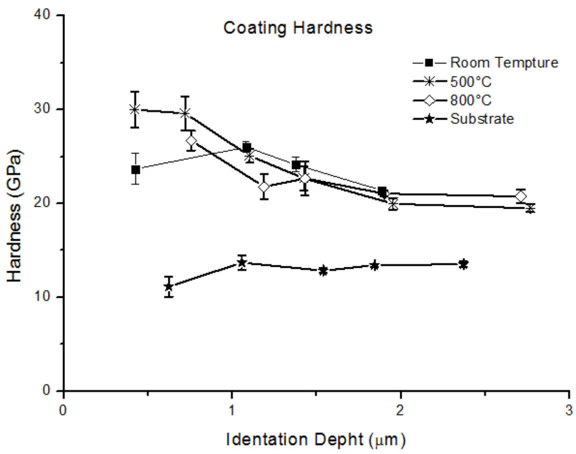

Figure 4 - Comparison of the hardness variation of the coating between the coating on the wear track and off the wear track, with the indentation depth after the tribological tests carried out at temperatures of 500 °C and 800 °C.

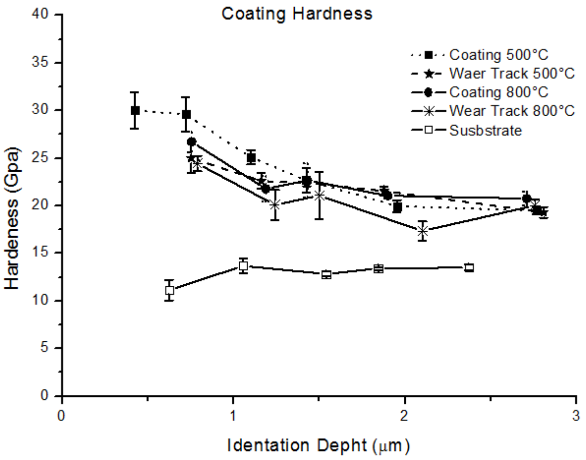

Figure 5 - Comparison of the hardness variation of the coating between the coating on the wear track and off the wear track, with the indentation depth after the tribological tests carried out at temperatures of 500 °C and 800 °C.

The comparative analysis between the coating's hardness levels and the wear track do not demonstrate to have significant change in the structure or behavior of the coating regarding hardness, once the hardness values obtained on the track are very close to the values obtained in the coating outside the wear track (Figure 5). This analysis is important because there could have been changes in the coating, caused by the application of the load and temperature during the tribological tests, but it was not identified as showed are SEM images and Hardness Test.

5. CONCLUSION:

As identified at SEM the coating has good stability where there are no diffusion between TiSiN and AlCrN layers at temperatures tested.

By analyzing the microhardness values prior to the tribological testing with values obtained after the tests, it is not possible to identify significant changes in the microhardness of the coating, which makes it possible to assert that the coating has good stability, which is desirable for a coating applied to machining tools.

6. ACKNOWLEDGEMENTS

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