STUDY OF PLASMA-DEPOSITED LAYERS OF W-TIN ON CUTTING TOOLS.

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Abstract

In the mechanical industry, the success and the results obtained by the heat treatments in the improvement of the properties of mechanical parts and mechanisms, with the introduction of new alloy and composite materials, found that the introduction of other techniques is issentiels, The metal parts subject to wear must be hard, but the hard metals can be brittle, fragile and difficult to work.

A solution to this dilemma may consist in manufacturing the parts in a relatively soft and resistant alloy and then modifying its surface by the action of an appropriate treatment.

The application of surface treatments by the various spray coating techniques allow a considerable contribution to be made in order to improve the properties of resistance to wear, the friction and to increase the life time in the mechanical parts.

***Keywords**: Hardening, Wear, Spraying, Plasma, Coating. Titanium nitrides, cutting tools, machining.*

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INTRODUCTION

In spite of the progress made in materials science, the use of traditional treatments, the introduction of new carbide materials and nitrides, the performances of mechanical parts and cutting tools are still in a state of improvement,This is why the search for new substitute materials and coatings remains a covers area, in view of the fact that it is part of a very competitive industrial challenge, particularly in the field of mechanics and modern machining centers.

In this work, and on the basis of a comparative idea, we have introduced for the first time the plasma as a technique of deposition of layers of coatings of titanium nitrides on the active part of the cutting tools **[1]**

2. Preparation of coatings and their testing:

Despite the success achieved by the deposition of carbides and the development of cutting tools with high hardness and better endurance, it is noted that great interest is being paid to coatings by depositing thin layers of tungsten W-TIN (W 80% Ti 20%),

The applications of thin layers are multiple. They are generally based on the principle of modifying the surface of a material to make it a composite whose surface properties are different from that of the solid material. The so-called hard layers find uses in the protection of mechanical parts against wear, oxidation and corrosion and can considerably improve the mechanical properties of cutting tools and in particular their hardness, resistance to Wear, and therefore their lifetime, titanium nitride and is the most answered material for this type of application, the last years the deposition of a harder material such as tungsten became possible. W-TIN thin films produced by physical vapor deposition (PVD) are used for wear protection as a diffusion barrier. The development of protective coatings for cutting tools dates back to the early 1970s.

Coated cutting tools have invaded machining centers because they allow high production rates to be maintained by reducing the frequency of machine shutdown to replace worn tools. W-TiN coatings with a thickness of the order of 5 µm and a micro-hardness of more than 4000 HV make it possible to increase the lifetime of the cutting tools by a factor of 4 to 20 depending on the conditions of use **[2][3]**

For the deposition of coatings on cutting tools we used the RF sprayer, designed and made locally in the laboratory of ionized media on the CDTA center for advanced technology development, during this study the W-TIN coatings were developed in the sprayer after different preparation of the cutting tools.

3. Preparation of substrates:

In this stage of the work, the titanium layer coatings will be produced on cutting plates of high-speed steels TNMM 160 408 K10. Before being placed in the enclosure, the latter and in particular the active part of them have undergone, first a trichloroethylene degreasing treatment by ultrasound, then they are rinsed with deionized water and then with alcohol.

3.1 Deposition and Procedure:

After the preparation of the cutting tools and the pickling of the target by a bombardment flow which lasts a few minutes, the protective shield is activated and the coating operation is initiated under favorable conditions and deposition parameters.

These parameters were set as follows:

- Partial pressure of the first gas: 4 .10-5 mbar;
- Partial pressure of the second gas: 8.7 .10-4 mbar;
- Working pressure = 30 mtor
- Inter-target distance - substrate: 3 cm;
- Power: 200 watt
- Intensity applied = 0.3 - 0.5 amperes;
- Time of deposit = 50 minutes.

In order to carry out this coating operation of the cutting tools, which will subsequently be subjected to the various mechanical tests (hardness and life tests) by the operation of turning at different cutting speeds, We have made a deposit for which we have placed a cutting tool and performed a coating deposit of W-TIN and by following we will compare the mechanical characteristics without and with deposition, the operation of this study involves two steps:

In the first step, the control tools kept as reference samples were selected for the subsequent comparison of the initial mechanical properties.

In the second step**:** in this step the cutting tools on their active part have undergone a W-TIN coating layer.

4. Tests carried out:

After completing the coating operation and obtaining the layers, we have determined certain properties by subjecting these cutting tools to the various tests, which are preconditioned by the properties and quality of the coatings

4.1 Properties of coatings obtained:

Before the coated cutting tools are subjected to the machining operations by turning, we present the methods used for the characterization of the coatings obtained on the cutting tools.

Among the main mechanical characteristics favoring the performance of the cutting tools and their lifetime, attention is paid to the value of the thickness of the deposited layer, its adhesion and its hardness.

4.1.1 Thickness of the deposited layer:

Methods of measuring the thickness of the layer:

Two methods of measurement can be distinguished:

Direct measurement of thickness: it has two methods:

• Mechanical methods use a stylus that moves over the surface of the layer.

• Profile-meter (with laser emission) (ALTISURF 500)
This method requires the creation of a step which is carried out either by hiding part of the substrate during the deposition or by eliminating a part of the deposit (HNO 3 solution at 10 %). This measurement can be obtained by a mechanical Diamond tip that moves at constant speed along a defined line on the work piece or with profilometer.

The tip, all remaining in permanent contact, whose amplitude is recorded electronically. **[4]**

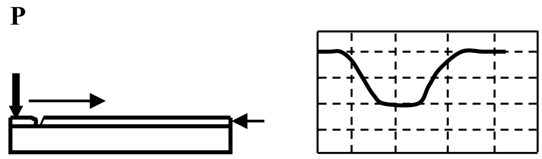

Figure 1: System for measuring the deposited layer (Perthometre-S10 D) mahr.

4.2 Adherence of the deposit:

These tests can be carried out using a scratch test or a stylus whose diamond tip is normally applied to the surface of the sample while progressively increasing the load and ending with a feeler Mechanical (Perthometre-S10 D) mahr, with scale 5 µm and a stroke of 5 mm in plotted the graphs (spectrum) of the surface and the depth of the step. The results can be given in the form of a curve or an adhesion diagram.

4.3 Hardness:

In the case of measuring the micro-hardness of the coatings, the most commonly used methods are Knoop hardness or Vickers hardness. In this case, the measurement of the Vickers hardness was carried out on a micro durometer (mechanical laboratory). W-TIN coatings were subjected to these tests under loads ranging generally from (200 to 1000) gf, expressed as the ratio of the maximum load applied to the surface of the contact impression.

$$H_V = \frac{1{,}854 \cdot P}{9{,}81 \cdot d^2}$$ P: applied load (N)

d : The diagonal of the impression in mm **[5]**

4.4 Wear:

After the hardness tests, the coated cutting tools were subjected to wear and endurance tests by the direct application of the machining processes by removal of chips. We selected the Taylor model for studying and evaluating wear and for establishing the relationship between the cutting time of a tool and the cutting speed under well-defined working conditions. We performed turning tests at different cutting speeds in accordance with the ISO3685 standard for life testing which is presented in table. [6]

Table 1: Machining Parameters

Parametres					
Cutting speed (m / min)	400	300	150	100	70
Feedrate (mm)	0,1	0,1	0,1	0,1	0,1
Depth of cut (mm)	1	1	1	1	1
Wear Criteria (mm)	VB	VB	VB	VB	VB

5. The results of the various tests:

5.1 Layer thickness:

In this work and to be sure to get exact results we measured the thickness of the deposited layer by two methods, with an electronic probe (Sth-perthometer-S10) mahr, with a scale of 5 µm and a stroke of 5 mm. we obtained the thickness around 2,50 µm, then to confirm that we use a profilometre with laser, the specter below show the final thickness value around 2,25 µm. figure 2.

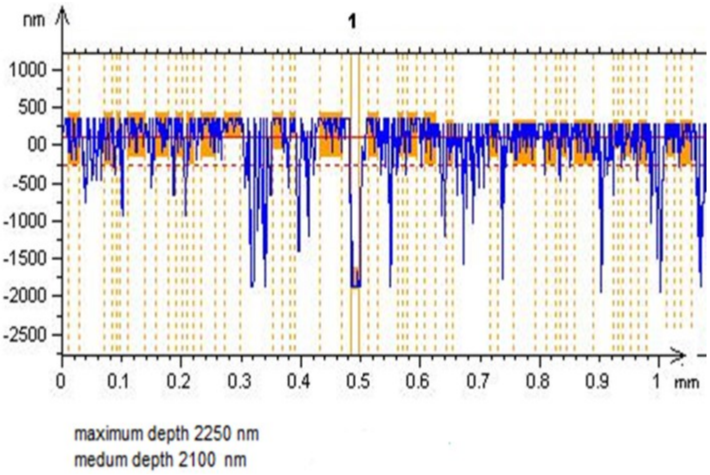

Figure 2: Measurement of the thickness of the deposited layer.

This figure shows that the value of the thickness of the deposited layer is 2.25 µm.

6.2 Adhesion of the layer

Among the techniques for determining the adhesion of the materials and the layers of deposited coatings are the scratch test method and the polishing method of the layer. For this study, the second method was carried out on a polisher (KNUTH-ROTOR.2 strueers). Thus, starting from an initial thickness of 2.5 µm, the polishing carried out at a speed of 3000 rpm with an abrasive paper of 1000, gave a reduction in the thickness of 1.45 µm during a severe exposure of 55 minutes.

This consumption of material expressed by the variation of the thickness is represented by the following spectrum. Measurement of the depth of the layer deposited after 55 minutes of polishing is around 0.80 µm. Figure 3.

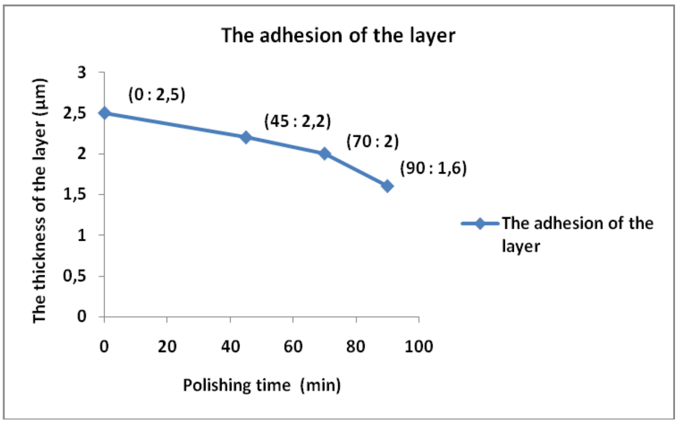

Figure 3: Measurement of the depth of the deposited layer after 55 minutes, 0.80 µm

6.3 Hardness:

Compared to the hardness value of an uncoated cutting tool, the comparative curves obtained show a marked increase in hardness. The evolution of this hardness is due to the W-TIN coating layer there is a marked significant difference in hardness. This hardness improves progressively from the initial state of a tool with a traditional surface treatment (toughening, tempering, annealing, etc.) to the W-TIN coating state.

The presentation of the hardness variation of these high-speed steel cutting tools is given in the following graphs:

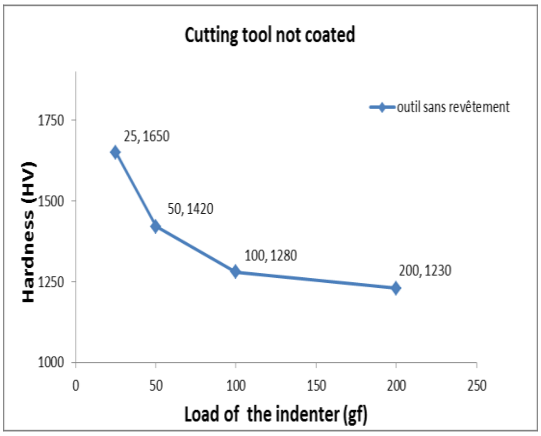

Figure 4: Hardness of the uncoated cutting tool

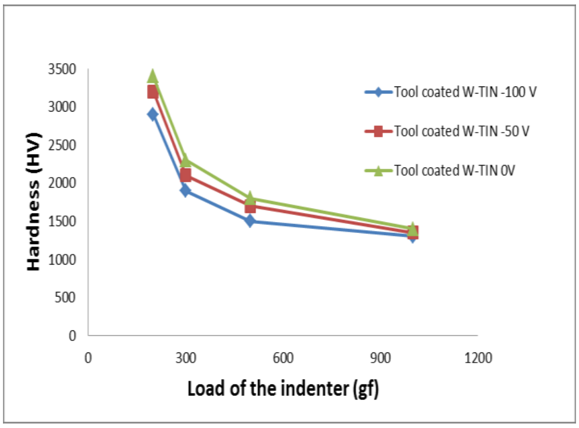

Figure 5: Hardness of cutting tools coated by W-TIN

We noticed an improvement over the hardiness compared with uncoated cutting tools, on the other hand, the hardness of the W-TIN layers also corresponds to the polarization, higher polarization gives a high hardness, **[7].**
lower volt gives a hardness better than -50 volt and -100 volt.

In this case, we found that the hardness tends to increase with polarization. This result is directly related to a high dense structure,and reduced grain size at a small amount of structural defaults.

6.4 Evaluation of wear (VB):

Because of the W-TIN coating surface treatment operation and after an improvement in the hardness, we have recorded the influence of this improvement on the tribological side of the wear of the cutting tools. For this purpose, we have subjected the cutting tools to turning tests with different cutting speeds and without lubrication (dry turning). After machining by turning, we have seen a considerable improvement in the wear resistance, resulting in an increase in the service life of the cutting tools submitted.

To demonstrate these mechanical properties and to make an effective comparison of these tools, we have performed a series of operations at different speeds. The results for the two types of tools are presented in the following figures:

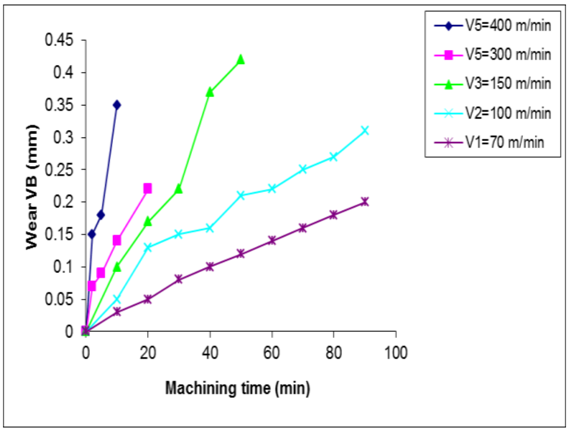

Figure 6: Combinations of the different wear curves for uncoated cutting tools.

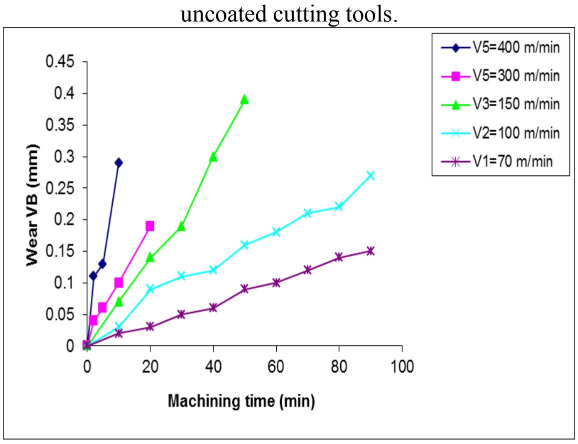

Figure 7: Combinations of different wear curves for W-TIN coated cutting tools

During the turning tests carried out according to the Taylor law, and in accordance with the conditions of ISO 3685 the graphs obtained in this work with deferent speeds show a rightward displacement

VB = f (T), which Explains a significant reduction in the wear of these coated plates.

This grouping graph, compared to the graph of **Figure 6**, makes it possible to say and in a significant way that there is indeed an improvement in the lifetime of these cutting tools, resulting in a collective displacement of these curves towards the right-hand side, thus reducing wear and thus increasing the service life.

7. Conclusion

This study allowed us to compare the evolution of the mechanical properties between the cutting tools covered by W-TIN and not covered one which is the main objective.

The results obtained in limit of the improvement of the mechanical characteristics are presented and commented, Result of the exposure of hardness has a very clear improvement of this in the direction of the evolution of the coating structure.

As for the second significant characteristic for the wear resistance, within the limit of the strength and lifetime of the cutting tools, and after the comparison of the tools covered by the uncovered tools subject to the Machining work by dry rotation, we have recorded a clear improvement of the wear resistance.

The rotation operations performed at different cutting speeds proved that the criterion of the use of VB (mm) cannot be reached which has periods of machining T (minute), largely considerable compared to the periods of the use of coating feel of cutting tools.

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