

WEAR AND DURABILITY VARIATION COMPARED WITH THICKNESS OF CUTTING INSERTS COATED WITH TIN THIN LAYERS

Bădănac Ana[1], Paraschiv Dragoş[2], Lupescu Octavian[3], Popa Mădălina[4], Cătălin Ungureanu [5] and Gheorghe Bosoancă[6]

[1]Technical University "Gheorghe Asachi" of Iasi - Romania, badanac_ana@yahoo.com
[2]Technical University "Gheorghe Asachi" of Iasi - Romania, dragosparaschiv21@yahoo.com
[3]Technical University "Gheorghe Asachi" of Iasi - Romania, olupescu@tcm.tuiasi.ro
[4]Technical University "Gheorghe Asachi" of Iasi - Romania, popa.madalina20@yahoo.com
[5] Technical University "Gheorghe Asachi" of Iasi - Romania, catalin_89ung@yahoo.com
[6]Technical University "Gheorghe Asachi" of Iasi - Romania,bosoanca_gheorghe@yahoo.com

ABSTRACT: Vacuum deposition of thin layers is a new field of study of advanced technologies to various fields of application in industry. The technology of thin coatings, resistant to wear and deposited by various methods on tool materials aroused much interest to producers, for many years. The mechanical strength and wear resistance of the cutting tools is obtained through the formation of thin coatings of other materials on the their surface, with applications characterized by differentiated chemical composition. The basic properties of the layers, such as their composition, crystal phase, the thickness and the microstructure are controlled by conditions of the deposition. The main purpose of the research is to present the variation of the wear and durability compared with the thickness of TiN thin layers deposited on the cutting inserts.

KEYWORDS: cutting inserts, PVD, wear, thickness, thin layers, durability.

1. INTRODUCTION

Due to mechanical loading, to variation of temperature, to chemical reactions which exist between cutting tool and workpiece, but also due to abrasion phenomenon and to adhesion phenomenon, the cutting tools surfaces are subject to wear. In the last decade, there was an increased interest for surface treatments, in order to reduce the reconditioning cost of the cutting tools surfaces.

The study of thin films advanced directly or indirectly in several new areas of research, in physics and chemistry of solid states; they are based on phenomena with typical characteristics for thickness, geometry and structure of layers. Thin film materials are key elements of technological advances made in the field of optoelectronic, photonic and magnetic devices.

Thin films are particularly suitable for applications on cutting tools. For a thin layer, thickness limit is considered between tens of nanometers and several microns.

Most of functional materials are applied in the form of thin layer, due to their specific properties: electrical, magnetic and optical or wear resistance [4].

Vacuum deposition of thin layers represents a new field of study of advanced technologies, with various fields of application in industry. Depositions of thin layers are applied on cutting tools, in order to improve the desired properties of the surface, such as wear resistance or hardness.

The research problems regarding the production of coatings are one of the most important surface engineering development directions, ensuring the production of coatings with superior properties in the field of applications where the mechanical characteristics and wear resistance are essential properties [1].

For those surfaces of the cutting tools, which are the most exposed to wear, in order to be used at maximum capacity, the tools could be hardened by some methods, based for example, on coatings processes how the physical vapor phase deposition and the chemical vapor phase deposition are.

The main characteristics which must be checked in the deposition process of thin layers are composition, structure, thickness, adherence, hardness, wear resistance, corrosion resistance and porosity [2].

2. METHOD AND EQUIPMENTS USED

In this study the authors present the results of researches developed by the in connection with the wear and durability variation compared with thickness of some cutting inserts coated with thin layers of titanium nitride TiN, deposited by plasma vapour deposition (PVD) method.

In order to determinate the thickness of thin layers obtained, the ball-cratering method was used and in order to measure the coated cutting inserts wear the microscope RMA 5 was used.

The ball-cratering technique is applied by many researchers in order to measure the thin layers thickness. In order to obtain information concerning the thin deposited layer thickness, a BAQ kaloMax device (shown in figure 1) and a microscope RMA 5 (shown in figure 3) were. These equipment exist in the S.C. RULMENȚI S.A. BÂRLAD company.

The BAQ kaloMax device is a cap grinder used for determination of the layer thickness of coatings and layer systems. The result of grinding process depends on both sides of friction systems, of the piece and kaloMax device.

The KaloMax device parameters that influence the result are the following: grinding paste, number of revolutions, grinding duration, diameter of the ball and the size of the normal force exerted by ball. The operation of BAQ kaloMax device is the following: a steel ball with a diameter of 30 mm is placed on a revolving shaft and also on the angular positioned sample. A small spherical cap is placed through the layer on the sample into the base material by means of the ball greased with abrasive slurry [4].

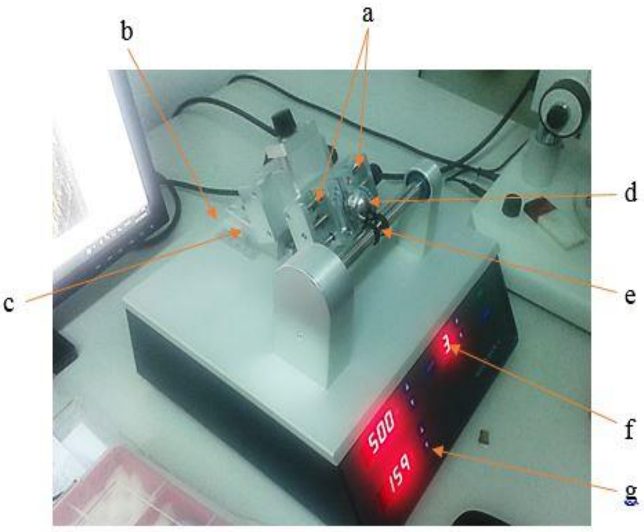

Figure 1. The BAQ kaloMax device: a - small vice; b - power switch; c- table that can be moved along a longitudinal and transversal directions; d - ball; e - movable stand; f - led readouts; g - buttons

In figure 2 it is shown the principle scheme by considering the front view of BAQ kaloMax device. The sample is caught in a small vice. In the upper part of vise, the position of jaws could be modified by the approaching and distancing, according to the shape of the part.

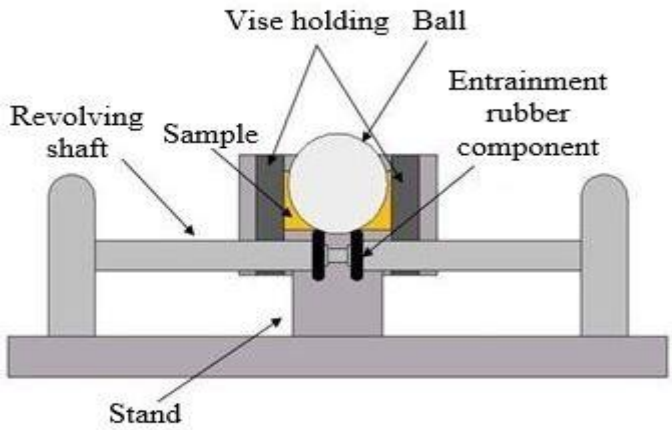

Figure 2. Principle scheme by considering the front view of BAQ kaloMax device

The fastening system is mounted on a stand that can be moved along a longitudinal and transversal directions.

The adjustment to different balls diameters or thicknesses of the sample is done by moving the entire unit of the fastening system and the movable stand, along longitudinal and transversal directions.

The layer thickness is calculated as a difference between the diameter of the gap from the sample surface and diameter corresponding to border between the layer and the base material. In the calculation of the layer thickness, the grinding diameter of the ball is considered.

The final calculation of the layer thickness (h) is given [4] by equation (1):

$$h = \frac{D^2 - d^2}{8R} \quad (1)$$

where h is the layer thickness;

R - ball radius;

D - diameter of the spherical cap at the surface of the sample;

d - diameter of the boundary between coating and base material.

In order to determine the thickness of layer deposited on the sample, the diameter of the cap from its surface and border diameter between the layer and the base material was measured. This diameter was measured using the microscope with reflected light RMA 5.

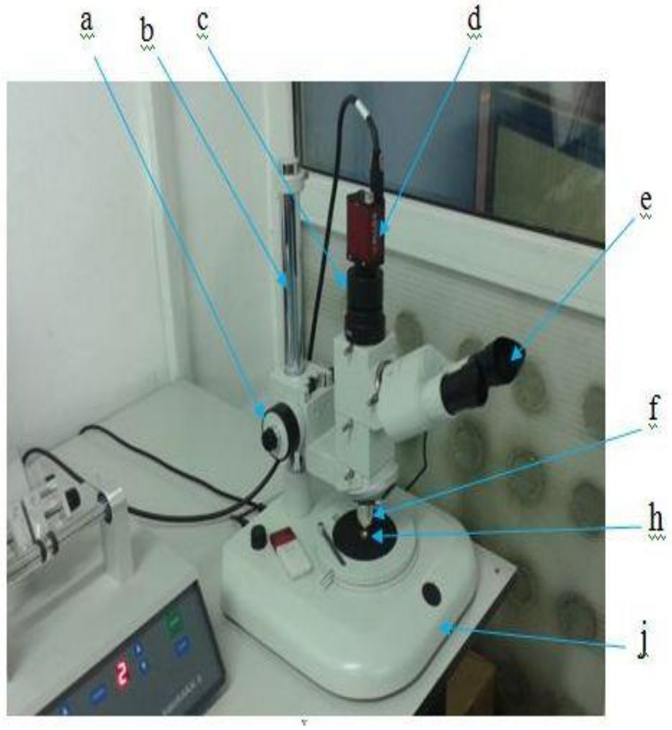

Figure 3. Microscope RMA 5: a - coaxial coarse and fine drive adjustment; b - pillar of the stand; c - photo tube; d - camera; e - eyecup with eyepiece; f - revolving nosepiece with objectives; h - sample; j - base plated - diameter of the boundary between coating and base material

3. RESEARCH METHOD AND RESULTS

In order to conduct the experimental researches, the authors used some cutting inserts type SPUN 120312.

These cutting inserts were coated with titanium nitride (TiN), in a thin layer and they were used to turn some different surfaces in order to obtain rounding radiuses and chamfers.

Some images of the cutting inserts are presented in figure 4.

Figure 4. Cutting inserts type SPUN 120312 coated with TiN

After the coating operation, the titanium layer thickness deposited on the cutting inserts was measured using the BAQ kaloMax device. Some images including also the thickness values of cutting inserts type SPUN 120312 resulted after using the ball-cratering method by means of the BAQ kaloMax device are shown in figure 5.

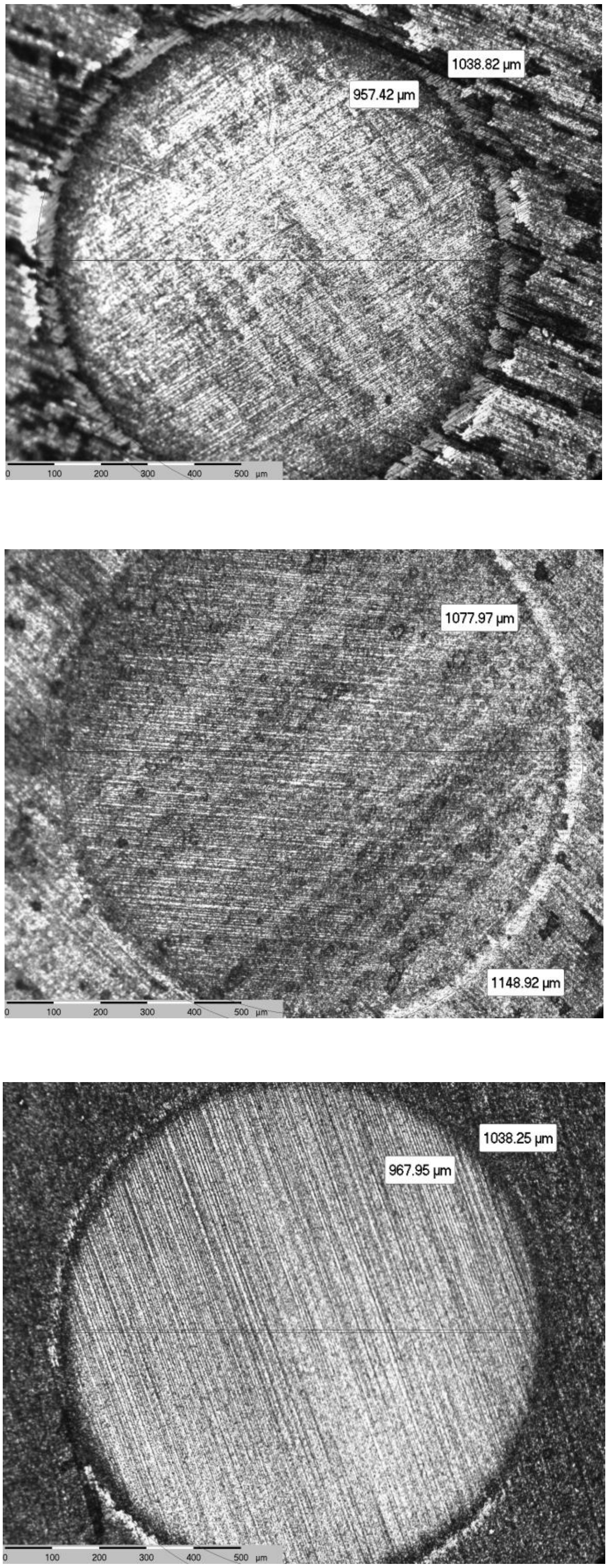

Figure 5. Thickness measurements of cutting inserts type SPUN 120312 coated with TiN

In figure 6 there are presented different wears appeared on the clearance face after turning operation, along with the measurements made by means of microscope with reflected light type RMA 5.

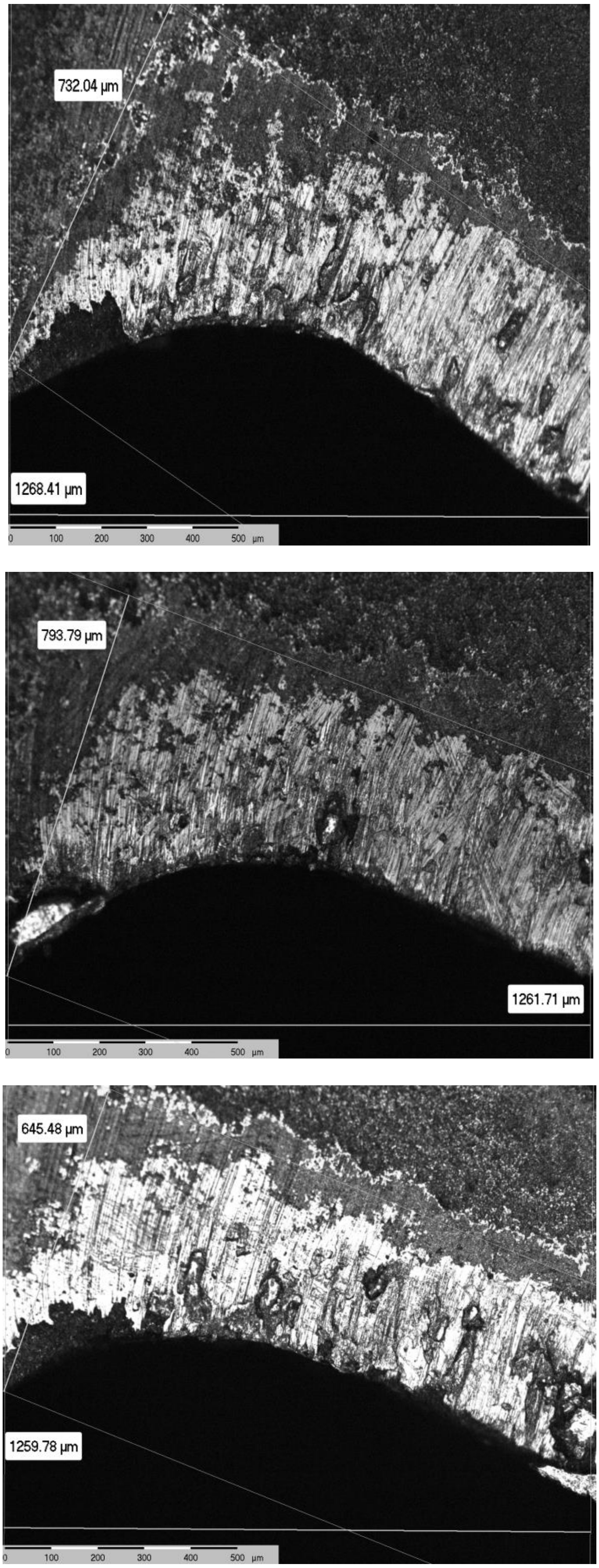

Figure 6. Inserts type SPUN 120312 coated with TiN worn on the clearance face

In figure 7 there are shown wears appeared on the settlement face after turning operation along with the

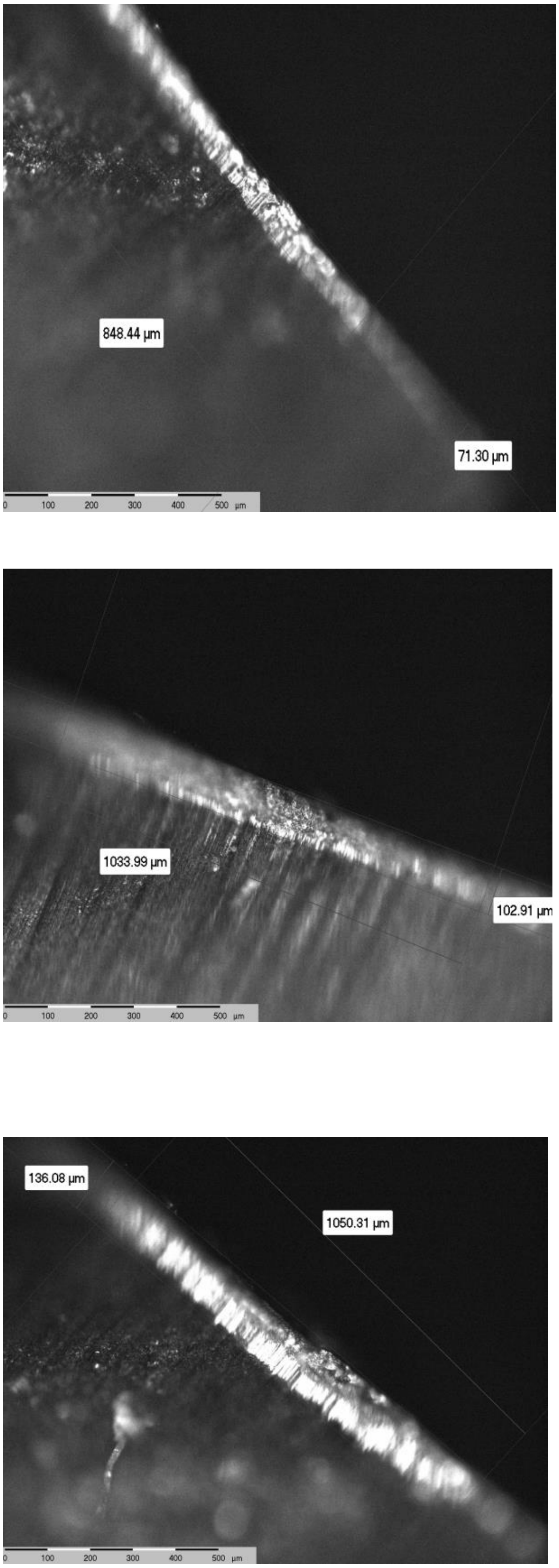

Figure 7. Inserts type SPUN 120312 coated with TiN used on the settlement face

measurements made by means of the microscope with reflected light RMA 5.

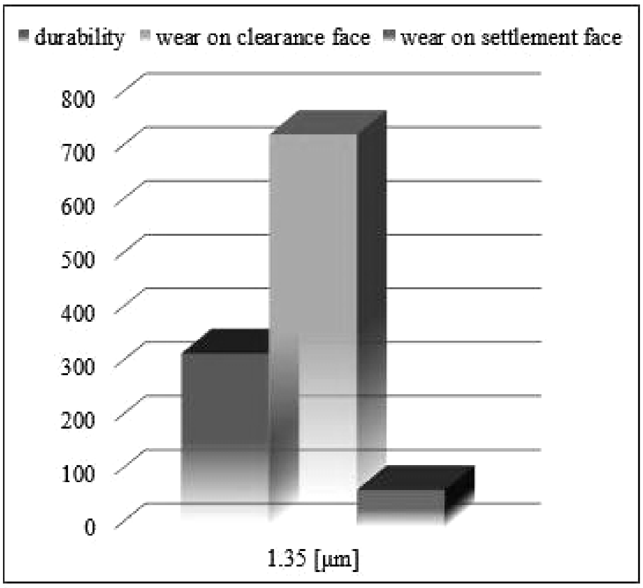

Figure 8. Graphical representation of wear and durability for a thickness layer 1.35 µm

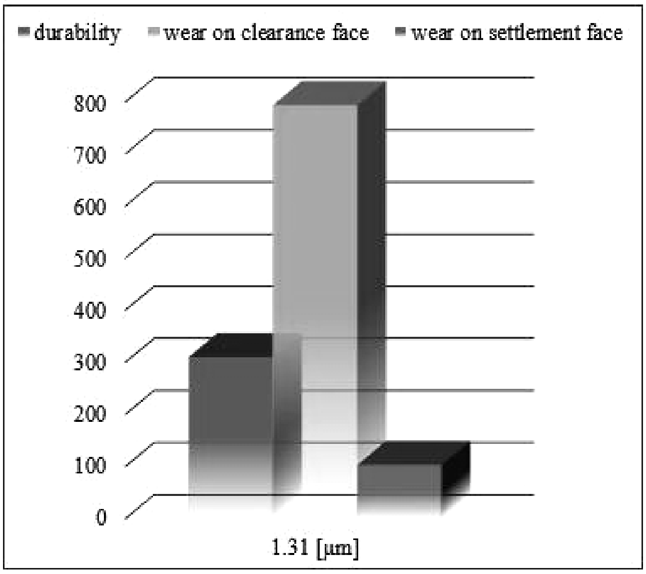

Figure 9. Graphical representation of wear and durability for a thickness layer of 1.31 µm

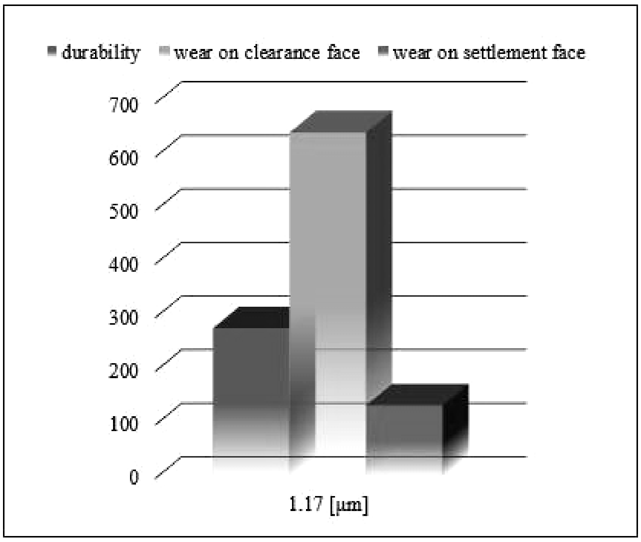

Figure 10. Graphical representation of wear and durability for a thickness layer 1.17 µm

Table 1. The values obtained for thickness layer, wear and durability

Type of Layer Deposited	Revolutions per minute	Layer thickness [μm]	Ball diameter	Wear values on clearance face [μm]	Wear values on settlement face [μm]	Durability tested [pcs]
TiN	500 1/min	1.35	30	732.04	71.30	325
TiN	500 1/min	1.31	30	793.79	102.91	310
TiN	500 1/min	1.17	30	645.48	136.08	280

During the use of the coated cutting inserts in machining process, their durabilities were determined, both in case of those with small thickness as well as in case of those with big thickness. At the same time, there was established the time of achieving the machined parts by means of the cutting inserts, up to the moment when their wear and loss of quality cutting. The values obtained for wear, durability and thickness layer are shown in table 1 and represented in figure 8, 9 respectively 10.

4. CONCLUSION

After completing the experimental research, it has been found an increased durability of the coated cutting inserts with big thickness, and a better resistance to wear, higher than that corresponding to a small thickness. When using the coated cutting inserts with big thickness, the wear occurs later than when using coated cutting inserts with small thickness. It was observed as the best time of use was for coated cutting inserts with big thickness. The results obtained opens new opportunities for continuing the studies in this domain, future researches following: the analysis of influence exerted by process input factors on the microhardness increase and, implicitly, on the durability of the cutting tools.

By determination of the hardness and roughness of deposited layers surface and establishing their optimum values will allow achieving the highest values of the tool durability.

5. REFERENCES

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