THE WEAR TESTS OF CUTTING INSERTS WITH DIFFERENT COATINGS DURING A MILLING PROCESS

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Abstract

The article presents the impact of cutting inserts with coatings on the roughness of the milled surface. Two types of coated steel inserts were selected for the research purpose. The first one was covered with Ti (C, N) + Al_2O_3 coating, while the other was TiC / TiN-CVD and Ti (C, N) + Al_2O_3. They were then mounted in a milling head. The process of surface milling has been subjected to C45 steel. Milling process for each inserts proceeded at the same rate of cutting. After a certain number of tool passages, the measurements of wear parameters and the roughness of the milled surface were measured. This allowed us to determine the effect of tool wear on the properties of the milling face layer.

Keywords: Wear of cutting inserts, milling, roughness, coatings

1. INTRODUCTION

As the industry grows, the demand for productivity increases. Production is largely based on machining. Tools were used to process materials made of materials much harder than the workpieces. The most commonly used tools for this purpose were carbide tools and high speed steel. These tools are characterized by high strength and durability. Put into use alloys with modified chemical compositions meant that existing tools have become inefficient. They were not able to work on some materials, or tools were quickly blunted. This resulted in downtime in production as well as additional production costs [1,2].

The solution to these problems was to modify existing tools. These tools are covered with coatings that increase their strength (improved cutting properties). This made it possible to cut many materials as well as increase tool life. There are many methods of covering the tools with coatings as well as many types of coatings. This allowed the creation of tools adapted to the processing of specific groups of materials [3].

2. METHODOLOGY OF MEASUREMENTS PERFORMED AND DESCRIPTION OF USED APPARATUS

2.1. Workpiece

C45 (1.0503) steel was used for research purposes. Steel C45 is used for bodies of tools and molds for plastics processing and auxiliary tools such as base plates, washers. Steel C45 is a high strength steel with high ductility. C45 steel is used in the normalized and improved, and hardened surface on the medium loaded machine parts and resistant to abrasion, such as crank shafts, axles, gears and spindles. The table (**Table 1**) shows its chemical composition. Samples were circular in shape with a diameter of 45 mm.

Table 1 Composition of C45 steel

Chemical element	C	Mn	Si	P	S	Cr	Ni	Mo	W	V	Al	Cu
%	0.42-0.5	0.5-0.8	0.1-0.4	Max 0.04	Max 0.04	Max 0.3	Max 0.3	Max 0.1	-	-	-	Max 0.3

2.2. Cutting tool

Two types of cutting inserts have been used for research purposes: RDHX 12T3 MOTN ST1400 [4], RDHX 12T3 MOTN ST900 [5]. These are 12 mm round cutting inserts with the same carbide insert base but differ in coatings. The RDHX 12T3 MOTN ST900 cutting board has TiC / TiN-CVD, Ti (C, N) + Al_2O_3 coatings. The RDHX 12T3 MOTN ST1400 cutting board had Ti (C, N) + Al_2O_3. These plates were mounted in the Garant 212145 milling head [6].

2.3. Milling process

The surface planning process was performed on the vertical milling center DMU 50 MONOblock.This is a 5 axis CNC numerically controlled milling machine on the Heidenhain iTNC530. The workpieces were mounted in a triple-screw holder on the machine table. Samples for each tile were treated under the same treatment conditions shown in table (**Table 2**). All processing parameters were machined with a single cutting insert. Each of the milled surfaces was made in 4 passes due to the width of the used milling head. The surface planning process was repeated 60 times.

Table 2 Milling parameters

Milling width a_e	42 mm
Depth of cut a_p	0.5 mm
Cutting speed V_c	235 $m \cdot min^{-1}$
Rotation speed n	2050 $rotation \cdot min^{-1}$
Feed f	0.72 $mm \cdot rotation^{-1}$
Feed on the blade f_z	0.18 mm
Feedrate speed v_f	369 $mm \cdot min^{-1}$

2.4. Milling process

Roughness measurements of milled specimens were made using measuring instruments:

- Taylor Hobson FORM TALYSURF PGI 1200 contact profilometer
- Taylor Hobson TALYSURF CCI Lite optical profilometer

This is an instrumentation that, due to its capabilities, is adapted to this type of measurement [7]. Measurements of wear inserts made on the microscope inspection SX80 behind an FOX Pixel software and IC Measure. Total milling time was 4800 seconds. Surface measurements and sample consumption were performed in approximately 360 seconds.

3. MEASUREMENT RESULTS

The results of VB_{Bmax} wear and roughness measurements are shown in **Table 3.**

Table 3 Parameters VB_{Bmax} and Ra

	RDHX 12T3 MOTN ST1400		RDHX 12T3 MOTN ST900	
T (s)	VB_{Bmax} (mm)	Ra (µm)	VB_{Bmax} (mm)	Ra (µm)
0	0	-	0	-
360	0.0061	0.2251	0.0039	0.249
720	0.0111	0.3475	0.0041	0.2534
1080	0.0226	0.5392	0.0053	0.3652
1440	0.0328	0.604	0.0066	0.4178
1800	0.0417	0.858	0.0073	0.4361
2160	0.0462	0.8723	0.0079	0.4597
2520	0.0545	1.1035	0.0094	0.4965
2880	0.0639	1.0477	0.0159	0.8272
3240	0.0662	1.1645	0.0199	1.13
3600	0.0694	1.3682	0.0211	1.1475
3960	0.0714	1.4648	0.0235	1.1508
4320	0.0738	1.5199	0.0261	1.2413
4680	0.0796	1.5846	0.0321	1.2657
4800	0.0818	1.744	0.0384	1.7607

Based on the measurements, graphs of blade wear curves were drawn on **Figure 1**.

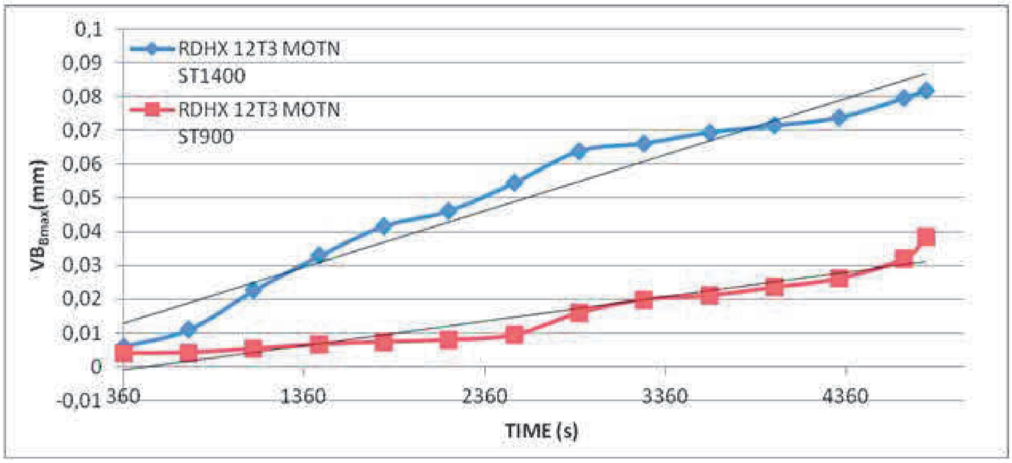


Figure 1 Graph of wear of cutting inserts

The RDHX 12T3 MOTN ST1400 plate wear analysis showed that the blade is permanently wear-free without clearly visible characteristic transition zones. The largest recorded tool wear was 0.0818 mm. Such a course could be due to uniform wear of the cutting insert coating. When working with the RDHX 12T3 MOTN ST900 board you will notice several characteristic zones on the graph. The first characteristic zone ends after 2520 seconds of machining. Such tool wear can be caused by a uniform cutting edge. After this there is an intensive increase in tool wear. This can be caused by scratching the insert.

After this there is a constant increase in tool wear. It can be seen that the TiC / TiN-CVD, Ti (C, N) + Al_2O_3 coated plate consumption is twice as low as Ti (C, N) + Al_2O_3 coatings. With this level of wear, a plate with more coatings will be able to cut more. The measurements also made a graph showing the roughness of the milled surfaces (**Figure 2**).

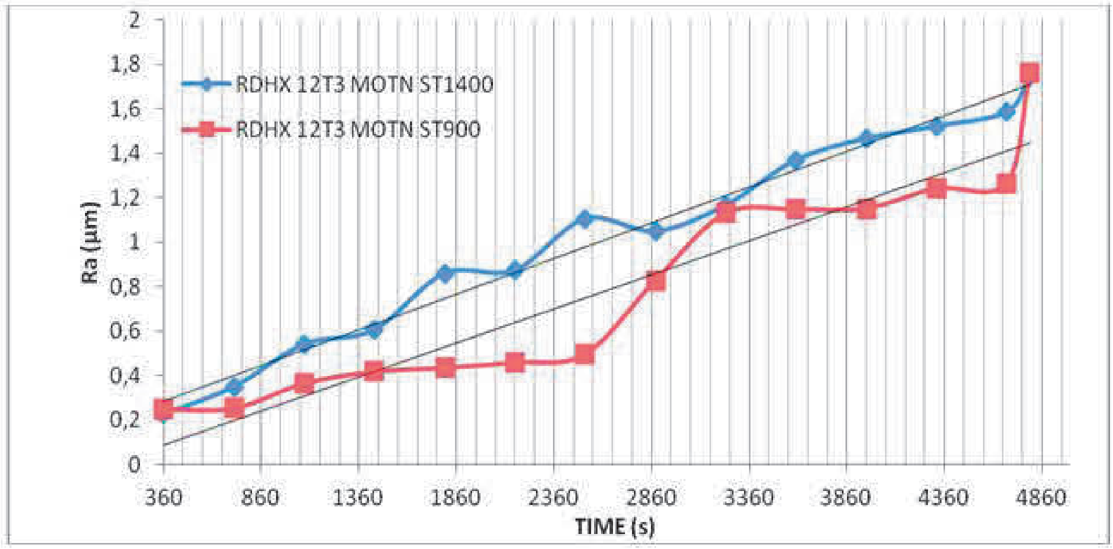
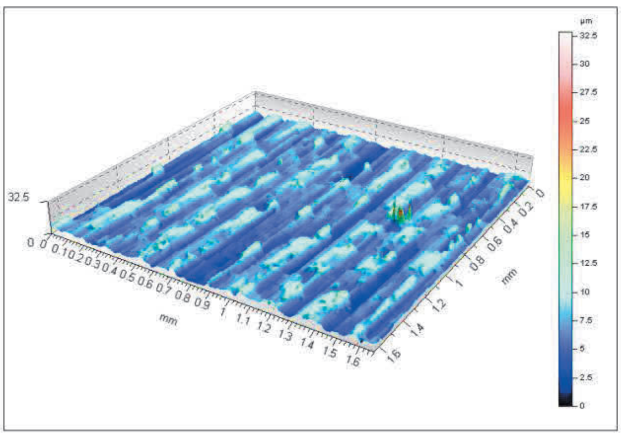


Figure 2 Graph of roughness of measured surfaces

On the chart, it can be observed that the surface treated RDHX 12T3 MOTN ST1400 maintains a constant level of roughness. This is caused by uniform wear on the plate surface. With regard to platelet wear levels, it can be observed that RDHX 12T3 MOTN ST900 has distinctive sections. At the beginning, a plate is reached, characterized by sudden increase in roughness of the surface to be measured. Then, the roughness of the surface to be measured is stabilized. After a certain number of cycles has taken place, the surface roughness of the surface is increased. This may cause wear of the outer shell of the cutting insert. After this step, the surface roughness increase again. At the end of the treatment process, there is another increase in roughness. By analyzing the approximation of roughness measurements of the surface of the measured samples with respect to the treatment of the various plates, a constant level of roughness increase in the surface area can be observed. The surface roughness of the measured surface was measured after a certain treatment time.

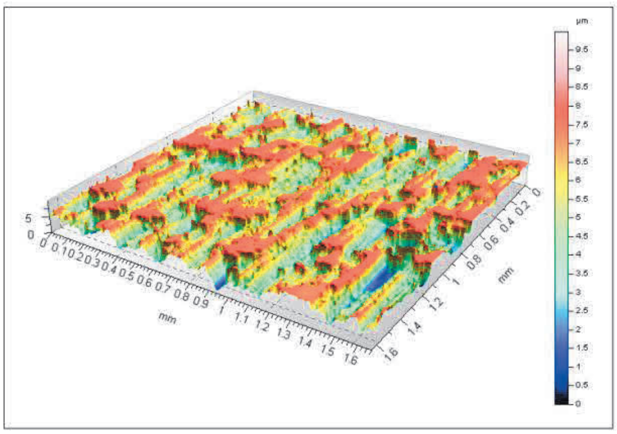
Only the selected measurement showing the final surface of each plate type by optical and contact method is shown in the paper (**Figure 3**).

RDHX 12T3 MOTN ST1400

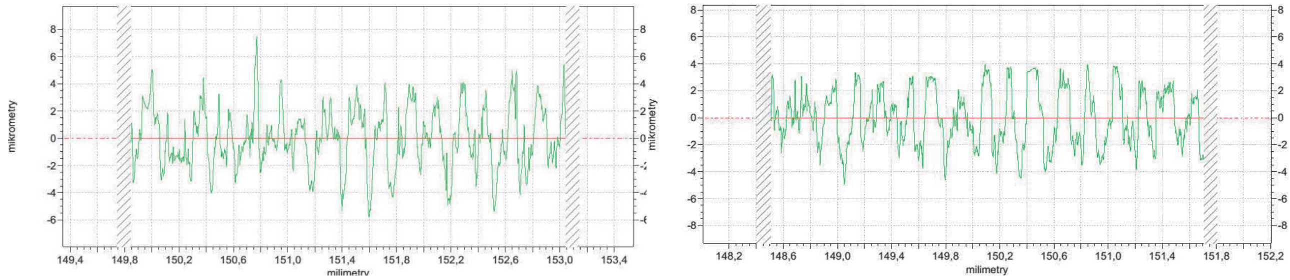


a) Topography of the surface

RDHX 12T3 MOTN ST900



c) Topography of the surface



b) Surface contact profile

d) Surface contact profile

Figure 3 Topography of the final surface of the measured samples along with the surface contour

4. CONCLUSION

The measurements allowed to determine the wear level of cutting inserts with different coatings during C45 steel processing. TiC / TiN-Ti, Ti (C, N) + Al_2O_3 and Ti (C, N) + Al_2O_3 were used for these purposes. Analysis of the measurements found that the plate with more coatings was characterized by lower wear levels. During measurements, it was found that its wear is twice as low. This will translate into increased cutting insert life. The roughness measurement showed a steady increase in the roughness of the surface measured. Approximation charts showed that using the plate RDHX 12T3 MOTN ST900, it is smaller in relation to the plate RDHX 12T3 MOTN ST1400.

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