ANALYSIS OF SELECTED CUTTING INSERTS IN TERMS OF THEIR COMPOSITION AND WEAR

NATASA NAPRSTKOVA, JAROMIR CAIS, JAN SVIANTEK

Jan Evangelista Purkyne University
Faculty of Production Technology and Management,
Department of Techmology and Material Science
Usti nad Labem, Czech Republic

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e-mail: naprstkova@fvtm.ujep.cz

The use of cutting inserts is currently a normal part of the manufacturing process. The article deals with structural and material analysis of selected inserts and resulting wear after their use. These analyzes are part of the extensive research carried out at the Faculty of Production Technology and Management of Jan Evangelista Purkyne University in Usti nad Labem. Machining been hardened steel class 16 343 according to CSN 41 0002. For the used VBD were implemented SEM and EDX analysis.

KEYWORDS

turning, cutting insert, electron microscopy, SEM, EDX

1 INTRODUCTION

At the Faculty of Production Technology and Management, which is part of the Jan Evangelista Purkyne University in Usti nad Labem is carried out several research projects. One of them is research of the tool life of cutting inserts. At FPTM is part of such research also realization of structural and material analysis of experimental cutting inserts, using electron microscopy and analysis of the resulting tool wear of used inserts after turning machining. Within the realized experiments have been used cutting insert subjected to analyzes SEM and EDX. [Beddoes 2003, Forejt 2006, Stancekova 2014]

2 EXPERIMENT

The experimental material was supplied by the contracting entity and it was a steel class 16 343 according to CSN 41 0002, tempered to 40-44 HRC. This material can be found in the catalogs of suppliers under the designation 34CrNiMo6 according to EN 10269. It is a steel with high hardenability, which is designed for highly stressed parts used in engineering. After processing it has a favorable ratio of strength to yield strength and a high toughness which inhibits crack growth. The material is therefore characterized by high levels of fatigue limit under static and dynamic loads. In Tab. 1 is the chemical composition of the material according to CSN 41 6343. [Bolzano 2007]

Table 1. Chemical composition according to CSN 41 6343 in wt. %

C	Mn	Cr	Cr
0,32–0,40	0,5–0,8	0,1–0,40	1,3–1,7
Ni	**Mn**	**P**	**S**
1,3–1,7	0,2–0,3	<0,035	<0,035

It was conducted microscopic and spectrometric analysis of this material. [Michna 2012]

To verify the structure of the experimental material was made a microscopic analysis using a confocal laser microscope LEXT OLS 3100 (Fig. 1). [Kusmierczak 2011]

Figure 1. The laser confocal microscope LEXT OLS 3100

Fig. 2 shows an example of the structure of the experimental material.

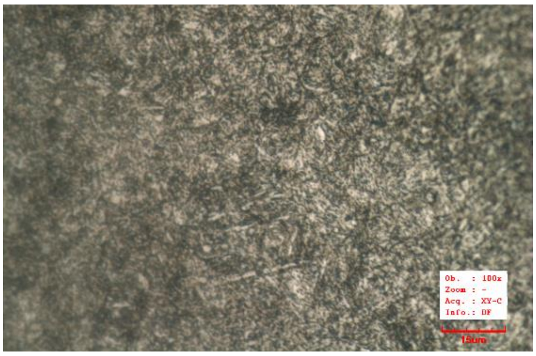

Figure 2. Sample of structure of the machined material

From the snap of the microstructure it was obvious that the material conforms to its declaration.

In Tab. 2 is the result of spectrometric analysis, which was performed using spark spectrometer Bruker Q4 TASMAN (Fig. 3). [Bruker 2016]

Figure 3. Spectrometer Q4 Tasman

When compared the Tab. 1 and 2, it can be concluded that the composition of the experimental material corresponded to the standard.

Table 2: Chemical composition according spectrometric measurement in wt. %

C	Mn	Cr	Cr
0,342	0,57	0,329	1,519
Ni	**Mn**	**P**	**S**
1,470	0,193	<0,005	<0,001

For the analysis were delivered cutting insert (plate) CNMG 120408-M KT-CTP25 (Figure 4) and CNMG 120408-M KT-CTP15 (Figure 5), from company Karned Tools s.r.o. and CNMG 120408E-M GRADE T9325 (Figure 6) and CNMG 120408E-M GRADE T9315 (Figure 7), from company Pramet Tools s.r.o. [Hricova 2013, Kalincova 2014]

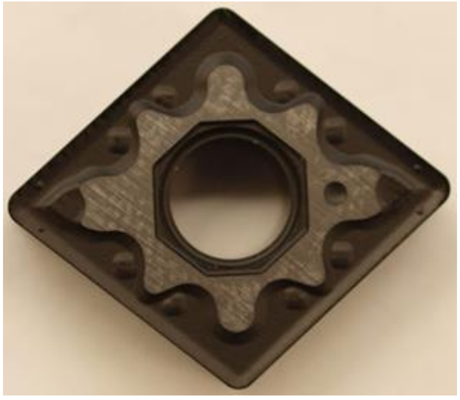

Figure 4. CNMG 120408-M KT-CTP25, Karned Tools s.r.o

Figure 5. CNMG 120408-M KT-CTP15, Karned Tools s.r.o

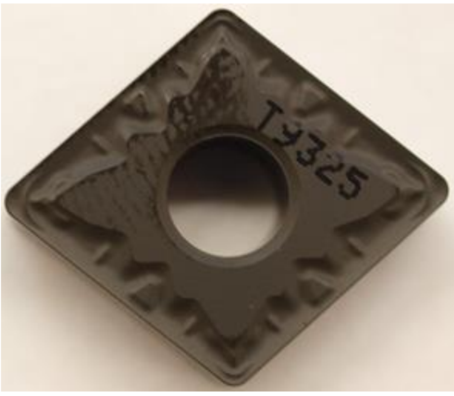

Figure 6. CNMG 120408E-M GRADE T9325, Pramet Tools s.r.o.

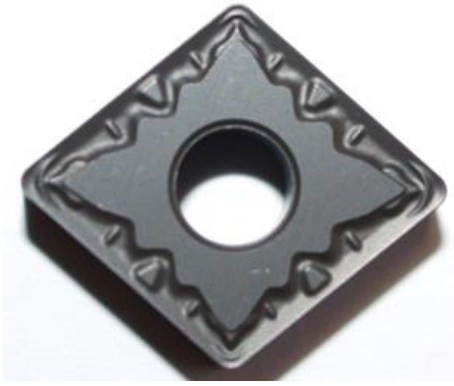

Figure 7. CNMG 120408E-M GRADE T9315, Pramet Tools s.r.o.

Experimental material was turning on the three-axis CNC lathe DOOSAN Lynx 220L with control system FANUC (Figure 8). [Kocman 2011]

Cutting depth was determined *as* a_p = 1.5 mm, because at indicative removal depth of 2 mm the whole system showed instability. Feed was set as f = 0,3 mm.ot^{-1}. For all investigated cutting inserts the same tool holder PCLNR 2020 K 12 was used. Experimental cutting speed was determined for all cutting inserts as v_c=80 m.min^{-1}, v_c=100 m.min^{-1}, v_c=120 m.min^{-1} and v_c=140 m.min^{-1}.

Figure 8. CNC turning machine DOOSAN Lynx 220L

2.1 EDX composition analysis cutting inserts

The first was conducted EDX analysis of the composition of experimental cutting inserts. For this purpose was used EDX analyzer Bruker 16 which is part of a scanning electron microscope Tescan Vega 3, which is on the FPTM JEPU available (Figure 9). [Cais 2015, Svobodova 2014]

EDX (energy dispersive spectrometer) is used as an accessory to the electron microscope and it is used to perform the spectral analysis. The principle is to capture X-ray radiation generated during the bombardment of samples by primary electrons. The output of EDX analysis is the frequency range of X-ray signal in the energy windows. It results the characteristic peaks that correspond to the elements in a given location. The height of these peaks is proportional to the concentration of the chemical element in the sample. [Beddoes 2003, Cierna 2013]

Figure 9. Sscanning electron microscope Tescan Vega 3

Figure 10 shows a cross-sectional of cutting insert CNMG 120408-M KT-CTP25. Figure 11 shows the result of EDX analysis of this cutting plate at the selected location. This plate is composed of substrate and double coat, as shown in Figure 10. The substrate is formed according to the EDX analysis by carbides of wolfram, titanium, tantalum and niobium with a cobalt binder. The lower coating with thickness of 15 µm is formed by titanium carbide, a top coating of a thickness of 3 µm then Al_2O_3. From the EDX analysis, it is also evident the presence of elements such as calcium, copper or iron. These elements are found more often in cutting insert from cutting ceramics.

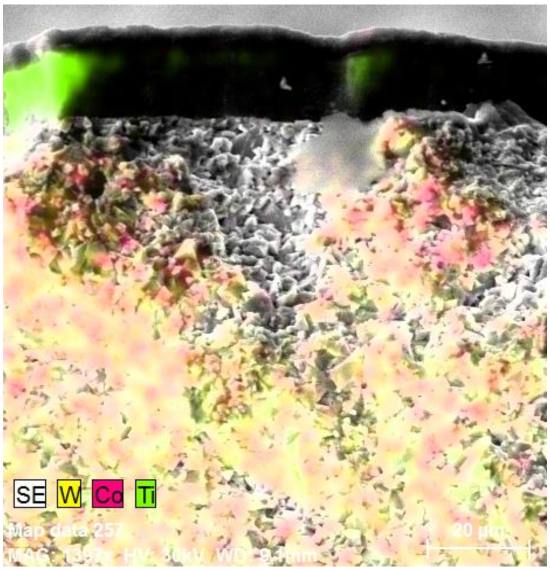

Figure 10. Structure of plate CNMG 120408-M KT-CTP25

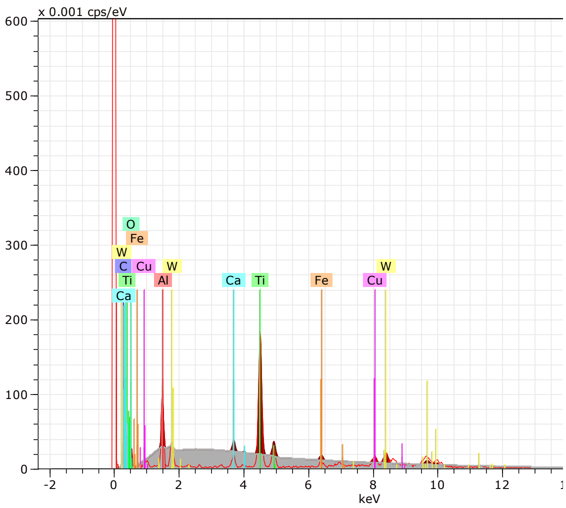

Figure 11. EDX analysis of plate CNMG 120408-M KT-CTP25

Fig. 12 shows snap of cutting insert CNMG 120408-M KT-CTP15 cross section. Fig. 13 shows the result of EDX analysis of the plate at the selected location.

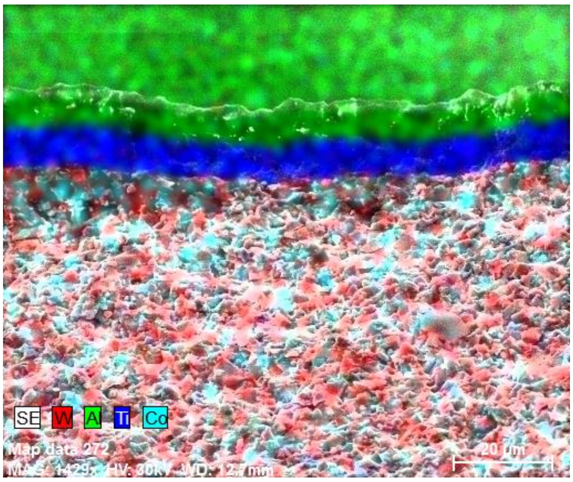

Figure 12. Structure of plate CNMG 120408-M KT-CTP15

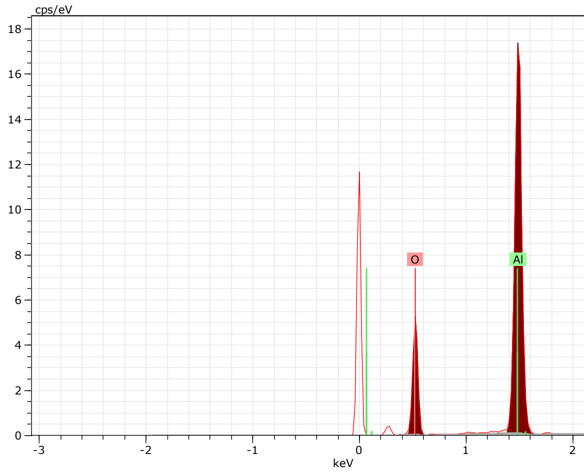

Figure 13. EDX analysis of plate CNMG 120408-M KT-CTP15

This plate is composed of a wolfram carbides substrate with a cobalt binder and a double coating. The analysis shows that the upper coatings with a thickness 7 µm is composed of Al_2O_3. Lower coatings with a thickness 7 µm is apparently composed of TiCN. From the analysis has been evident the presence of aluminum, which diffused from the upper coating

Fig. 14 shows a cross-sectional image of cutting insert CNMG 120408E-GRADE M T9325. Fig. 15 shows the result of EDX analysis of the cutting insert at the selected location. This plate (Fig. 14) forms a substrate of wolfram carbide with cobalt binder and a double coating. Point EDX analysis (Fig. 15) showed that the top coating of a thickness of 5 µm is formed of Al_2O_3. There is, however, the measurable presence of components titanium and carbon. These elements diffused from the lower layer coating. Lower coatings with a thickness 7 µm is formed by titanium carbide (Fig. 16), but can be observed the presence of aluminum and oxygen, which indicates on the contrary the diffusion of elements from the top coating.

Fig. 17 shows a cross-sectional of cutting insert CNMG 120408E-M GRADE T9315. Fig. 18 shows the result of EDX analysis of the cutting insert at the selected location. Fig. 19 shows the result of EDX analysis of place at lower coating.

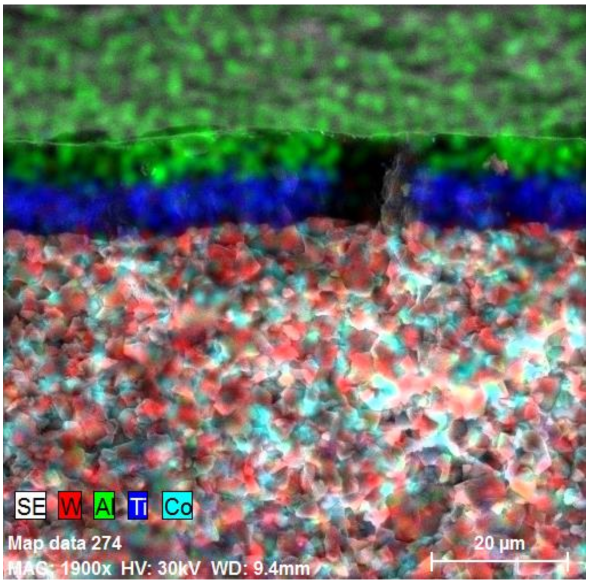

Figure 14. Structure of plate CNMG 120408E-M GRADE T9325

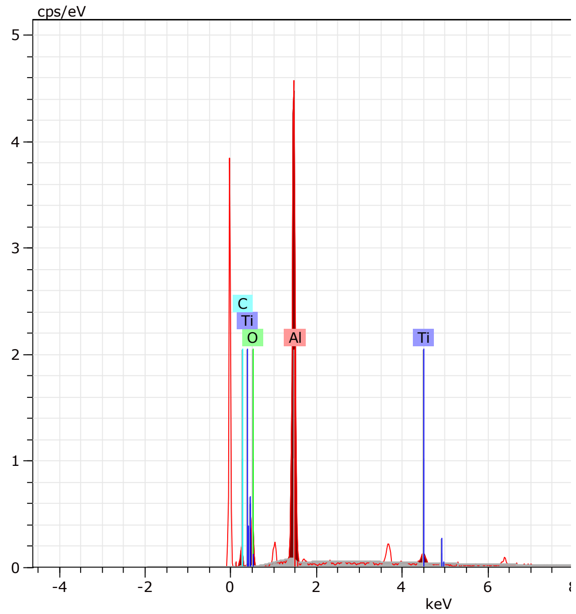

Figure 15. EDX analysis of plate CNMG 120408E-M GRADE T9325

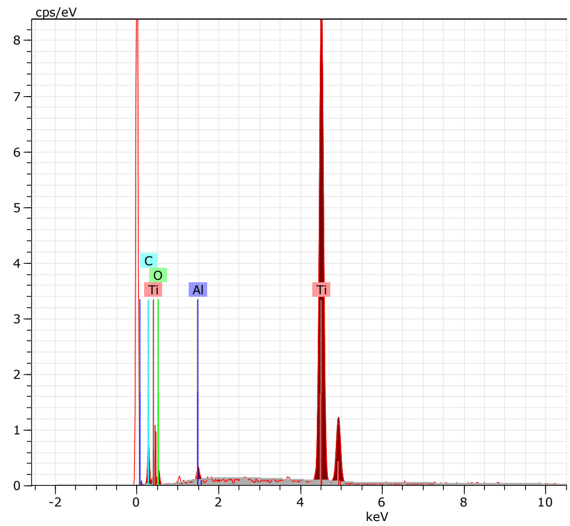

Figure 16. EDX analysis of plate CNMG 120408E-M GRADE T9325, lower coating

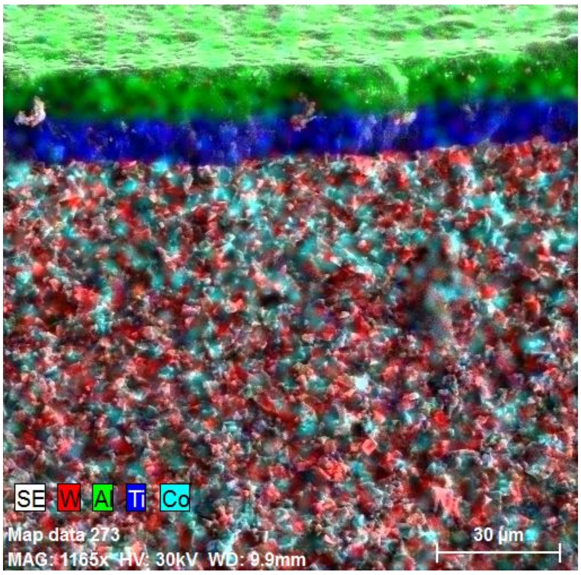

Figure 17. Structure of plate CNMG 120408E-M GRADE T9315

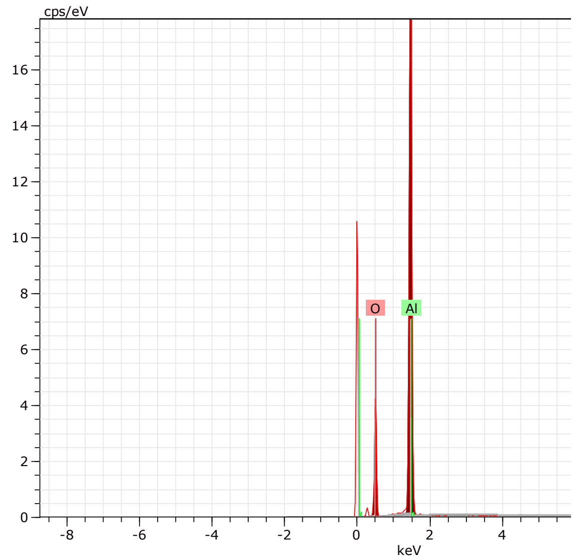

Figure 18. EDX analysis of plate CNMG 120408E-M GRADE T93125

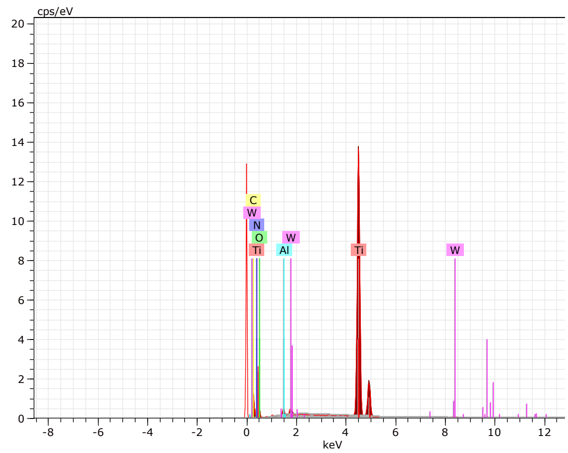

Figure 19. EDX analysis of plate CNMG 120408E-M GRADE T9315 (lower coating)

By EDX analysis, the cutting insert CNMG 120408E-GRADE M T9315 consists of a substrate and a double coating. The substrate is composed of wolfram carbide and titanium carbide, which are connected by a cobalt binder. The top coating in according to the EDS analysis is composed of Al_2O_3. Lower coating (Figure 19) consists of TiCN, but according to the EDS analysis are also present oxygen, aluminum and wolfram.

This can be explained by diffusing of Al and O from the top coating, W from the substrate.

2.2 SEM analysis of plate tool wear

At all replaceable cutting inserts was performed SEM analysis of tool wear. The abbreviation SEM means a scanning electron microscope (Fig. 9). This microscope is working with a narrow electron beam. To create the image are used the primary and secondary electrons backscattered from the sample surface. These electrons formed by the interaction of atoms of the sample with electrons of the electron beam. Electrons detector receives and processes so as to obtain a sharp image of the sample surface. Rather than a traditional optical microscope is its advantage a large depth of sharpness and the ability to get more magnification. [Czajkowska 2013,]

SEM analysis revealed for inserts CNMG 120408-M KT-CTP25 intensive wear on the tip and back edge (Fig. 20**Chyba! Nenalezen zdroj odkazů.**). From the figure there is clearly evident the individual layers of the coating and the inserts substrate itself. It could be a delamination wear, which is for coated inserts relatively common.

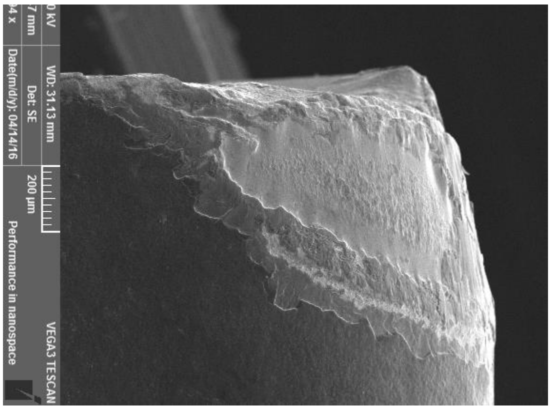

Figure 20. SEM analysis of tool wear for plate CNMG 120408-M KT-CTP25

Tool wear on the cutting edge of cutting insert CNMG 120408-M KT-CTP15 was according to the SEM analysis uniform (Fig. 21). However, there was breaking off the coating portions and from the closer view it can be seen that the both layers of coating were dislodging. The picture shows also large heat-affected zone, which was caused by high temperatures during machining.

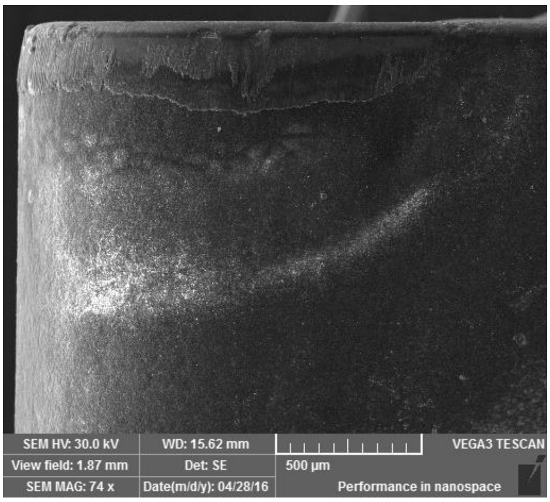

Figure 21. SEM analysis of tool wear for plate CNMG 120408-M KT-CTP15

SEM analysis of the insert CNMG 120408-M KT-CTP15 showed that the insert wear takes place evenly without any obvious signs of damage (Fig. 22). There is no apparent significant heat-affected zone and no significant abrasive wear, too.

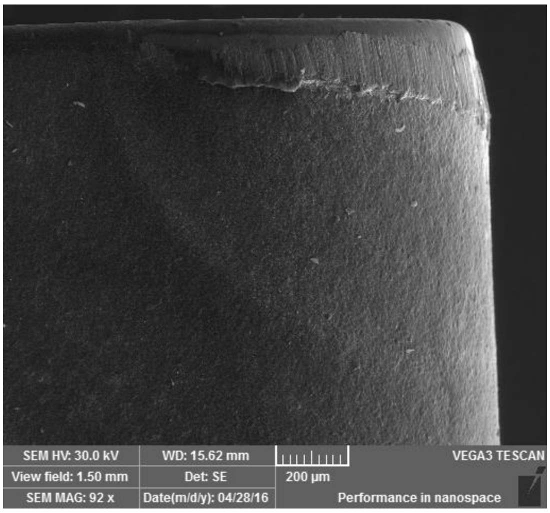

Figure 22. SEM analysis of tool wear for plate CNMG 120408E-M GRADE T9325

SEM analysis of the insert *CNMG 120408E-M GRADE T9325* is on Fig. 23 and there it can be seen especially large heat-affected zone in the tip area, less than in back area. Further, there it is evident a specific adherence of machined material over the entire length of the useful part of the back.

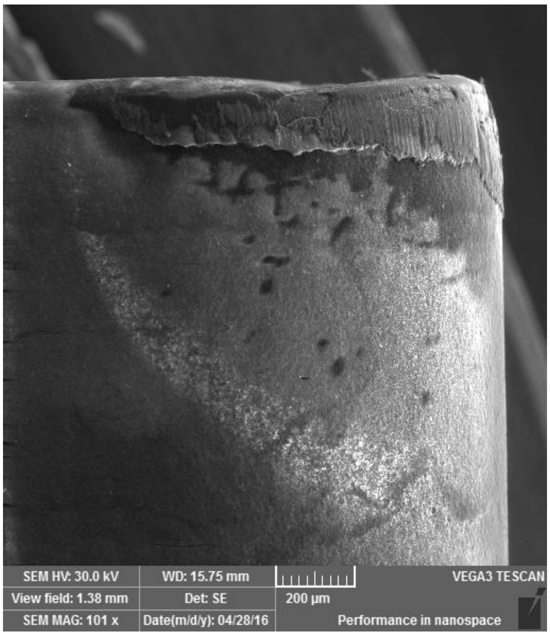

Figure 23. SEM analysis of tool wear for plate CNMG 120408E-M GRADE T9315

3 CONCLUSIONS

For experimental insert CNMG 120408-M KT-CTP25 by firm Karned Tools Ltd. on the basis of the analysis it was determined by EDS analysis that the plate coating was not sufficiently chemically connected to the substrate, and therefore according to SEM analysis the tool wear unevenly formed and there was causing the exfoliation of the insert coating.

For experimental insert CNMG 120408-M KT-CTP15 SEM analysis showed appreciable heat affected zone on the back. It was also noticeable tearing relatively large parts of the coating. By EDX analysis was chemically attached the upper and lower coating, but has not been confirmed interconnection diffusion of elements between the lower coating and the plate substrate.

For experimental insert CNMG 120408E-M GRADE T9325 Pramet Tools Ltd. it was determined that the wear according to the SEM analysis was uniform, not to flaking the coating layers or tearing off of particles. According to EDX analysis there it occurred adequate diffusion of elements between all layers of the insert.

For experimental insert VBD CNMG 120408E-M GRADE T9315 was possible to state that the substrate and the coating layer according to EDX analysis were sufficiently chemically connected. SEM analysis showed a significant heat affected area of the back and the tool tip, and also the presence of up edge.

EDX analysis indicated that all tested inserts are composed of a substrate and a double coating. The substrate was mostly made of wolfram carbide and titanium carbide with a cobalt binder. Lower coating was formed of TiCN or TiN, then top each Al_2O_3. It was observed as the diffusion connection of the individual layers of the coating and the coating with the substrate. Inserts differed mainly in the thickness of the individual coatings.

According to SEM analysis of inserts wear there was possible to see relatively uniform abrasion wear on the tool front and back edge. There were also chipping blade wear and abrasive wear on the surface of the tool back. It was observed also delamination tool wear.

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CONTACTS:

Doc. Ing. Natasa Naprstkova, Ph.D.
Jan Evangelista Purkyne University in Usti nad Labem
Faculty of Production Technology and Management
Department of Technology and Material Science
Pasteurova 7, Usti nad Labem, 400 96, Czech Republic
Tel.: +420 475 285 513,
e-mail: naprstkova@fvtm.ujep.cz
http://cz.fvtm.ujep.cz/