METABK 56(3-4) 419-421 (2017)
UDC – UDK 621.75:669.21/.23:621.793:620.178.1=111

FUNCTIONAL PROPERTIES OF COATED BY CHEMICAL VAPOUR DEPOSITION SINTERED TOOL MATERIALS INVESTIGATED WITH USE OF TRIBOLOGICAL TESTS

Received – Prispjelo: 2016-12-16
Accepted – Prihvaćeno: 2017-03-25
Preliminary Note – Prethodno priopćenje

The purpose of the work is to present the results of investigations into the structure and properties of sintered carbides with deposited wear resistant coatings after a tribological test carried out with the method of combined examination of abrasion wear resistance and edge fracture resistance.

Key words: tool materials, sintered materials, coatings, tribotesting; abrasion

INTRODUCTION

Abrasion wear resistance and fracture resistance are the main parameters characterising the materials used for tool cutting edges. The importance of such properties is a consequence of the two dominant damage mechanisms leading to the loss of tool edges' operating fitness, namely their abrasion wear and fracture in contact with the material processed in technological operations. The requirements imposed on the materials used for cutting tools have been growing due to the development of industry. Numerous works are carried out to improve functional properties of sintered tool materials, especially in the field of surface engineering and modelling [1-5]. In parallel, it becomes necessary to improve research methods of a multi-criteria evaluation of abrasion wear and fracture as the fundamental factors of tool wear [6-9].

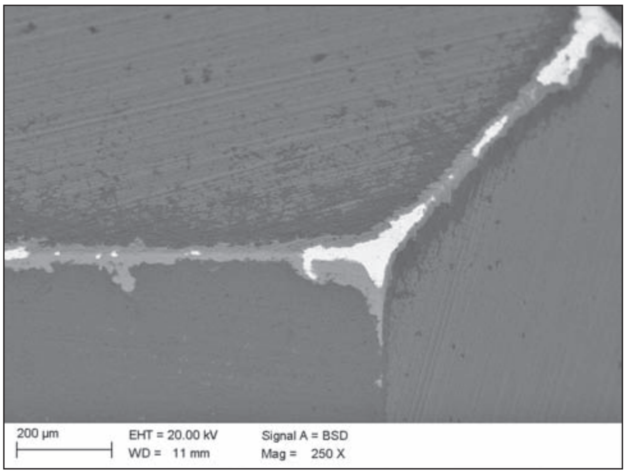
MATERIAL AND METHOD

The tests were performed on specimens of sintered carbides of H10 and S30 grade covered and not covered with the layers of wear resistant coatings of the TiCN + Al_2O_3 + TiN and TiCN + TiN type. The coatings were produced in chemical vapour deposition method processes. The abrasion wear resistance tests of the substrate material and of the materials with coatings deposited were carried out on a laboratory station for testing tribological properties of structural and tool materials and granulated materials and such properties are manifested during interaction in a friction node with specific structural characteristics. The test consists of the controlled combined activity of hard loose mineral both, as an abradant and as a multi-point source of load on the specimen of the examined sintered carbides near their edge. The characteristics of the abradants used for the tests and test parameters are presented in Table 1. The tests results were used for assessing abrasion wear resistance of the selected specimens of sintered carbides with multilayer coatings deposited and not deposited onto them. The entire activity of a grainy abradant took place in a cylindrical chamber where the normal stress σn was controlled by the external load Fn. The torque T on a drive shaft was used for overcoming the shear resistance of the abradant and the friction resistance on the contact area of the specimen edge and abradant. The test method, enabling to examine at the same time brittle cracking and abrasion, allows to simulate stress conditions and advancement speed between the drill and rock. Another advantage of the test friction node is that the crushed abradant can escape from the abrasion area through a gap between a specimen holder and a cylindrical chamber wall, as is the case in real drilling or crushing conditions. A detailed description of the progress of the test procedure is presented in [10]. The observations of surface topography of the specimens were made in a scanning electron microscope, Zeiss SUPRA 35, with the accelerating voltage of 15 - 20 kV and the maximum magnification of 50 000 x. Chemical composition microanalysis tests were carried out using the energy dispersive scattered X - ray radiation spectroscope

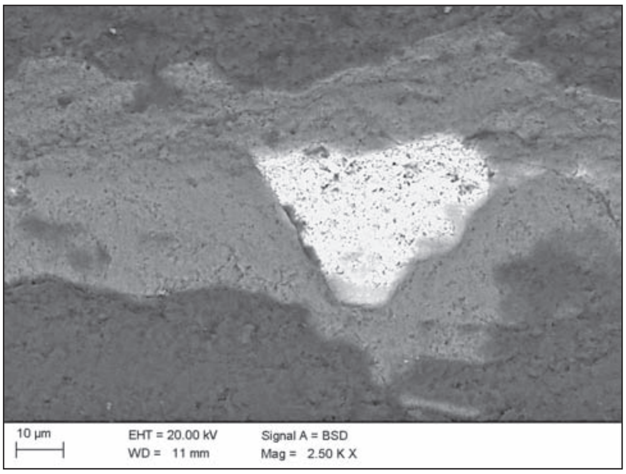
Table 1. **Specification of the apparatus and experimental details**

No	Parameters	Edge abrasion tribotester			
1	Normal load /N	500	1 000	15 000	2 000
2	Normal stress /MPa	1,3	2,5	3,8	5,1
3	Drive shaft speed /rpm	30			
4	Test duration /number of rev.	100			
5	Mean sliding distance /m	33,8 ±12			
6	Abradant - Quartz sand SiO_2	600 – 1 200 μm			

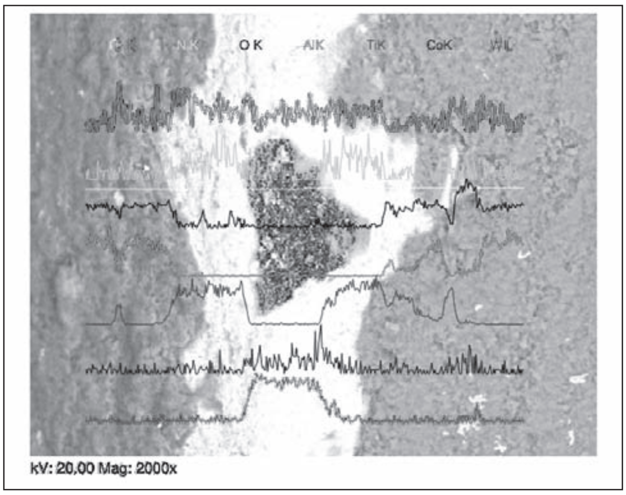
J. Mikula, W. Grzegorzek, K. Golombek, D. Lukowiec, M. Sroka, Silesian University of Technology, Gliwice, Poland



a)



b)



c)

Figure 1 a) Topography of H10 sintered carbide surface with the TiCN + Al_2O_3 + TiN coating deposited after the performed tribological test, character of edge wear; b) details from Fi. a); c) character of edge wear together with the linear diagram of intensity of backscatter X - ray radiation for the energy value corresponding to particular chemical elements.

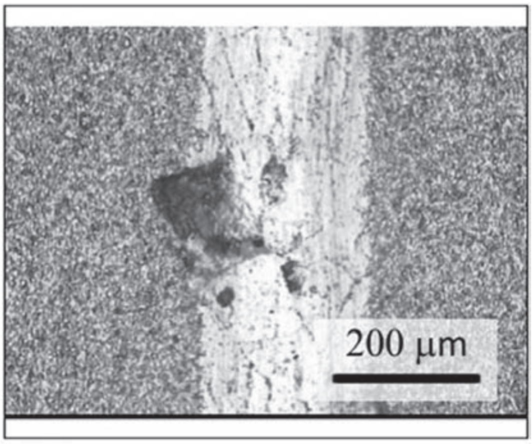
fitted with the SUPRA 35 microscope. The adhesion of coatings to the substrate material was appraised with a scratch test applied commonly for coatings produced in chemical vapour deposition method processes. The tests were performed using a Revetest device by Anton Paar.

RESULTS AND DISCUSSION

A strong qualitative relationship was identified between the results of the scratch test made and the results of a tribological test of the combined examination of abrasion wear resistance and edge fracture resistance. The TiCN + Al_2O_3 + TiN coating, deposited onto an H10 sintered carbide substrate, exhibits the highest durability in both cases, whilst the TiCN + TiN coating deposited onto an S30 sintered carbide substrate shows the smallest resistance. The TiCN + Al_2O_3 + TiN coating shows higher durability than the TiCN + TiN coating despite smaller microhardness, which can be linked to the character of microhardness measurement and the substantial total thickness of the TiCN + Al_2O_3 + TiN coating. Microhardness measurement for this coating was limited to the Al_2O_3 + TiN layer without considering the hardness of the TiCN layer adhering to the substrate. The observations of the indenter track after a scratch test, performed with a scanning electron microscope, for TiCN + Al_2O_3 + TiN deposited onto the H10 sintered carbide substrate, are indicating the nature of abrasion wear where individual layers are worn off, without delamination and significant chippings within a significant range of pressing force. This signifies that particular layers are adhering very well and also signifies good adhesion to the substrate. The topography observations of the H10 sintered carbide surface with the TiCN + Al_2O_3 + TiN coating deposited after the performed tribological test also indicate the abrasive character of wear and provoke similar conclusions. The linear diagrams of chemical composition, performed using energy dispersive scattered X-ray radiation spectroscopy, allow to confirm that gradual wear takes place in the case of the TiCN + Al_2O_3 + TiN coating deposited onto the H10 sintered carbide substrate, where the top Al_2O_3 layer is wearing off with the TiCN layer being maintained, which signifies that the coating is adhering very well to the substrate material.

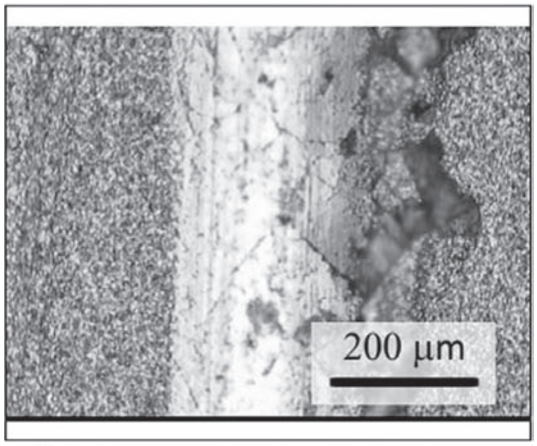
CONCLUSIONS

It was found that specimens during the test with the method of combined examination of abrasion wear resistance and edge fracture resistance are becoming worn by being abraded and with the coating being delaminated on the edges. The existence of local chippings, likely to be microchippings of the substrate material, was also found. The degree and character of wear of



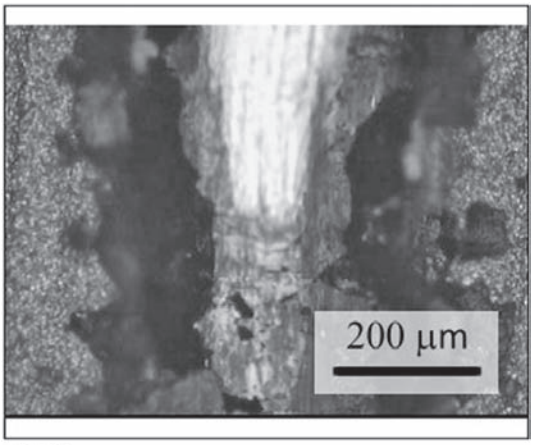
a)

69N.



b)

84N.



c)

147N.

Figure 2 Optically identified characteristic indenter track sections (corresponding to critical loads of L_C3, L_C4, L_C5) of the TiCN + Al_2O_3 + TiN coating deposited onto the H10 sintered carbide substrate after scratch test.

particular specimens is responding qualitatively to the results of comparative tests performed with the scratch test method. The tests carried out and the correlations found show that the employed method of combined examination of abrasion wear resistance and edge fracture resistance is applicable to the tests of adhesion and durability of coatings deposited onto sintered tool materials, including sintered carbides.

Acknowledgements

The publication was partially financed by statutory grant from Faculty of Mechanical Engineering, Silesian University of Technology for year 2016, researches were supported by Faculty of Mining and Geology, Silesian University of Technology.

REFERENCES

[1] L. Żukowska, A. Śliwa, J. Mikuła, M. Bonek, W. Kwaśny, M. Sroka, D. Pakuła, Finite element prediction for the internal stresses of (Ti, Al) N coatings, Archives of Metallurgy and Materials 61 (2016) 1, 149-152

[2] A. Śliwa, W. Kwaśny, W. Sitek, M. Bonek, Computer simulation of the relationship between selected properties of PVD coatings, Archives of Metallurgy and Materials 2 (2016), 481-484

[3] L.A. Dobrzański, D. Pakuła, Structure and properties of the wear resistant coatings obtained in the PVD and CVD processes on tool ceramics. Advanced Materials and Technologies; Book Series: Materials Science Forum, Volume 513 (2006) 119-133

[4] M. Madej, D. Ozimina, R. Gałuszka, G. Gałuszka, Corrosion, friction and wear performance of diamond – like carbon (DLC) coatings, Metalurgija, 55 (2016) 4, 679-682

[5] B. Sovilj, I. Sovilj-Nikić, D. Ješić, The effect of specifi c relationship between material and coating on tribological and protective features of the product Metalurgija 51 (2012) 1, 21-24

[6] J.C. Caicedo, C. Amaya, L. Yate, M.E. Gómez, G. Zambrano, J. Alvarado-Rivera, J. Munoz-Saldana, TiCN / TiNbCN multilayer coatings with enhanced mechanical properties, Applied Surface Science 256, Issue 20 (2010) 5898-5904

[7] I. Hussainova, M. Antonov, A. Zikin, Erosive wear of advanced composites based on WC, Tribology International 46 (2012), 254–260

[8] S.F. Scieszka, Simultaneous abrasion and edge fracture resistance estimation of hard materials by the tribotesting method, Scientific Problems of Machines Operation and Maintenance 166 (2011) 2, 55-104

[9] S.F. Scieszka, Abrasion and edge fracture resistance estimation of hard materials by tribotesting method, Tribotest (2007) 13, 103–113

[10] S.F. Scieszka, W. Grzegorzek, M. Zolnierz, Tribotesting system for hardmetals mechanical characterization, International Journal of Refractory Metals and Hard Materials 41 (2013), 470-482

Note: The responsible translator for English language is Michał Lisek Gliwice, Poland