CHIP AND CHIPLESS WOODWORKING PROCESSES, 11(1): 211–216, 2018
Zvolen, Technical University in Zvolen, ISSN 1339-8350 (online), ISSN 2453-904X (print)

THE EFFECT OF THE WC-CO PROPERTIES ON THE TOOL WEAR DURING PARTICLEBOARDS MILLING

Jacek Wilkowski[1] **– Marek Barlak**[2] **– Zbigniew Werner**[2] **– Paweł Czarniak**[1] **– Joanna Wachowicz**[1]

Abstract

This work presented influence of hardness and fracture toughness of WC-Co tool material on wearing and durability of edges during chipboards milling. Measurement of WC-Co hardness was done according to Vickers method with usage of universal device. Fracture toughness was assessed due to length of cracks with Palmquist method, created during hardness measurement. Tool life tests were carried out maintaining constant cutting parameters with working center CNC. There were observed differences in character of WC-Co edges wearing process. Results shows directly proportional influence of edge material hardness on its durability.

Key words: *WC-Co, hardness, fracture toughness, CNC milling, tool life, particleboard*

INTRODUCTION

Cemented carbides type WC-Co is widely used material designed not only for metal cutting purposes but also for machining of wood and wood based materials and plastics. The structure of them consist of wolfram carbides grains WC and metal binder in form of cobalt Co. Exemplary structure of WC-Co is showed in Fig.1. Cobalt is distinguishes by very good thermal conductivity, high melting temperature and high strength to bending. Grain size and contribution of cobalt are the main elements of WC-Co composition, having crucial influence on functionality of this material in cutting tools applications. Density and hardness of WC-Co increases together with decreasing of WC grain size. In turn, came up improvement of resistance to abrasion during wearing process and through this phenomena decreasing of fracture toughness. However, increase of cobalt contribution follows that fracture toughness is higher but simultaneously resistance to wear abrasion is lower (Cichosz 2006, Dobrzański 2002, Kupczyk 2009). These relationships determined certain level of mentioned above components of WC-Co that ensure optimal structure regards to durability of cutting tools applied in machining of given material (Rosiński et al. 2014). Surely, WC grain size and contribution of cobalt is differentiated in metal or wood based materials machining. Material and cutting parameters imposes manufacturing of tool materials according to particular applications (Dobrzański 2002). Therefore, in this work influence of WC-Co appropriable properties (hardness and fracture toughness) on theirs wearing during chipboards machining was examined.

[1] Warsaw University of Life Sciences - SGGW, 159 Nowoursynowska Str., 02-787 Warsaw, Poland
e-mail: jacek_wilkowski@sggw.pl
[2] National Centre for Nuclear Research Świerk - NCBJ, 7 Andrzeja Sołtana Str., 05-400 Otwock, Poland

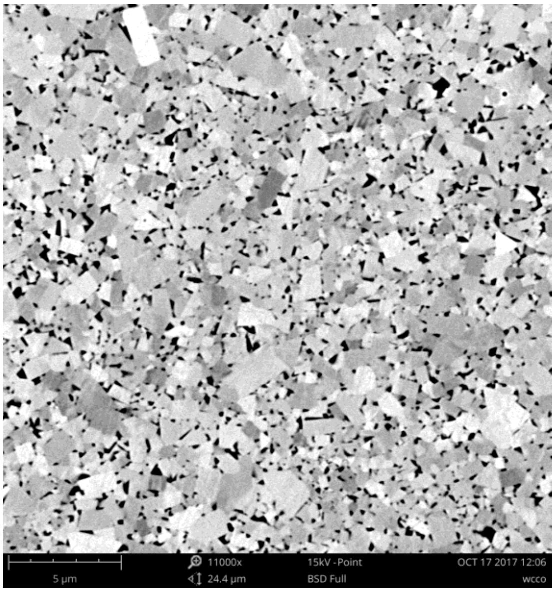

Fig.1. Microstructure of WC-Co tool material

MATERIAL AND METHODS

Knifes from WC-Co produced by Ceratizit with dimensions 29,5x12x1,5 mm were used for tool materials properties measurement (hardness, durability in milling mode). Properties of materials used in experiments according to producer data were presented in Tab.1.

For hardness and fracture toughness measurement was applied universal device Verzus 700AS produced by Innovatest. Hardness (HV30) was measured with Vickers method (PN-EN ISO 6507-1:1999) consisted on pushing in sample diamond tip with shape of pyramid with square base and vertex angle 136° with 30N and measurement of diagonal length on created in this way imprint. Measure of hardness is assumed as ratio between loading force and area of imprint. This procedure was carried out on clearance face of edge with five repetitions.

Fracture toughness (K_{Ic}) was assessed due to measurement of cracks length with Palmquist method created during Vickers hardness procedure with usage of Shetty formula (Rumman et al. 2015).

Tab.1. Chosen properties of WC-Co material (according to producer)

Material symbol	Density [g/cm^3]	WC grain size [µm]	Binder content Co [%]
UMG04	15,30	<0,2	2,0
SMG02	15,25	0,2 - 0,5	2,4
KCR08	15,20	0,5 - 0,8	3,2

Three layers particleboard produced by Pfleiderer with thickness of 18 mm and density 648 kg/m^3 was subjected to durability tests. Mentioned above panels are standard construction material commonly used in furniture industry. Workpieces with dimensions 1000x400x18 mm were milled on working center CNC Busellato Jet 130 equipped with one edge milling head (left rotations) Faba FTS.07L4043.01 with diameter 40 mm.

There were made grooves (with width equal to tool diameter – 40 mm) in particleboard panels on depth 6 mm. During machining, constant cutting parameters (feed speed 2,7 m/s, spindle speed 18 000 rpm, feed per tooth 0,15 mm) were maintained. On each work piece 10 repetitions were done. After each passage (1 m of feed) measurement of tool wear with workshop microscope was carried out. The clearance surface of edge was took into account. Maximal width of wear (direct indicator VB_{max}) was estimated. Machining was stopped as soon as wear width was equal or higher than 0,2 mm. Thus, this value was assumed as tool wear criterion. Feed distance up to achieve with edge, tool wear criterion (VB_{max} = 0,2 mm) was its durability indicator.

RESULTS AND DISCUSSION

Visible differences in tool wear nature were observed. WC-Co denoted as UMG04 with the highest density and the WC smallest grain size was wearing mainly because of microchipping and chipping (Fig.2). However, material described as KCR08 with the lowest density and biggest grains distinguishes by high contribution of abrasive wearing what presented Fig.3.

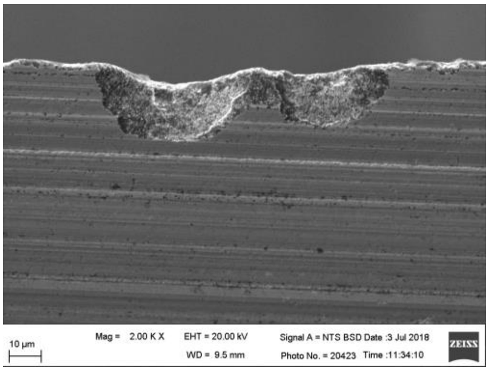

Fig.2. Chipping of UMG04 tool material (SEM image)

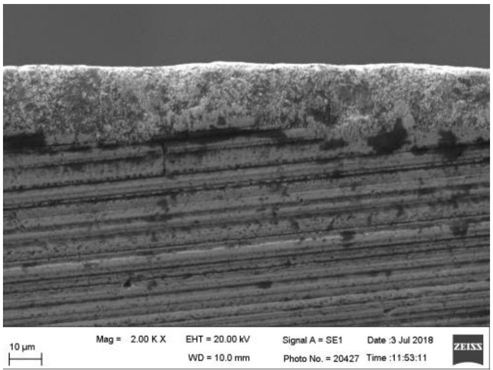

Fig.3. Abrasive wear of KCR08 tool material (SEM image)

Fig.4-6 shows measured properties of examined WC-Co materials. The highest hardness was obtained for UMG04 (HV30 = 2705), namely material with the smallest WC (<0,2 μm) grains and the lowest contribution of cobalt (2,0 wt% Co). However the lowest (HV30 = 1789) for KCR08 – the biggest WC size (0,5 - 0,8 μm) and the highest contribution of cobalt (3,2 wt% Co) (Fig.4).

The highest fracture toughness was noticed for WC-Co with symbol SMG02 (K_{Ic} = 12,16), the lowest for UMG04 (K_{Ic} = 11,32), in other words the hardest (Fig.5).

The highest durability (cutting distance for blunted tool VB_{max} = 0,2 mm amounted 5262 m) was received during chipboards milling with knives of the smallest WC grains and the lowest cobalt contribution. The lowest tool life was observed for KCR08 distinguishes by big WC grains and high cobalt contribution (Fig.6).

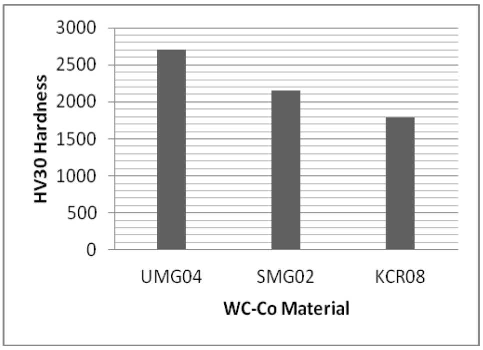

Fig.4. Hardness of examined WC-Co

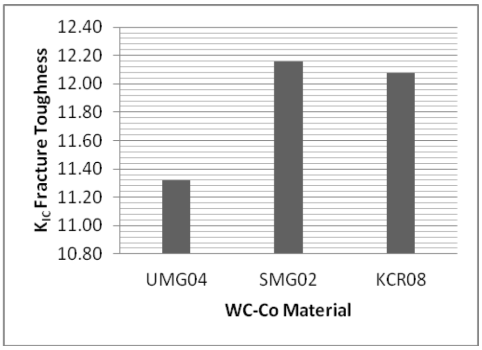

Fig.5. Fracture toughness of WC-Co edges.

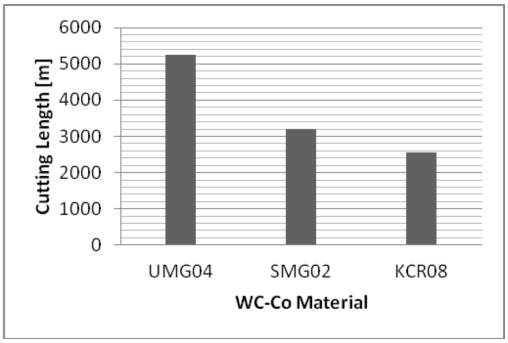

Fig.6. Tool life of examined WC-Co edges.

In Fig.7-8 were showed correlation relationships between investigated properties of tools made of WC-Co. The strongest correlations (Fig.7) were detected between hardness with tool durability expressed with cutting length (up to blunting on the level VB_{max} = 0,2 mm). However the weakest between hardness and fracture toughness (Fig.9). This relationship is inverted. It means that with increase of one property come up the decrease of the second one: fracture toughness and cutting length (Fig.8) or hardness and fracture toughness (Fig 9).

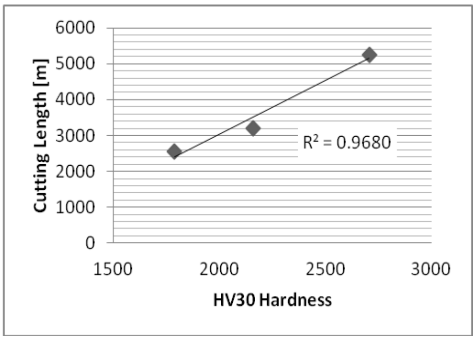

Fig.7. Relationship between tool life and hardness of WC-Co edges.

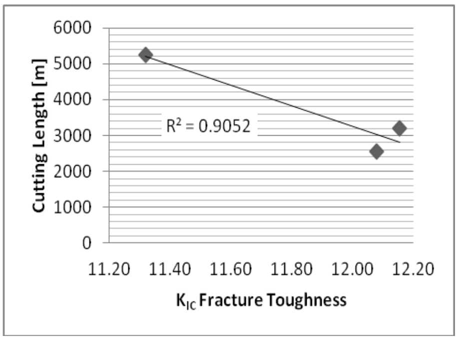

Fig.8. Relationship between durability and fracture toughness of WC-Co edges.

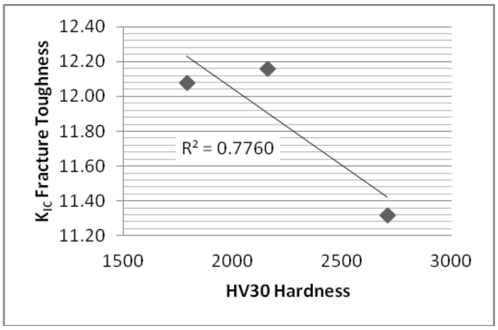

Fig.9. Dependence of fracture toughness on WC-Co edges hardness.

CONCLUSION

According to obtained results can be formulated following conclusions:

- Edges with the highest density, hardness, and the smoothest WC grains were wearing in consequence of microchipping and chipping. However, in case of these with the lowest density, hardness and the biggest WC grains took place mainly abrasive mechanism of blunting.
- WC-Co edges with the smoothest WC grains and low contribution of cobalt proved the highest hardness and durability. However increase of WC grain size and cobalt contribution caused decrease of hardness increase of fracture toughness and decrease of tool durability.

ACKNOWLEDGMENTS

This scientific work financed from funds for science in 2017-2018 granted for the implementation of an international co-financed project “Influence of nitrogen ions implementation on WC-Co composites used in wood based materials machining” (grant of the Polish Ministry for Science and Higher Education No W83/HZDR/2017).

REFERENCES

1. Cichosz P., 2006: Narzędzia skrawające. Wydawnictwo Naukowo-Techniczne. Warszawa.
2. Dobrzański A., 2002: Podstawy nauki o materiałach i metaloznawstwo. Materiały inżynierskie z podstawami projektowania materiałowego. Wydawnictwo Naukowo-Techniczne. Warszawa.
3. Kupczyk M.J., 2009: Wytwarzanie i eksploatacja narzędzi skrawających z powłokami przeciwzużyciowymi. Wydawnictwo Politechniki Poznańskiej, Poznań.
4. PN-EN ISO 6507- 1:1999. Metale - Pomiar twardości sposobem Vickersa.:Metoda badań.
5. Rosiński M., Wachowicz J., Plocinski T., Truszkowski T., Michalski A., 2014: Properties of WCCo/Diamond composites produced by PPS method intended for drill

bits for machining of building stones. *Ceramic Transactions*. Innovative Processing and Manufacturing of Advanced Ceramics and Composites II, 24: 181-191.

6. Rumman R., Xie Z., Hong S.J., Ghomashchi R., 2015: Effect of spark plasma sintering pressure on mechanical properties of WC-7,5wt% Nano Co. *Materials and Design* 68: 221-227.