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DETERMINATION OF PERFORMANCE INDICATORS OF PCD ABRASIVE WHEELS FOR SHARPENING TUNGSTEN CARBIDE WOOD CUTTING TOOLS

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ABSTRACT

Some results of the research on the performance of various diamond abrasive wheels for grinding of carbide knives are presented in the paper. The diamond wheels designed with metal coated and aggregated grains with organic bonds were used. The studies were performed at two levels of intensified, multi-pass sharpening TC (tungsten carbide) knives type K20, the part of a cutter head for longitudinal flat milling of solid wood and wood-based materials. The obtained results were analysed and relevant conclusions and recommendations were made. The process of sharpening carbide tools and its optimization can be better understood this way.

Key words: diamond abrasive wheel, sharpening, carbide tipped knives, wood, wood-based materials.

INTRODUCTION

The diamond sharpening TC tools provides a significant increase in the productivity, accuracy, quality of surfaces, reliability, and durability of their cutting elements. The cost of maintaining them is significantly reduced. Due to their high hardness, diamond grains penetrate the hard alloy relatively lightly, deforming the surface layer slightly and causing no high stresses.

The performance of diamond wheels is an indicator that characterizes both the quality of the abrasive tool itself and the results of its impact on the sharpened TC tools (ZAHARENKO 1981).

This article aims to study the performance of diamond wheels under various sharpening conditions.

MATERIAL AND METHODS

For the research, a cutter head with replaceable knives and TC edges was used for the preliminary and fine longitudinal planing of solid wood and wood-based materials (Fig. 1) (https://www.zmm-sm.com/zmmsm/english/wood.htm).

The basic parameters of the cutter head and the replaceable knives are given in Table 1. The tool body is made of aluminum and planer knives are with TC edges type K20 and heat-treated to hardness HRA 92.

Tab. 1 Basic parameters of the cutter head and knives.

D, mm	*d*, mm	*L*, mm	*B*, mm	*s*, mm	*z*, mm	*β*, ⁰	Type
120	30	120	30	3	4	45	TCT – K20

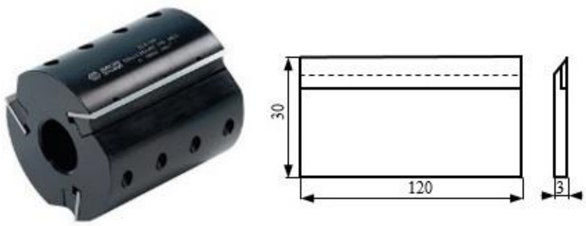

Fig. 1 Assembled cutter head with insert knives and TC cutting edges, type K20.

The indications in Table 1 correspond to:
D – Diameter of the cutter head;
d – Bore size;
L – Length of the knife;
B – Width of the knife;
s – Thickness of the knife;
z – Number of knives;
β – Angle of sharpening;
TCT – Tungsten carbide teeth.

The cutter head is designed for shaper machines and four-side processing machines. The TC edges type K20 (ISO grade classifications) consists of 94% tungsten carbide (WC) and 6% cobalt (Co) with a tungsten grain size of 1.0–2.0 µm (http://carbide.ultra-met.com/viewitems/iso-grades/iso-grade-classifications-tungsten-carbide).

The abrasive PCD grinding wheel (Fig. 2) has 12A2-45 shapes (conical cup - CC) and works with its front surface (manufacturing of Russia).

The characteristics of the experimental disks according to the FEPA (Federation of European Producers of Abrasives) are given in Table 2 and Fig. 3.

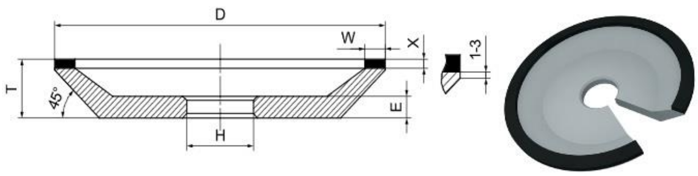

Fig. 2 Abrasive grinding wheel shape 12A2-45 (conical cup).

Tab. 2 Characteristics of experimental diamond abrasive wheels.

Shape and dimensions, mm	Abrasive type	Mesh Size, µm	Bond Type	Concentra-tion, %	Hardness	Work conditions
12A2-45 125 × 5 × 3 × 32	SDC 2	D126	B2-01	K100	R	s
12A2-45 125 × 5 × 3 × 32	SDC 2	D126	B1-13	K100	R	s
12A2-45 125 × 5 × 3 × 32	SDC 4	D126	B2-01	K100	R	s
12A2-45 125 × 5 × 3 × 32	SDC 4	D126	B1-13	K100	R	s

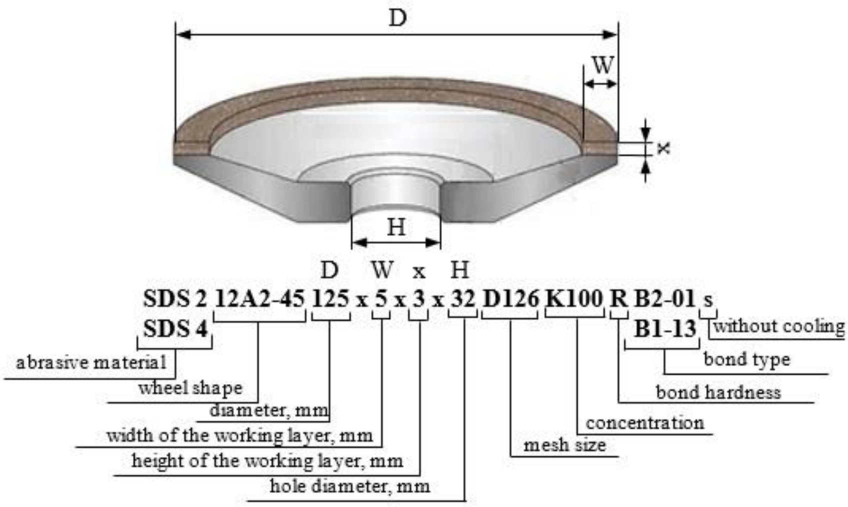

Fig. 4 Abrasive wheel indication.

The indications of Fig. 4 correspond to:

SDC 2 – Metal-coated synthetic diamond with aggregated grains and ordinary strength;
SDC 4 – Metal-coated synthetic diamond with aggregated grains and increased strength;
D126 – Mesh size 125/100;
K100 – Concentration of diamond grains 100%;
R – Hard bond;
B2-01 – Phenol-formaldehyde-based organic bond with boron carbide filler enhancing self-sharpening process
B1-13 - Phenol-formaldehyde-based organic bond with barium sulphate filler and talc for clean sharpening and smoothing

Metal-coated diamond grains are better retained by the organic bond due to the presence of a metal film on their surface. This film protects the grains from shavings and ruptures, increases their strength and improves the conditions of heat removal from the sharpening zone. This results in a reduction in the specific diamond consumption and increases sharpening performance.

Aggregated grains (up to 10 pieces in one aggregate) have a significantly larger unfolded surface (regardless of the initial abrasive mesh size). Such diamond grain aggregates are better retained by the organic bond and withstand much higher loads. Abrasive wheels have better cutting abilities. (KURDYUKOV 2014).

The investigations were carried out with the intensified multi-pass sharpening of a sharpening machine model HMS 700 of HOLZMANN - Austria, under the following conditions:

- Cutting speed (V) – 18 m/s;
- Longitudinal feed speed (V_{l}) – 2.0; 2.5 m/min;
- Cross feed speed (V_{dm}) – 0.03; 0.05 mm/double motion.

The following indicators for evaluating the performance of diamond wheels in a multi-pass sharpening of TC tools have been determined (OSTROVSKII 1981, ZAHARENKO 1981, GOCHEV 2008, 2019):

- Relative consumption of SDC determined by the weight method - Q_{r}, mg/g;
- Coefficient of cutting capacity - C_{c};
- Effective sharpening power of direct motion - $\vec{N}_e$, W;
- Relative power consumption of sharpening – $E_{r.e}$, kWh/kg;
- Complex performance indicator – $C_{c.i}$, mm^3.g/min.kg.

The first four indicators were determined using the methodology set out in the Ohrid and Zagreb publications (GOCHEV 2019).

Some researchers determine the performance of diamond wheels using a Grinding Ratio (ZAHARENKO 1981, ROWE 2009, KOROTOVSKIKH 2012, 2017).

The complex performance indicator takes into account the diamond wheel's durability, productivity, conditions, and sharpening mode and can be defined as:

$$C_{c.i} = c\frac{P_{ac.}}{Q_r} \quad (1)$$

Where c is a coefficient dependent on the magnitude of the cross feed speed (c = 0.2 at W = 5 mm и V_{dm} < mm/double motion):

$P_{ac.}$ – Actual sharpening performance, mm^3/min;

RESULTS AND DISCUSSION

Table 3 shows the summary results of studies of synthetic diamond wheels with metal-coated and aggregated grains with organic bond with intensified multi-pass sharpening without cooling of TC edges type K20.

The study was conducted at two levels of sharpening modes. In mode 2, the theoretical productivity ($P_{th.}$) was increased to the maximum possible - 1050 mm^3/min.

The comparison of the results shows that the performance indicators of the studied diamond wheels are comparable and practically are in the same confidence intervals. Diamond wheels with metal-coated and aggregated abrasive grains have high cutting properties.

Tab. 3 Performance indicators for intensified multi-pass sharpening without cooling of TC edges type K20.

Diamond wheels	Mode №	V_l, m/min	V_{dm}, mm/dm	$P_{th.}$, mm^3/min	Performance indicators				
					C_c	Q_r, mg/g	$C_{c.i}$, mm^3.g/min.kg	$\vec{N}_e$, W	$E_{r.e}$, kWh/kg
SDC 2 D126 B2-01	1	2.0	0.03	504	0.91	0.24	382	295	41
K100 s	2	2.5	0.05	1050	0.88	1.60	116	610	40
SDC 2 D126 B1-13	1	2.0	0.03	504	0.92	0.21	442	260	39
K100 s	2	2.5	0.05	1050	0.89	1.19	157	560	29
SDC 4 D126 B2-01	1	2.0	0.03	504	0.92	0.23	403	230	36
K100 s	2	2.5	0.05	1050	0.89	1.27	147	490	32
SDC 4 D126 B1-13	1	2.0	0.03	504	0.93	0.19	439	250	40
K100 s	2	2.5	0.05	1050	0.90	0.72	263	430	32

Organic bond, type B2-01 provides more efficient operation of diamond grains when sharpening under mode 1. At the same time, this type of bonding does not allow us to take advantage of metal-coated diamond grains (especially for the SDC 4 brand) as it does not provide reliable grains retention under heavier mode 2.

The use of diamond wheels with bond type B1-13 results in lower relative consumption of diamond, effective power of sharpening of direct motion and relative power consumption. Diamond wheels with this type of bond can operate in cross-feeding up to 0.03 mm/double motion, below 1 mg/g relative consumption of SDC and large values of the complex performance indicator.

It is difficult to compare the results with those of other authors. For example, various studies have been conducted such as: Sharpening modes of deep diamond grinding of hard materials tools have been studied. Grinding wheels of different granularities and diameters were examined to sharpen YT and YG cemented carbide cutting tools. The influence of sintering temperature to the relative density (R.D.), hardness and service life of diamond grinding wheels with AlSnTi, AlSnTiNiCo, AlSnTiNiand AlSnNiCo bonding agent was studied and others. Some factors, which have significant effects, like the radial wear of the diamond grinding wheel, the components of the grinding forces, the normal and the tangential grinding force, and the surface quality of the tools are studied. Various variables such as the cutting and feed speed and the coolant supply method were varied to investigate the effect on grinding of different tool materials, the brittle silicon nitride, and the ductile cemented carbide material and others (BIERMAN *et al*. 2009, SHANG-XI *et al*. 2008, VOYACHEK *et al*. 2013, ZHANG *et al*. 2004).

CONCLUSIONS

The analysis shows that when sharpening TC knives type K20, the SDC wheels with organic bond type B1-13 have a high coefficient of cutting capacity and the main work is done in the direct motion of the longitudinal feeding. Diamond grains retain well from the bond and do not fall out before they become blunt. This is confirmed by the relatively low relative consumption of SDC. Analysis of the results also shows that:

- Sharpening processes by multi-pass grinding without cooling can be intensified to a productivity greater than 500 mm/min using diamond discs with metal-coated and aggregated grains type SDC 2 D126 B1-13 K100 s and SDC 4 D126 B1-13 K100 s.
- The sharpening performance, the type of bonding, the brand of diamond grains and their coverage all have a significant impact on the productivity of diamond wheels when sharpening TC tools. These indicators characterize the quantitative side of the process.
- Knowledge of the quality side of the process is also required, i.e., what phenomena occur in diamond grains and bond when interacting with the surface layer of the polished hard alloy. What is the reason for the higher or lower consumption of diamond, the higher or lower the sharpening resistance, etc.?
- Joint analysis of the quantitative and qualitative sides of the process will allow the optimization of the sharpening process of tungsten carbide tools.

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