INVESTIGATION ON THE GRINDING QUALITY OF PLANING KNIVES MADE OF HIGH-SPEED STEEL (HSS) TYPE M2 AND SPECIFIC CONSUMPTION OF CUBIC BORON NITRIDE (CBN)

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Abstract

This article presents experimental results in respect of planning knives sharpening made of high speed steel, type M2 with abrasive tools from cubic boron nitride (CBN). The specific consumption of CBN abrasive wheels was made. The grits of CBN abrasive were with common and heightened durability, silicate holding and organic bonded. Some qualitative indices when grinded planning knives were investigated.

Key words: *planning knives; sharpening; abrasive tools; cubic boron nitride; high speed steel*

INTRODUCTION

Sharpening of cutting tools is a responsible operation that in drift is a system from scientific and practical base rules. The aim is to make repair as to its angular parameters of the tool, so to the cutting brain to its teeth as well .

Using the heavy duty and wear out cutting tools is one of the crucial conditions on a higher productiveness, short production cost and high quality to the product of its article of wood-processing and furniture industry.

The goal of the present article is doing comparatively test research for assignment to the specific expense from abrasive cubic boron nitride (CBN) of grinder instruments, fabricated in Bulgaria and Russia, as well as some qualitative indices of planning knives made from high speed steel, type M2 (Bulgarian standard P6M5).

MATERIAL AND METODS

Flat knives for longitudinal milling were being used for test research. The knives were fabricated in ZMM Smolyan (Fig .1).

Fig. 1 Flat knife for planning machine

The main parameters of the knives are shown in Table 1. The knives were manufactured from high speed steel (HSS), type M2 and heat-treated to solidity HRC 62-64 as well.

Table 1 *The main parameters of the knives*

Catalog №	L, mm	B, mm	s, mm	β, ^{0}	type	quality
MH113-20	200	40	3	40	A	HS

Tungsten-Molybdenum steel, type M2 (6 % - W and 5 % - Mo) increases to major degree the red-hardness and has high resistance to abrasion of the tool edges. In implication to the significant number of molybdenum (5 percent), the cutting properties of this steel are close to these of the HSS with 12 % and 18 % tungsten, despite the content of tungsten is 2-3 times more small.

The abrasive wheel from CBN (Fig. 2) has a form 12A2 45 ^{0} (a conic cup) and works with it frontal surface.

The abrasive materials from CBN are similar diamond modification of the boron nitride with hardness 10 in Moos scale. The characteristic of experimental abrasive wheels are given in Table 2.

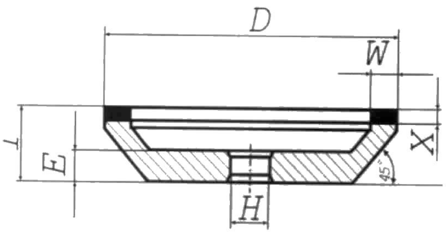


Fig. 2 *Abrasive wheel with 12A2 45 ^{0} form (conic cup)*

Table 2 *A characteristic of the* of *experimental abrasive wheels*

Form and size	Kind of abrasive material	Grit size	Bond	Concentration, %	Producer
12A2 45 ^{0} 125x5x3x32	КОС	125/100	Б8	100	Russia
12A2 45 ^{0} 125x5x3x32	КРС	125/100	Б8	100	Bulgaria
12A2 45 ^{0} 125x5x3x32	КРС	125/100	Б1	100	Bulgaria

КОС (Bulgarian standard) – CBN abrasive material with commonly hardness of the grain and silicate covered.

КРС (Bulgarian standard) – CBN abrasive material with heightened hardness of the grain and silicate covered.

Б1 (Bulgarian standard) and Б8 (Bulgarian standard) the organic (resin) bonded types that are composition on the base of organic novolac phenol-formaldehyde resin with urotropin. This type organic bond had enough good ability for auto regulation of the relief of the abrasive grains that admits continuing their cuttings properties of one permanent degree. They disagree by the type of the filler:

- Б1 – type of filler is boron carbide that increased the process of self-sharpening. It is suitable for sharpening of HSS tools with cooling and for hone without cooling.

- Б8 – type of filler is barium sulfate and talc powder for pure grinding and for honing with cooling.

The resin typed bond increased heat conductivity of abrasive wheel what decreased the temperature of contact surface of the sharpened tool. At work with abrasive wheels with bond type Б8 the lowest temperatures and cutting forces are being established because it contained anti-frictional filler (talc) that reduced in major degree the friction coefficient and temperature through grinding.

The overall volume is 50 % in the layer of CBN and the filler. The number of the filler depends on the concentration of CBN and is respectively 25 % of the bulk of layer CBN at 100 % of concentration [3].

The indicators on the property are valuated indicator on the suitability of the sharpened tool and the effectiveness of the due regime. They included:

A. *A roughness of the grinding surfaces (R_a):*

The parameter of roughness (R_a) was measured with profile measurement device, type AII model 283 П-63 (Russia) according to methods indicated in [2]. For each knife were made of eight measurements by it two faces. Four measurements lengthwise as well four abeam to the furrows stand by the abrasive grains.

B. A *micro-jagged of the cutting edge:*

The maximum breaks (H_i, µm) of the cutting edge were measured (Fig. 3). For that purpose a microscope with eyepiece-micrometer, model "Technival 2" (Germany) was used. The measuring numbers were analogous with the index of roughness.

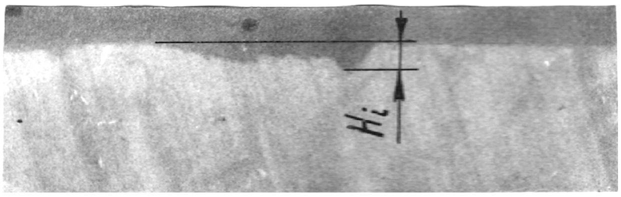


Fig. 3 *Maximum breaks (H_i) of the cutting edge*

C. Width of the gutting edge (B_i):

It was measured by analogy to the micro-jagged of the cutting edge in the narrowest and the widest parts.

D. *Availability of cracks, micro cracks, burns, blue in the face and some other defects in the cutting edge area:*

These indices were located by visual observation and with the help of a magnifying lens in the process of knives sharpening or after already sharpened knives. Besides that they were perceived as a limitation, eliminated using the regime they are appeared.

To the quality of sharpened knives were put the following restrictive conditions:

- roughness of surfaces, R_a=0,32÷0,63 µm;
- micro-jagged of the cutting edge, H_i=18÷25 µm;
- width of the gutting edge, B_i=5÷15 µm;
- is allowed in the close of knife edge: availability of burns, blue, change of the surface structure.

The specific consumption of CBN (Q_s, ct/mm^3) is a basic index for wear out resistance of the abrasive tool [3]. It is defined as attitude of the mass of the consumed CBN (m_a, ct) to the volume of the take down material (V_m, mm^3), i.e.:

$$Q_s = \frac{m_a}{V_m} \qquad (1)$$

The relative consumption of CBN (Q_r, *ct/g*) is defined as attitude of the mass of consumed CBN to the mass of take down material (m_m, g):

$$Q_r = \frac{m_a}{m_m} \qquad (2)$$

The consumption of CBN is defined to the weight method or by measuring of the linear wearing out of the CBN layer.

The weight method is related with the accurate weight out the abrasive wheel previously and after doing specified consistency of work as well. A main fault is the inaccuracy during process as a result of the weight of the products in the lubricant cooling fluid. The weight of the take down material was determined for each of the knives with the help of an electronic scale model "Sartoris"-type 610-D (Germany).

The mentioned faults are scaled by using of method for measuring the linear wearing out of CBN layer in a major extent. That was performed immediately previously after and after work as well, by means of a stereo-light microscope on the breadth of the radial intersections of CBN layer.

The relative spending on CBN is the specified according to weight method:

$$Q_r = \frac{W_a}{m_m}\alpha_a \qquad (3)$$

Where W_a is wearing out of the CBN layer during each test, mg;

α_a – a coefficient give the bond density and concentration of CBN in the layer

The same index definite according to the linear wearing out of CBN layer in a wheel worked with it frontal surface is defined on the next formula:

$$Q_r = \frac{h_a}{X}\frac{200m_a}{m_m} \qquad (4)$$

Where h_a is wearing out of the wheel in the thickness of CBN layer during the tests, μm;

X – the thickness of CBN layer before the tests, μm;

For the volumetric on CBN specific spending to be had it is needed to be multiplied (Q_r) with the density of the workable material γ_m (g/cm^3), i.e. $Q_s = Q_r\gamma_m$.

The investigations were carried out with the help of automatic high productivity grinding machine for flat knives, model HMS I of a firm „Vollmer" (Germany) and lubricant cooling fluid - 1~2% an aqueous solution of calcinated soda (Na_2CO_3).

The separate groups of the experiments were realized in the following values of the regime parameters:

- cutting speed (V) – 18 m/s;
- in feed lengthways ($V_{l.}$) – 1,0 m/min;
- crosswise in feed ($V_{d.m.}$) – from 0,03 to 0,20 mm/double motion;

The crosswise in feed was done before each proceeded motion of lengthways in feed (Table 3).

Table 3 *A scheme of the test carried out*

Characterization of the abrasive wheel	Crosswise in feed, mm/double motion							
	0,03	0,05	0,08	0,10	0,12	0,15	0,18	0,20
КОС Б8	×	×	×	×	×	×	-	-
КРС Б8	×	×	×	×	×	×	×	×
КРС Б1	×	×	×	×	×	×	×	×

RESULTS

For investigation the different components on the operating capability and the quality of the sharpen process were being used the methods of the many-factor analysis [1]. The sought dependences with sufficient accuracy can be reported with equations from the sort:

$$\hat{y}_i = b_0 + \sum_{i=0}^{n} b_i . x_i \qquad (5)$$

Where $\hat{y}_i$ is the approximate value of the outcome quantity;

b_i – coefficients of the model;

x_i – function of the incoming variable.

The results on the tests flat knives are represented in graphic kind to the crosswise in feed in different values (Fig. 4÷7).

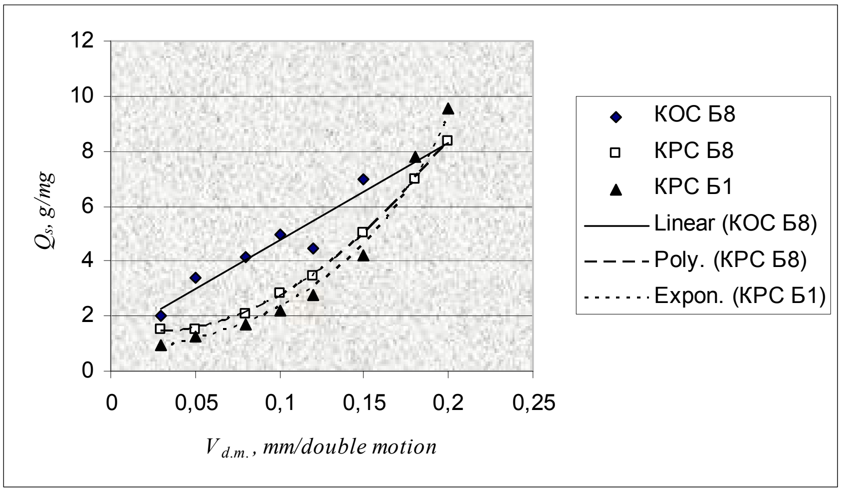


Fig. 4 *Dependence between specific consumption of CBN (Q_s) and magnitude of the crosswise in feed ($V_{d.m.}$)*

DISCUSSION

Figure 4 shows the dependence of the specific consumption of CBN for abrasive wheels КОС Б8, КРС Б8 and КРС Б1. An intrinsic influence on the specific consumption proves the quality on the crosswise in feed, the bond and the quality of the abrasive grains.

The consumption of CBN wheel from КОС Б8 is the biggest. For the wheels produced in the Factory for Abrasive Instruments (FAI) in Bulgaria the specific consumption is changed at the same borders and it is lower than КОС Б8.

The bond Б8 of the Bulgarian wheels kept a little bigger specific consumption up to $V_{d.m.}$=0,15 mm/double motion., after that decreased in comparison with bond Б1. The lower consumption of CBN by КРС Б1 wheel for $V_{d.m.}$<0,15 mm/double motion is connected with in time exemption of the abrasive wheel from the blunted grains and probably less hardness of the bond Б8.

The gap of physic mechanical properties of the grains is formulated the best in the span of the cross - sectional feed from 0,05 of up to 0,12 mm/double motion. The specific consumption at a wheel КОС Б8 is two times greater than a wheel КРС Б8 and a 2,4 times from wheel КРС Б1.

The models of the equations, show in Table 4 are being used for showing the characteristic dependences.

Table 4 *Models of the equations for* Q_s

№ in order	Characteristic of the wheel	Model of the equation	R-squared
1.	КОС Б8	$y=1,1955+35,428x$	0,8917
2.	КРС Б8	$y=1,5234-10,347x+224x^2$	0,9993
3.	КРС Б1	$y=0,5815e^{13,806x}$	0,9916

From figures 5, 6 and 7 are seen that the qualitative indexes get worse the time of increasing of the cross feed. In the interval $V_{d.m.}\in(0,03\div0,15$ mm/double motion), R_a is in the borders of the rate but at bigger values of the crosswise feed, R_a increased that we could be escaped if for one double motion we don't had crosswise feed. It is necessary to get a rectilinear cutting edge of the knife.

The models of the equations showed parameter R_a we can see in the Table 5.

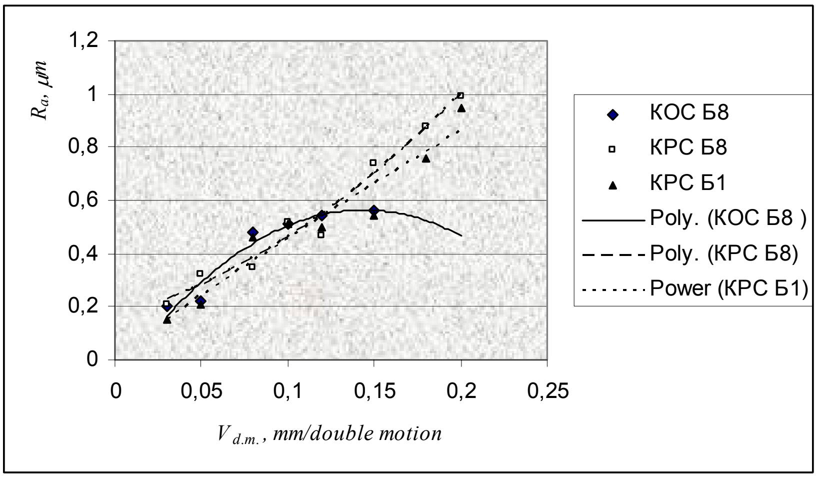


Fig. 5 *Dependence between the size of the cross feed* ($V_{d.m.}$) *and parameter of roughness* (R_a)

Table 5 *Models of the equations for* R_a

№ in order	Characteristic of the wheel	Model of the equation	R-squared
1.	КОС Б8	$y=-0,0743+8,878x-30,856x^2$	0,9378
2.	КРС Б8	$y=0,1644+1,7694x+12,044x^2$	0,9742
3.	КРС Б1	$y=3,7922x^{0,9215}$	0,9497

The models of the equations showed micro-jagged H_i we can see in the Table 6.

Table 6 *Models of the equations for* H_i

№ in order	Characteristic of the wheel	Model of the equation	R-squared
1.	КОС Б8	$y=10,208+40,034x-143,7x^2$	0,9554
2.	КРС Б8	$y=12,359+32,053x+0,8581x^2$	0,9079
3.	КРС Б1	$y=15,413+26,85x-39,253x^2$	0,8844

For the index B_i that means the cutting edge breadth the used model-equations are shown r in Table 7.

Table 7 *Models of the equations for* B_i

№ in order	Characteristic of the wheel	Model of the equation	R-squared
1.	КОС Б8	$y=4,7395-0,5193x+102,08x^2$	0,8841
2.	КРС Б8	$y=5,9704+0,6671x+72,889x^2$	0,8719
3.	КРС Б1	$y=6,3818-0,8178x+47,869x^2$	0,7421

On figure 8 the comparison is made between the quality of the sharpened surfaces with common wheel of white electro corundum (8A) after sharpening with a wheel from CBN with heightened hardness of the grain as well. As is seen by the made pictures, the knives that are sharpened with wheel from CBN are of major better quality.

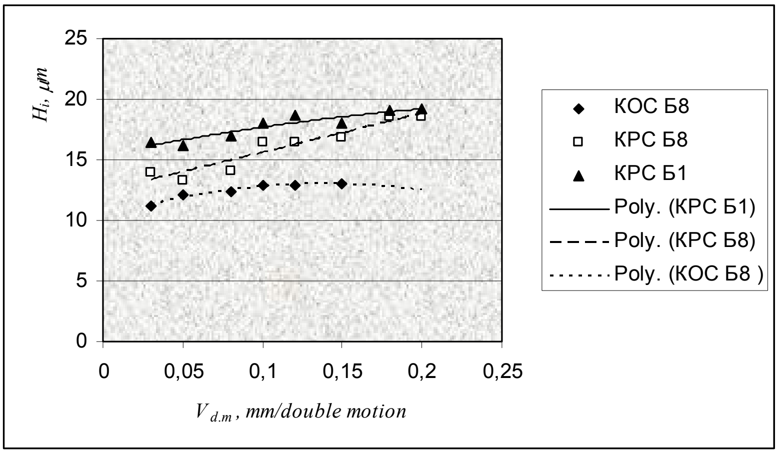


Fig. 6 *Dependence between the size of the cross feed ($V_{d.m.}$) and the parameter (H_i)*

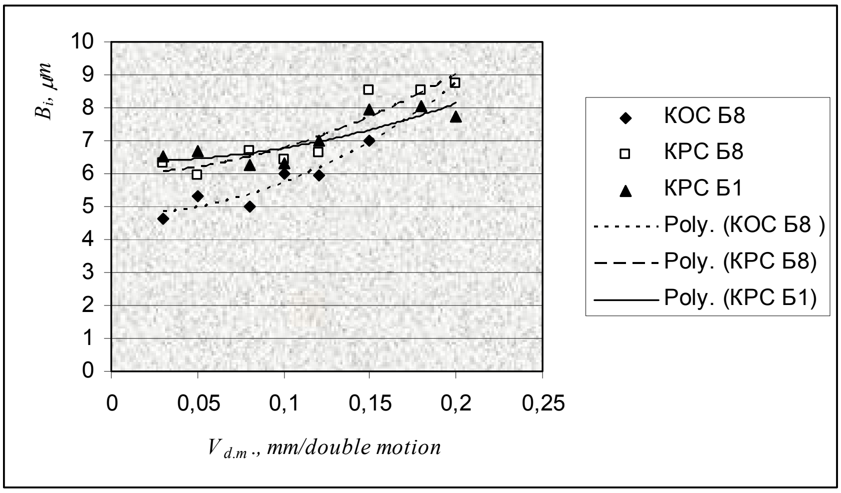
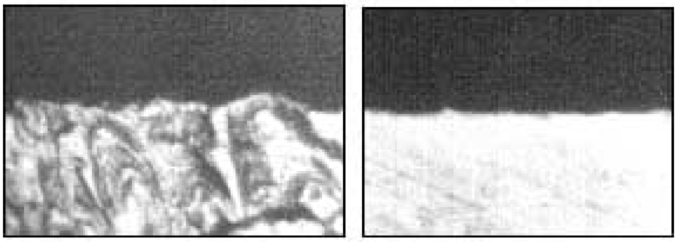


Fig. 7 *Dependence between the size of the cross feed ($V_{d.m.}$) and the parameter (B_i)*



а   в

Fig. 8 *A quality of the knife sharpened surfaces :*
a/ with wheel from electro corundum, в/ with CBN wheel.

Moreover during the observation of the knives work in the production process was established that the durability of the sharpened flat knives with abrasive wheels from CBN had a durability over ten times in comparison with sharpened with white electro corundum.

CONCLUSION

On the basis of experimental investigations and their analyses were made we could make the next conclusions:

1. The explored abrasive tools production of FAI – Bulgaria (КРС Б8 and КРС Б1) have well better opportunities than the produced in Russia (КОС Б8) in following directions:

– they can work faultlessly up to 0,20 mm/double motion at cross - sectional passage;

– they have lower consumption of CBN.

2. The noted abrasive wheels КРС 125/100 with bond Б1 had better indicators for the operating capability at the cross-section passage to $V_{d.m.}$=0,15 mm/double motion At cross-

section passage more huge than 0,15 mm/double motion the abrasive instruments with Б8 have smaller consumption of CBN and have higher indices for operating capability.

3. From stand for the indices of performance capability can recommended for different wheels the following regimes for sharpening:

– for КОС Б8: $V_{d.m.} \in (0,10 \div 0,12)$ mm/double motion;

– for КРС Б8: $V_{d.m.} \in (0,10 \div 0,15)$ mm/double motion;

– for КОС Б1: $V_{d.m.} \in (0,10 \div 0,15)$ mm/double motion.

A Cooling off is needed amply to double move at that passage.

4. The qualitative indexes H_i and B_i for the three wheels as well are the normal borders. The index for roughness R_a wheels КРС Б1 and КРС Б8 is in the norm till $V_{d.m.}$=0,15 mm/double motion. Over these values of the crosswise for double motion R_a increases but after honing that indicator decreased to 0,40÷0,45 μm, that is in the borders of the normal.

5. At sharpening of the flat knives made from HSS type M2 (P6M5) the productiveness of the procedure is augmented by using of CBN instruments as being possible well to avoid itself the operation to honing.

6. Disks use by CBN with the increased hardness of the grains production of FAI are particularly appropriate for sharpening of instruments made from HSS type M2 (P6M5) that advances of their operating lastingness and cutting capabilities.

LITERATURE

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