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INFLUENCE OF TIN-COATINGS OF HARD ALLOY KNIVESON EXPLOITATION OF WOOD-CUTTING MILLING TOOL WHEN PROCESSING LAMINATED CHIPBOARD

The influence of TiN-coatings surface of cutters mill wood tools on wear of cutters for milling special woods was investigated. The TiN-coatings were formed on surfaces of import cutting inserts of mill tools by the method of condensation from a plasma phase in a vacuum with ion bombardment of surface. The element composition coatings and tools, the surface morphology of cutting tools were studied by X-ray microanalysis and transmission electron microscopy. The phase composition of import cutting tools is a hard alloy with type of WC-3. The tools consist of double-blade cutters with TiN coatings for milling special woods showed growth of wear resistance by 20% in comparison with bare tools. There is abrasive chemical type of wear on surface coating of cutters mill tools.

Introduction. At present time in the republic of Belarus range of processed materials on the basis of wood is being expanded. Additionally, to process wood mechanically, only import wood-cutting tool is used. That's why increase of durability period as a main parameter of work resources of applied wood-cutting tool, creation of new materials for manufacturing of domestic wood-cutting tool is a relevant and economically justified task.

While previously maximal value for durability period for wood-cutting tool was achieved only at the expense of calculation of its rational construction and geometry, of search for optimal cutting modes [1], at present time leading foreign companies on production of wood-cutting tools (Leitz, AKE, JSO, TIGRA, Stark, Gold, Schunk, Faba, LEUCO, KANEFUSA CORPORATION), tools are made of hard alloys or high-speed steel with unique configuration, also with commonly used hard alloy plates [2] to enhance its durability period.

Wood-cutting tool with application of synthetic diamond, offered among technological novelties of foreign companies, despite of attractive prospects of its simplicity in use, cannot always be applied in terms of enterprises production in Belarus.

One of the most effective materials for woodworking from the point of view of durability is hard alloy on the basis of wolfram carbide WC coating on cutter surface. In the market of the republic of Belarus of wood-cutting tools used for woodworking and board materials, for manufacturing of milling tools elements, finely grained hard alloys with low content of binding components from import manufacturers are mainly used (Table 1), that allows to increase reliability and durability of milling tools.

Among the most efficient ways to modify surface of steel and hard alloy shears of wood-cutting tools is a method of substance condensation from plasma phase in vacuum with ion impact of surface (CIB), essentially increasing cutters work resource [3.]
The purpose of the work is to obtain TiN ion-plasma coatings on surface of shears for knives Leitz (Germany) of milling wood-cutting tool, investigation of element composition of import knives, influence of coatings on durability of tool shears when processing laminated chipboard.

Table 1

General classification of hard alloys of different companies manufacturers

Company manufacturer (country)	Standard ISO										
	0.1	0.5	10	15	20	25	30	35	40	45	50
(Russia)	VK3 (BK3) VK3M (BK3M)				VK6 (BK6)						
			VP322 (ВП322)				VK8 (BK8)				
TIZIT			TW10								
			TW15								
					TW220						
					TW20		TW30		TW40		
		TSM10									
			TSM20								
					TSM30						
TIGRA	T03SMG										
		T04F			T06MF		T08MF		T10MF		T12MF
			T06MG		T06MG		T10MG				Tigra
Ceranetal			HC05		HC20		HC27				
							HC35				
Ceratizil	BC01										
		BC05	BC10		BC20		TS30				

Main part. At woodworking enterprises there are often large difficulties when choosing material for wood-cutting tool. Basing on catalogues of manufacturing company of hard alloy, there are some main parameters, describing hard alloys:

1) grain size (Table 2);

2) amount of binding substance.

Physic-mechanical properties of hard alloy depend on these parameters.

Table 2

ID of hard alloys grains

ID	Grain size, μm
NG	<0.2
UMG	0.2–0.5
SMG	0.5–0.7
MG	0.7–1.0
F	1.0–1.4
MF	1.4–2.5
M	2.5–4.0
C	4.0–10
EC	10>

It was determined, that amount of binding material (cobalt) influences on durability and impulse load perception. The more the cobalt content, the higher the tool stress limit.

Despite the increase of durability with grain size increase, preparation of tool with low angles of sharpness becomes difficult. Decrease of grain size (at the same concentration of binding substance) leads not only to decrease of tool durability, but also to more uniform wear of knife, that results in more qualitative preparation of the tool.

In Fig. 1 layout of interaction of knife cutter element with processed board wood material is given.

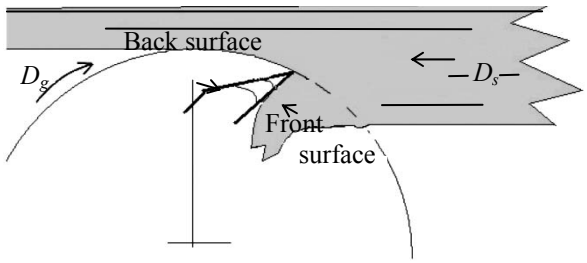


Fig. 1. Layout of interaction of cutting element of milling tool with material processed

Particular characteristics of board materials processing in contrast to cutting of natural wood, is that there are no chip formed by front surface [4]. This peculiarity is reflected on the peculiarities of cutter element wear (more intensive loss of cutting ability on its back surface).

Hence, strengthening of cutting elements should be performed by their back surface, allowing, from the one hand, to reduce main wear of knife, and from the other hand to save strengthened layer after recovery of cutting ability.

TiN-coatings were precipitated on surface of two-shear shank cutters by method of CIB on setup ВУ-1Б "Bulat" at the department of wood-working machines and tools (WWMT) in BSTU using two stages – with preliminary treatment with titanium ions in vacuum 10^{-3} Pa at substrate potential – 1 kV and subsequent coating at current of cathode arcing 100 A and reference voltage –100 V at nitrogen atmosphere at pressure 10^{-1} Pa [5]. To obtain high adhesion of coating to knife shear, the time of preliminary ion cleaning and time of direct deposition of the coating varied. Temperature during deposition of coating was 400–450°C. Thickness of the coatings obtained was 1.5 μm and lower.

To find out elementary composition of import tool, tool shear wear mechanism and to determine durability period of knifes with TiN-coatings at treatment of chipboard, fractographic studies of morphology and elementary composition of wear cutting edges of tool shears were carried out by means of methods of electron probe microanalysis (EPMA) and scanning electronic microscopy (SEM) on scanning electronic microscope JSM-5610 LV (Japan). Laboratory tests of durability of knives shears of assembly milling tool with diameter of 21 mm when cutting laminated chipboard with thickness 25 mm with two-side facing of surfaces were performed at the department of WWMT in BSTU at machining center ROVER-B 4.35 (Italy) with the following modes: milling tool rotation frequency – 12,000 min^{-1}; supply rate – 4 m/ min; overlength – 5.0 mm / pass; chip thickness at contact arc – 0.15 mm; value of cutting length – 10 000 m. Criterion of cutting ability loss is board facing damage occurrence.

It was found before, that TiN-coatings, deposited by method of substance condensation from plasma phase in vacuum with ion bombardment of surface on disposable hard alloy knives (production of Germany), have BCC structure with texture (111), formation of which is connected with grains growth in the direction of plasma flow [5].

As a result of the work fulfilled on formation of TiN-coatings on surface of two-shear knives of instrument, optimal geometry of positions of knives shears edges when depositing coatings is determined – edges surface of knives deposition should completely be in the area of plasma flow.

It was found, that composition of test knives WC ~ 96%, Co ~ 4% (Table 3) corresponds to hard alloy VK-3.

Table 3

Results of composition determination for knives

Element	Concentration, at. %	Error of measurement, at. %
C	32.89	0,22
W	62.86	0.33
Co	4.25	0.34

According to the data of Table 1, material of import instrument corresponds to fine grain hard alloy T03SMG of company TIGRA. Use of the material performed for manufacturing of milling tool, exploited for treatment of board materials and wood, is justified by the reduction of probability of tearing out of carbides grains from cobalt matrix. This ultimately leads to increase of reliability of wood-cutting tool and its durability period.

Studies of wear knives shears edges surface morphology confirm the conclusion on finely divided structure of knives material (Fig. 2). Basing on the data of SEM one can suppose, that Co grains size in knives material structure is less than 0.1 μm.

Results of calculations made for wear edges of knives at cutting of board (Table 4), fulfilled basing on measurement of cutting edges on SEM-pictures (Fig. 3), showed, that maximal value of durability period is for knives shears with maximal obtained thickness of TiN-coating.

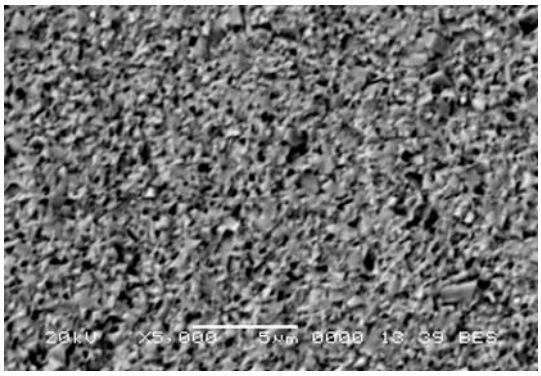


Fig. 2. SEM-image of surface of wear edge of knife shear

It was found before, that working surface of hard alloy knives without coating is exposed to brittle fracture, such as breaking and dyeing, during exploitation [6].

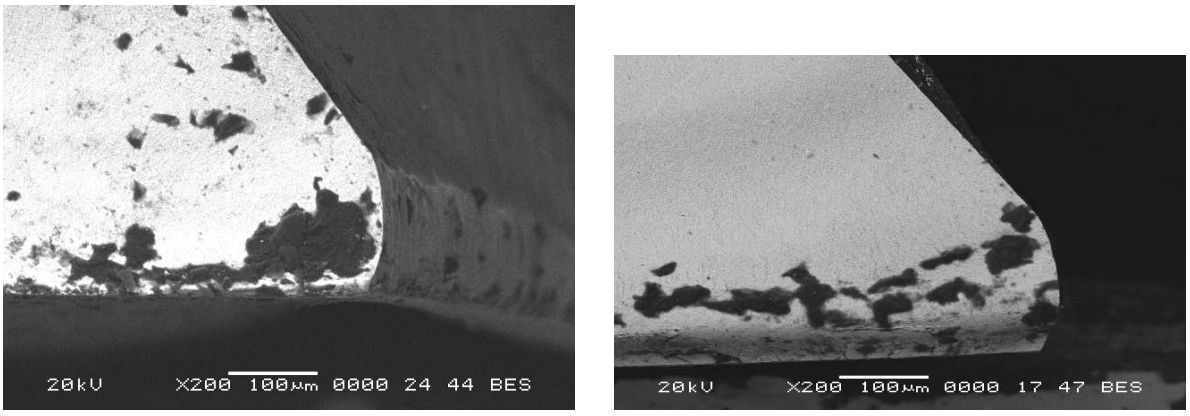
Basing on SEM-images obtained for wear edges of shears with TiN-coatings (Fig. 4) it can be concluded, that these coatings on surfaces of cutter do not change durability of cutting edge of the tool.

Industrial test of durability period for the tool with disposable cutters with TiN-coating, performed at OJSC "Minskdrev" (Minsk) when cutting chipboard, showed increase of durability period for the tool with coatings by 20% comparing to cutters without coating.

Table 4

Parameters of deposition of TiN-coating and the results of calculation of sizes for wear edges of knife

No. of knife	Time of knife ion cleaning, s	Deposition time of TiN-coating on knife, min	Sputtered edge of knife	Dimensions of knife edges $b \times a$, μm at milling of laminated layer of chipboard (b – back edge of knife, a – front edge of knife)	Thickness h of TiN-coating of edge of knife, μm
1	–	–	–	245×165	0
2	80	5	back	230×145	0.5
3	80	10	back	210×140	0.8
6	140	10	back	45×34	1.2



a *b*

Fig. 3. SEM-image of surface of knife shear face without coating (*a*), knife shear (No. 3) with TiN-coating (*b*), after cutting of chipboard

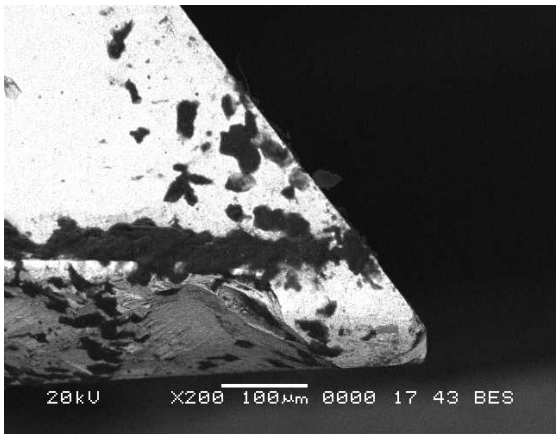


Fig. 4. SEM-image of wear shear of back edge of knife (No. 6) with TiN-coating after cutting of laminated chipboard

Conclusion. It was found, that tested knives of wood-cutting milling tool have composition of finely divided hard alloy of VK-3 type and correspond to material of import tool knives of mark T03SMG of company TIGRA (Germany).

Due to the fact, that wear behaviour of knife is connected with more intensive loss of cutting ability by its back edge, strengthening of cutter elements is necessary to be carried out by their back surface, thus allowing, from the one hand, to reduce main wear of a knife, and from the other hand – to save strengthened layer after recovery of cutting ability.

TiN-coatings, deposited by method CIB on import two-shear knives made of hard alloys of VK-3 type of shank cutters, provide essential enhancement of durability period of cutting tool, when processing materials of laminated chipboard. Maximal value of durability period is for knives shears with maximal obtained thickness of TiN-coatings. Pilot testing of tool modified with TiN-coatings at OJSC "Minskdrev" (Minsk) confirms relevance of the tests carried out, as well as necessity to enhance durability period and, hence, resource of wood-cutting tool work.

When cutting laminated chipboard by two-shear hard alloy knives, abrasive-chemical surface wear type of hard alloy shears of milling tool is observed.

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