National Council of Ukraine for Mechanism and Machine Science
(Member Organization of the International Federation
for Promotion of Mechanism and Machine Science)
Council of Scientific and Engineer Union in Khmelnitsky Region
Khmelnitsky National University
Independent Academy for Development of Sciences of Israel

MODERN ACHIEVEMENTS OF SCIENCE AND EDUCATION

XI INTERNATIONAL CONFERENCE

September 29 – October 6, 2016
Jerusalem, Israel

СОВРЕМЕННЫЕ ДОСТИЖЕНИЯ В НАУКЕ И ОБРАЗОВАНИИ

Сборник трудов
XI Международной научной конференции

29 сентября – 6 октября 2016 г.
г. Иерусалим, Израиль

УДК 001+378
ББК 72:74
С56

Утверждено к печати советом
Хмельницкой областной организации СНИО Украины
и президиумом Украинского Национального комитета IFToMM,
протокол № 2 от 1.09.2016

Представлены доклады XI Международной научной конференции "Современные достижения в науке и образовании", проведенной в г. Иерусалим (Израиль) в сентябре–октябре 2016 г.

Рассмотрены проблемы образования, материаловедения и нанотехнологий, динамики и прочности механических систем, экономики, управления и права. Доклады участников конференции, опубликованы в авторской редакции.

Для ученых, инженеров, работников и аспирантов ВНЗ.

С56 **Современные** достижения в науке и образовании : сб. тр. XI Междунар. науч. конф., 29 сент. – 6 окт. 2016 г., г. Иерусалим (Израиль). – Хмельницкий : ХНУ, 2016. – 163 с. (укр., рус., анг.).
ISBN 978-966-330-263-8

Рассмотрены проблемы образования, динамики и прочности, материаловедения, нанотехнологий, экономики и права.

Для научных и инженерных работников, специализирующихся в области изучения этих проблем.

Розглянуті проблеми освіти, динаміки і міцності, матеріалознавства, нанотехнолгий, економіки та права.

Для науковців та інженерних працівників, які спеціалізуються в області вивчення цих проблем.

УДК 001+378
ББК 72:74

ISBN 978-966-330-263-8

COATING GRAIN SIZE INFLUENCE ON THE MATERIAL REMOVABLE VOLUME FOR THE RESISTANCE PERIOD, THE CUTTING TOOL DURABILITY AND THE HARDENED 66MN4 STEEL

[1]*Kostyuk G.*, [2]*Bruiaka O., Kantemir I.*
[1]*National Aerospace University named after N.E. Zhukovsky (KhAI)*
Kharkov, Chkalov, 17, +380577884206, gennadiykostyuk206@gmail.com
[2]*National aviation University, Kiev*

In order to evaluate the grain size influence on the efficiency of the 66Mn4 hardened steel machining were conducted the investigations of the

grain size in the 0.18 HfN + 0.82 ZrN coating on the WCCo8 (Russia), MS221 hard alloys.

Surface layer composition (a) of the coating and cutting tool, this layer percentage, plate photograph (b) and the surface layer photomicrograph with grain sizes are shown on the Figures 5.11 – 5.15 [1]. Similar studies for WCCo8 (USSR) plate with the same coating are shown on the Fig. 1 [1].

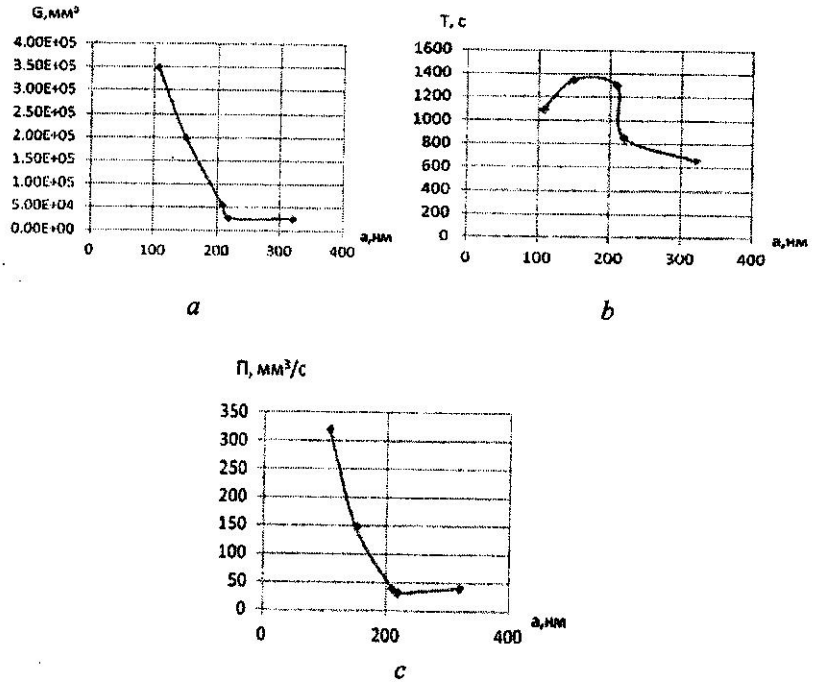


Fig. 1. Dependencies of the 66Mn4 hardened steel removable volume for durability period (*a*), the 0.18HfN + 0.82ZrN coated WCCo8 (Russia) cutting tool durability (*b*) and processing performance (*c*) from the grain size

It is seen that the grain size is in the range of 106...219 nm. If the plates are located on the ions flow axis, the zirconium percentage composition is 56.5 % and hafnium percentage composition is 38.48 %. Whereas if they are located on the periphery, then Zr and Hf percentage is 55.29 % and 37.67 % accordingly. It is seen that in this case the surface layer zirconium-hafnium ratio is increased in relation to hafnium (relative to its cathode portion). It is shown that the coating grain size on the WCCo8 plate is slightly higher than for WC TC15Co6 plate. In this case is realized sub-

microstructure grain and the surface layer percentage determines the zirconium and hafnium evaporation nature (Zr evaporates faster than Hf).

Similar dependences for the case of the 66Mn4 hardened steel processing by the WCCo8 (Russia) cutting tool with the same coating (Fig. 1) allow to provide the same volume of the removable material over the durability period $3.5 \cdot 10^5$ mm^3 and at the almost nanostructured grain size 106 nm, the grain size growth decreases rapidly to $2.5 \cdot 10^4$ mm^3. The maximum cutting tool durability is realized with another grain size (in the 140...210 nm range) and at the further grain growth cutting tool durability is reduced. Processing performance dependence from the grain size repeats dependence for G and the maximum value is 320 mm^3/s (Fig. 1).

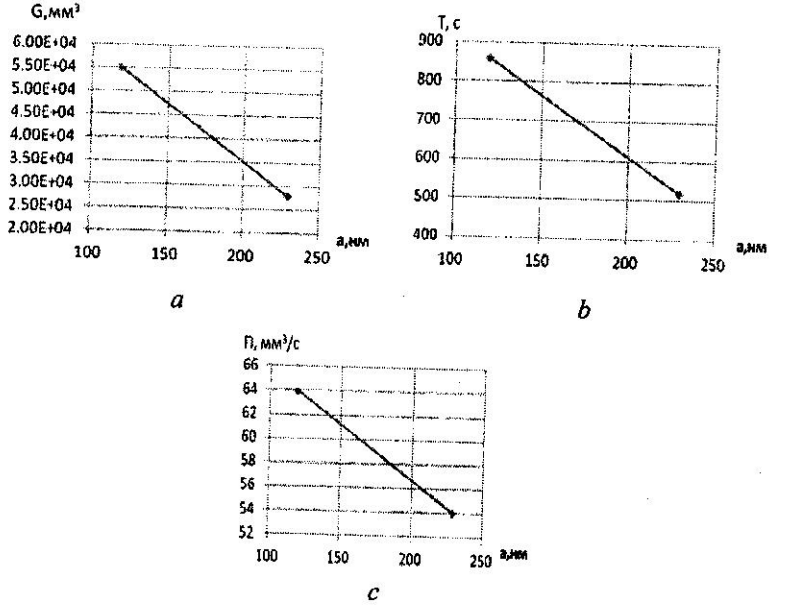


Fig. 2. Dependencies of the 66Mn4 hardened steel removable volume for durability period (*a*), the 0.18HfN + 0.82ZrN coated MS221 cutting tool durability (*b*) and processing performance (*c*) from the grain size

The spectral composition and percentage analysis of the coating on the MS221 plate didn't performed unfortunately. The grain size investigations in the MS221 plate coating is shown on the Figure 15.12 [1]. Grain size is in the range of 110...229 nm for plates on the flow axis and grain size is 128...428 nm on the flow periphery. In this case microhardness were measured, which, depending on the grain size, in the first instance was in

the range 1270...1413 Hv and a larger value corresponds to a smaller grain size, while for the plates, located on the periphery, microhardness ranges is in the range from 915 to 1,184 Hv. Measurements were performed by the PMT-3 instrument. In the last case lower microhardness values from 732 to 891 Hv were observed, which are associated with the submicrostructure grain size presence, which turn into microstructure grain. In this case, the microhardness minimum values were implemented.

Analysis of the removable volume dependencies for the durability period G, durability T and processing performance P for 66Mn4 hardened steel turning by the cutting tools from 0.18 HfN + 0.82 ZrN coated MS221 plate shows that the maximum value of the removable volume $G = 5{,}5 \cdot 10^5$ mm^3 is obtained with 120 nm grain size, cutting tool durability T = 870 s and processing capacity P = 64 mm^3/s at the same grain size. It can be seen that 0.18 HfN + 0.82 ZrN coated MS221 cutting tool allows to obtain acceptable results at the 66Mn4 hardened steel processing (Fig. 2).

Conclusions

1. It is shown that at the effectiveness and efficiency assessing of the coated hard alloys at the 66Mn4 hardened materials steel processing it is necessary to take into account the coating grain size at that to the smaller grain size is generally (but not always) corresponds to more effective processing (the maximum removable material volume for the durability period) and its working capacity.

2. It was found that 0,18 HfN + 0,82 ZrN coated WCCo8 hard alloy and MS221 plate with the same coating have greater efficiency for the 66Mn4 hardened steel processing.

References

1. Kostyuk G. Efficient cutting tools with nano-coating and nanostructured modified layers: monograph-reference book / 2 books / G. Kostyuk. – "Planeta-print Ltd" 2016 B. 1. Plasma-ion and ion-beam techno-logy. – 735 p.

ABOUT POSSIBILITY TO DETERMINE THE GRAIN FORMATION ENERGY AT THE NANOSTRUCTURES PRODUCTION IN THE CASE OF THE DIFFERENT KINDS, CHARGES AND ENERGIES IONS ACTION ON CONSTRUCTIONAL MATERIALS

Kostyuk G., Matveev A.
National Aerospace University named after N.E. Zhukovsky (KhAI)
Kharkov, Chkalov, 17, +380577884206, gennadiykostyuk206@gmail.com

Assuming that the grain formation energy is equal to or slightly more than grain atomization energy, it can be calculated by using the me-

thod from [2, 3]. This energy can be determined after the initial finding of the nanoclusters (NC) particles number and the particles types definition: atoms or chemical compounds. Then, after the grain atoms and chemical compounds fractions determination, and knowing the grains atomization energy of each cluster type (consisting of atoms and chemical compounds) and multiplying them by the its number, we obtain the grain formation ex-pended energy as a sum of the atoms and chemical compounds cluster formation energies.

After nanocluster particles number determining we have to find the cluster particles atomization energy, which can be calculated taking into account the two energies: the Coulomb repulsion energy Ek and ion bond energy Eu by formula:

$$E_{co} = E_u + E_k = \varepsilon^2 U + \left(1-\varepsilon^2\right)^{\frac{1}{2}} D_0 N = \frac{\varepsilon^2 kAe^2 z^2 N}{R_0}\left(1-\frac{\rho}{R_0}\right) + \left(1-\varepsilon^2\right)^{\frac{1}{2}} D_0 N, \quad (1.1)$$

where ε – degree of ionic; k – proportionality factor called the electrostatic constant, depends on the measurement units choice in the International System of Units, $k = \frac{1}{4\pi\varepsilon_0} \approx 8{,}987742438 \cdot 10^9 \left[\frac{\text{Н} \cdot \text{м}^2}{\text{Кл}^2}\right]$; A – Modelung constant; e – electron charge, $e = 1{,}6022 \cdot 10^{-19}$, C; z – ion charge; N – particles amount; R_0 –shortest interatomic distance; – repulsion degree; D_0 – substance single particle dissociation energy.

As the calculations result we obtain atomization energy for the chemical compounds with different charge numbers, repulsion degrees of and dissociation energies. Thus, for a number of carbides and nitrides results are given in Table. 1.

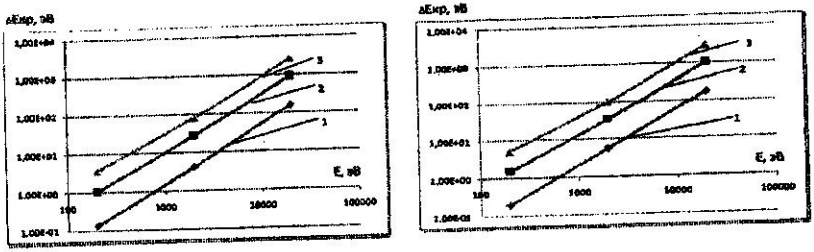
Table 1

Atomization energy of the metal nitrides and carbides with different charge numbers z, repulsion degrees and dissociation energies D

Материал покрытий (Coating materials)	Степень отталкивания ρ, [м] (Repulsion degree ρ, [m])	Теория (Theory)			Эксперимент (Experiment)		Энергия диссоциации D, эВ (Dissociation energy D, eV)
		$z=1$	$z=2$	$z=3$	$z=1$	$z=2$	
TiN	$0{,}287 \cdot 10^{-10}$	5,756	9,125	14,74		13,23	4,9035
ZrN	$0{,}287 \cdot 10^{-10}$	6,874	11,4427	19,0572		14,53	5,8148
AlN	$0{,}295 \cdot 10^{-10}$	4,476	7,376	12,209		10,169	
HfN	$0{,}433 \cdot 10^{-10}$	6,6699	9,1749	13,349		16,09899	

Obviously, in this case additional crystallization energy is commensurate with material acting ion energy, while at the transi-tion to the

zirconium and hafnium ions (Fig. 1), this value is almost one magnitude order less than the ions energy (at energies ~ 2·104 eV). In this case, it is obvious that it can be ignored.



a *b*

Fig. 1. Ion energy dependence of the additional crystallization energy at different ion charge (curve 1–1, 2–2, 3–3), acting on the D16T aluminum alloy

Thermal and mechanical materials properties calculated using quantummechanical approach.

Conduction electron heat capacity in metals. The electronic heat capacity expression is

$$C_V^{эл} = \pi^2 Nk\frac{kT}{2E_F} = \frac{1}{2}\pi^2 R\frac{T}{T_F} = \gamma T \qquad (1)$$

The metals thermal conductivity in general consists of lattice thermal conductivity (heat conductivity due to phonons) and thermal conductivity due to the free electrons:

$$\lambda = \lambda_{реш} + \lambda_{эл} \qquad (2)$$

The electron gas thermal conductivity:

$$\lambda_{эл} = \frac{l_{эл} C_{эл} v_F}{3}. \qquad (3)$$

Lattice thermal conductivity coefficient:

$$\lambda_{реш} = \frac{l_\phi C_V v_{эл}}{3},\ \lambda_{реш} = \frac{l_\phi C_V v_{эл}}{3} \qquad (4)$$

Phonon-phonon thermal conductivity. Phonon-phonon thermal conductivity, which explicitly takes into ac-count the resistive and normal phonons scattering processes, described by the Callaway expression:

$$\lambda = \lambda_1 + \lambda_2, \tag{5}$$

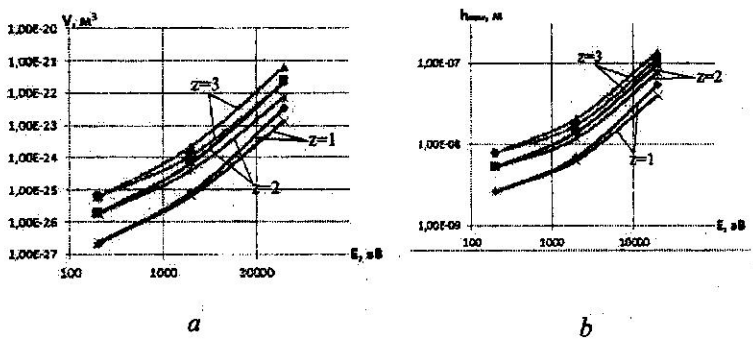
$$\lambda_1 = \frac{k}{2\pi^2 \nu}\left(\frac{k}{\hbar}\right)^3 T^3 \int_0^{\theta_D} \frac{1}{\tau_R^{-1} + \tau_N^{-1}} \cdot \frac{x^4 e^x dx}{\left(e^x - 1\right)^2}, \tag{6}$$

$$\lambda_2 = \frac{k}{2\pi^2 \nu}\left(\frac{k}{\hbar}\right)^3 T^3 \frac{\left[\int_0^{\theta_D/T} \frac{\tau_N^{-1}}{\tau_R^{-1} + \tau_N^{-1}} \cdot \frac{x^4 e^x dx}{\left(e^x - 1\right)^2}\right]^2}{\int_0^{\theta_D/T} \frac{\tau_N^{-1}\tau_R^{-1}}{\tau_R^{-1} + \tau_N^{-1}} \cdot \frac{x^4 e^x dx}{\left(e^x - 1\right)^2}}, \tag{7}$$

Young's modulus. Young's modulus due to intercluster interaction is associated with the crystal lattice internal parameters as follows:

$$E_{capes} = \frac{|2\Delta E|}{21.21 d_0^3 e^2}. \tag{8}$$

For aluminum alloy D16T comparison of the structure parameters calculation results (grain size (radius), nanoclusters (NC) volume and its occurence depth) was performed; parameters were obtained with the thermal and mechanical properties use in its calculation on the quantum-mechanical theory and on the experimental reference data [2.19].



a *b*

Fig. 2. Comparison of the maximum temperature (a), nanocluster (NC) volume (*b*), the maximum (*c*) and minimum (*d*) NC occurrence depth of the B+ ion energy at different ions charges (z = 1, 2, 3) (aluminium alloy D16T)