ISSN 2409-9066. Sci. innov. 2018, 14(1): 71—75 https://doi.org/10.15407/scine14.01.071

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THE CREATION OF NEW TYPES OF COMPETITIVE CUTTING PLATES AND MANUFACTURE OF PILOT INSTRUMENT FOR MECHANICAL PROCESSING OF HARD-TO-MACHINE MATERIALS

Introduction and Problem Statement. *The use of tools with cutting plates made of hard alloys and ceramics is a constant trend in the development of modern metalworking. Practical experience proves that it provides upgrading modes of cutting, reducing the idle time of equipment and the machine use per one detail. Taking into account the production output, it is important to improve the technologies of manufacturing such products with the requirements of environmental safety and the use of low cost technological components.*

Purpose. *The aim of the research is to create a more environment friendly technology for the production of competitive cutting plates made of hard alloys and ceramics using low cost technological components.*

Materials and Methods. *To prepare powders for sintering, a grinding method based on simultaneous shear and shock action, which enables to obtain a two-fractional composition of powder mixture with a narrow size range of spherical shape particles, has been improved. The application of PVA solution in alcohol as a plasticizer has enabled the production of plates with twice reduced content of dry residue of organic component, as compared with the rubber solution in gasoline, and to thrice reduce the duration of distillation in vacuum.*

Results. *A batch of RNMN 120400T and SNMN 120412T cutting inserts has been manufactured. They have been tested while turning and milling the parts made of iron and steel. The tests have shown a 1.12–2.0 times increase in stability of cutting tools.*

Conclusion. *An advanced environment safe technology for manufacturing highly wear-resistant cutting inserts from hard alloys and ceramics has been developed.*

Keywords: cutting inserts, hard alloy, ceramics, manufacturing technology, pilot batch, turning, and milling.

Today, the range of hard alloys and ceramics produced has changed markedly as the manufacturers use advanced manufacturing and testing equipment and much more efficient technologies, which improves the quality of materials.

The service life and reliability of cutting tools depend on the stability of physical and mechanical properties of materials from which they are made and on configuration of their cutting part. The instrument design in each particular case is determined by the requirements for the operation conditions.

Practical experience has shown that the cutting tools equipped with disposable inserts almost always have enhanced cutting parameters, reduced downtime and wear of instrument per workpiece, and can use one holder for employing the working elements of different geometrical parameters, which are made of a number of materials.

The state-of-the-art technology for manufacturing competitive cutting plates from hard metal and ceramics shall be developed based on low-cost source components for powdered mix design, and the whole manufacturing process must be environmentally safe.

Conventional powder mixes WCo8, WTi5Co10 and $70Al_2O_3$—20TiC—$10ZrO_2$ were used as initial powdered mixes for manufacturing hard-alloy and ceramic plates, respectively. The initial powders were white synthetic corundum with the main phase of 99.2 % Al_2O_3, titanium carbide, and partially stabilized tetragonal aluminum oxide.

The initial ceramic powders are polydisperse systems with wide grades of particles. They differ in the proportion of small (up to 100 μm) to large (100—500 μm) grains. To obtain a high-quality product, these powders need to be further ground. To implement this process, a grinding method based on simultaneous shear and impact effects on powder particles was improved. This enabled to obtain a two-fraction composition of powder mix with a narrow range of grades. The particles had a spherical shape: the first fraction was the powder with a particle size of 0.9—1.3 μm, and the second one had a size of 0.2—0.3 μm.

The powder mix preparation includes the stirring process to obtain a uniform distribution of the individual components. The plasticizer must be introduced to provide a mix with a certain plasticity, which is important when pressing briquettes.

As of today, the most common and advanced plasticizer is 8% solution of synthetic rubber in gasoline (*Galosh*). Its advantages are a high plasticity and strength, while the disadvantage is environmental pollution during its manufacture. Therefore, PVA adhesive solution in alcohol was proposed as a plasticizer, which makes the technology much more environment friendly.

The amount of PVA in the plasticizer was calculated based on a dry residue of 2.0—2.2 wt. %.

After about 6 hours of drying at a room temperature, about 0.7% of the solvent remained from PVA mix. In the case of rubber solvent, the residue made up 0.15%.

Having dried the mix in the air for 12 hours and sieved it through a mesh of 250 μm, cold pressing was carried out in metal molds at a specific axial load of 50 MPa.

The 0.7% PVA residue and the same amount of liquid solvent under the mentioned pressing conditions provide the same porosity of sample (48%) as the 1.5% rubber and 0.15% gasoline residue. That is, in this case, the volume of organic compound used decreases twice.

Among the advantages of PVA glue as a plasticizer there is also a three times higher heating rate while distilling.

The hot pressing of ceramics is preceded by preparing a graphite mold and stacking the briquettes after the cool pressing. The purpose of hot pressing is to obtain a highly dense material with the maximum physical, mechanical, and cutting properties. The instrument is equipped with an induction heating system in the graphite mold. Unlike the conventional presses, it enables the hot pressing in a vacuum at a pressure of p = 133 Pa and a temperature of T = 2100 °C.

The pressing parameters are as follows: T = 1450—1600 °C, isotheral heating during 20—30 min; specific axial load pressure p = 25—30 MPa.

The microstructure of the resulting material is typical for the ceramics offered by various world manufacturers. Also, it should be noted that the size of most titanium carbide inclusions in the ceramics ranges from 0.5 to 3 μm, with that of some part with a total content under 2—3% reaching about 7—11 μm. In this case, in the proposed material structure, the single pores do not exceed 0.5—1.5 μm.

At the final stage, the hard-alloy plates were sintered in vacuum, at a pressure of p = 80–90 Pa. Also, the method of step-by-step cooling was implemented.

The cutting plate billets were made in the conditions under which the material with the maximum physical and mechanical properties was obtained.

The billets had a round shape with a diameter ranging from 10 to 20 mm, the height was calculated based on the requirements of ISO 1832-2012.

Table 1 shows the structural, physical, and mechanical properties of WCo8 alloy.

The use of PVA solution in alcohol affects neither the size of carbide grains and the cobalt layer in the alloy structure nor the cobalt layer static mechanical properties, but reduces the residual pore size from B2 to A2, as well as changes the size of individual large pores. This positively influences the performance of the cutting tool under mechanical and shock loads.

The proposed machining of precision cutting plates made of composites obtained is notable for treating the flat surfaces by the group method, with a loose abrasive on cast iron grinding machines, and the curve surfaces with grinding wheels. In some cases, when several plates (up to 10) are processed, the flat back surfaces can be treated with grinding wheels.

The use of cast iron grinders and diamond abrasive slurry has enabled to create an effective process of machining the cutting plates of hard alloys and ceramics, which ensures a high quality of surface finish (flatness, roughness, precision) and its efficiency (several dozen plates are processed simultaneously).

Grinding wheels on metal-polymer (MP) and silicone (siloxane) (PK brand) bonds are used for the treatment.

Particularly promising is the use of these tools for rough treatment of working surfaces of disposable multifaceted cutting plates. For the general-purpose grinding machines, the following wheels are recommended 12A2-45 125 × 5 × 3 × 32 AC6 80/63 (MP) PK 100%; for the centerless grinders, OD machines, and flat grinding machines the recommended wheels are: 1A1 200 × 5 × 20 AC6 80/63 (MP) PK 100%. It is advisable to use nickel-plated diamonds.

The tools equipped with ceramic plates are recommended for shock-free finishing of carbon, alloyed and hardened steel products, while those with hard-alloy plates are suitable for treating the products made of gray and high-strength cast iron (WCo group), carbon and alloyed steels with a hardness up to 350–400 HB (WTiCo group).

A batch of disposable round- and square-shaped multifaceted hard-alloy and ceramic cutting plates of typical sizes RNMN 120400T and SNMN 120412T in compliance with ISO 1832-2012 standard was manufactured according to the developed specifications.

The approximate treatment conditions are given in Tables 2, 3.

The cutting plates have been tested at the following plants and factories: *Standard-Plus* House of Commerce LLC (Kyiv), *YUKA Invest* LLC (Zhytomyr), Novokramatorskyi Machine-Building Plant (Kramatorsk), *Ivchenko-Progress* (Zaporizhzhia), Kriukiv Railway Car Manufacturing

Table 1

Physical, Mechanical, and Structural Properties of WCo8 Alloy

Parameter	Plasticizer	
	rubber + gasoline	PVA + alcohol
Coercive field strength H_c, kA/m	11.1–11.6	11.2
Density, ρ, g/cm^3	14.64	14.65
Rockwell hardness (HRA)	89.5	89.5
Bending strength, R_{bm}, MPa	1820	1840
Average size of grain, d_{wc}, μm	2.1	2.25
Volume porosity, %	B2 0.2	A2 02
Number of pores larger than 50 μm at ×100, pores/cm^2	65.78	54.58
Number of large tungsten carbide grains and their aggregates at ×500, grains/cm^2	12–17	15–18
Cobalt phase size μm	0.5–0.7 (1.5)	0.5–0.8 (1.6)

Table 2

Approximate Conditions of Treatment Using the Instrument with Ceramic Material

Treated material		Cutting modes		
Grade	Hardness	Cutting speed v, m/min	Feed S, mm/rev	Cutting depth t, mm
Steel ШХ15	60–62 HRC	80	0.2	0.1
Steel ХВГ	50–55 HRC	150	0.25	0.1
Steel 45	230–270 HB	200	0.25	0.1

Table 3

Approximate Conditions of Treatment with Hard-Alloy Instrument

Treated material		Operating conditions		Cutting modes		
Grade	Hardness	Without impact	With impact	Cutting speed *v*, m/min	Feed *S*, mm/rev	Cutting depth t, mm
VK group hard alloys						
Gray cast iron						
СЧ 18-36	170—240	+	–	250	0.3	2
СЧ 18-36	170—240	–	+	200	0.3	1
СЧ 35-56	200—270	+	–	220	0.3	2
СЧ 35-56	200—270	–	+	180	0.3	1
High-strength cast iron						
ВЧ 40-10	150—200	+	–	180	0.3	2
ВЧ 40-10	150—200	–	+	150	0.3	1
ВЧ 60-2	200—270	+	–	150	0.3	2
ВЧ 60-2	200—270	–	+	120	0.3	1
TK group hard alloys						
Carbon and alloyed steels						
Steel 45	До 230	+	–	250	0.2	2
Steel 45	До 230	–	+	250	0.2	2
Steel 40X13	300—330	+	–	180	0.2	2
Steel 40X13	300—330	–	+	150	0.2	1

Plant (Kremenchuk), *Daniko* LLC (Cherniakhiv), *Techna* LLC (Novohrad Volynskyi).

The tool tests for sharpening and shaping of cast iron and steel articles have shown that the strength of hard-alloy cutting tools increases 1.2—2 times as compared with the tools made of conventional hard alloys, whereas the strength of Al_2O_3—TiC—ZrO_2 ceramic cutting tools is comparable to that of CC650 ceramic instrument manufactured by *Sandvik Coromant* (Sweden). The former is promising for treating alloyed steel articles.

CONCLUSION

The developed special technique of grinding ceramic materials for preparing the initial powders both under intensive impact and shear loads has enabled obtaining two-graded ceramic powders: the first fraction was the powder with a particle size of 0.9—1.3 μm, and the second one had a size of 0.2—0.3 μm.

The use of PVA solution in alcohol as plasticizer has made it possible to obtain blanks for manufacture of cutting plates with a twice less content of dry organic residue as compared with the rubber solvent, which, in turn, reduces trice the duration of distillation while heating up to 470 °C in vacuum and improves significantly the environment safety.

The process description for cutting place manufacture from hard alloys and ceramics has been elaborated.

A batch of disposable round- and square-shaped multifaceted hard-alloy and ceramic cutting plates of typical sizes RNMN 120400T and SNMN 120412T in compliance with ISO 1832-2012 standard was manufactured.

The tool tests for sharpening and shaping of cast iron and steel articles have shown that the strength of hard-alloy cutting tools increases 1.2—2 times as compared with the tools made of conventional hard alloys. The strength of Al_2O_3—TiC—ZrO_2 ceramic cutting tools has been established to be comparable to that of CC650 ceramic instrument manufactured by *Sandvik Coromant* (Sweden). The former is promising for treating alloyed steel articles.

Received 15.05.17

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СТВОРЕННЯ НОВИХ ТИПІВ КОНКУРЕНТОСПРОМОЖНИХ РІЗАЛЬНИХ ПЛАСТИН ТА ВИГОТОВЛЕННЯ ДОСЛІДНОЇ ПАРТІЇ ІНСТРУМЕНТУ ДЛЯ МЕХАНІЧНОЇ ОБРОБКИ ВАЖКООБРОБЛЮВАНИХ МАТЕРІАЛІВ

Вступ та постановка задачі. Використання інструментів з різальними пластинами з твердих сплавів та кераміки є сталою тенденцією розвитку сучасної металообробки. Практичний досвід доводить, що це забезпечує підвищення режимів різання, скорочення часу простою обладнання, зниження витрат інструменту на одну деталь. Враховуючи обсяги виробництва, вкрай важливим є вдосконалення технологій виготовлення таких виробів із забезпеченням вимог екологічної безпеки та використанням технологічних компонентів низької вартості.

Мета. Створення більш екологічно безпечної технології виготовлення конкурентоспроможних різальних пластин з твердих сплавів та кераміки з використанням технологічних компонентів низької вартості.

Матеріали й методи. Для підготовки порошків до спікання вдосконалено метод розмелу, що базується на одночасному зсувовому та ударному впливі та дозволяє отримати двофракційний склад порошкової суміші з вузькими інтервалами розмірів частинок сферичної форми. Застосування розчину ПВА в спирті як пластифікатора дозволило одержати заготовки пластин з вдвічі меншим вмістом сухого залишку органічної складової, порівняно з розчином каучуку в бензині, та втричі скоротити тривалість процесу відгонки в вакуумі.

Результати. Виготовлено партію різальних пластин форморозмірів RNMN 120400T та SNMN 120412T. Їх випробування при точінні та фрезерування деталей з чавунів та сталей показало підвищення стійкості різальних інструментів в 1,12—2,0 рази.

Висновки. Розроблено та впроваджено вдосконалену екологічно безпечну технологію виготовлення різальних пластин з твердих сплавів і кераміки, які характеризуються високою зносостійкістю в інструменті.

Ключові слова: різальні пластини, твердий сплав, кераміка, технологія виготовлення, дослідна партія, точіння, фрезерування.

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СОЗДАНИЕ НОВЫХ ТИПОВ КОНКУРЕНТОСПОСОБНЫХ РЕЖУЩИХ ПЛАСТИН И ИЗГОТОВЛЕНИЕ ОПЫТНОЙ ПАРТИИ ИНСТРУМЕНТА ДЛЯ МЕХАНИЧЕСКОЙ ОБРАБОТКИ ТРУДНООБРАБАТЫВАЕМЫХ МАТЕРИАЛОВ

Введение и постановка задачи. Использование инструментов с режущими пластинами из твердых сплавов и керамики является устойчивой тенденцией развития современной металлообработки. Практический опыт показывает, что это обеспечивает повышение режимов резания, сокращение времени простоя оборудования, снижение затрат инструмента на одну деталь. Учитывая объемы производства, особенно важным является совершенствование технологий изготовления таких изделий с обеспечением требований экологической безопасности и использованием технологических компонентов низкой стоимости.

Цель. Целью работы было создание более экологически безопасной технологии изготовления конкурентоспособных режущих пластин из твердых сплавов и керамики с использованием технологических компонентов низкой стоимости.

Материалы и методы. Для подготовки порошков к спеканию усовершенствован метод размола, основанный на одновременном сдвиговом и ударном воздействии, что позволяет получить двухфракционный состав порошковой смеси с узкими интервалами размеров частиц сферической формы. Применение в качестве пластификатора раствора ПВА в спирте позволило получить заготовки пластин с вдвое меньшим содержанием сухого остатка органической составляющей по сравнению с раствором каучука в бензине, и втрое сократить продолжительность процесса отгонки в вакууме.

Результаты. Изготовлена партия режущих пластин форморазмеров RNMN 120400T и SNMN 120412T. Их испытания при точении и фрезерования деталей из чугунов и сталей показало повышение стойкости режущих инструментов в 1,12—2,0 раза.

Вывод. Разработано и внедрено усовершенствованную экологически безопасную технологию изготовления режущих пластин из твердых сплавов и керамики, характеризующихся высокой износоустойчивостью в инструменте.

Ключевые слова: режущие пластины, твердый сплав, керамика, технология изготовления, опытная партия, точение, фрезерование.