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AREAS OF APPLICATION IN CUTTING, TURNING, MILLING, DRILLING AND OTHER PROCESSING METHODS OF HARD ALLOYS

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Abstract. *According to the patent and scientific literature on the research topic, the grain size of tungsten carbide determines the processing modes of the material and the presence of grain growth inhibitors containing some rare metals. The structure of the hard alloy, in turn, affects the bending resistance and hardness of the material. The best results were recorded for small-sized tungsten carbide grains. Due to the relatively high cost of tungsten, a group of tungsten-free hard alloys called kermites has been developed. These alloys contain titanium carbides (TiC) and titanium carbonitrides (TiCN) bonded to a nickel-molybdenum base. Their production technology is similar to hard alloys containing tungsten. Compared with tungsten hard alloys, these alloys have lower bending strength and impact strength, are sensitive to temperature changes due to low thermal conductivity, but have the advantages of increased heat resistance (1000 °C) and low adhesion to workpieces.*

Key words: *tungsten, cobalt, rhenium, tungsten carbide, hard alloys, cakes.*

Annotatsiya. *Tadqiqot mavzusidagi patent va ilmiy adabiyotlarga ko'ra, volfram karbidining don hajmi materialni qayta ishlash rejimlarini va ba'zi noyob metallarni o'z ichiga olgan don o'sishi ingibitorlari mavjudligini aniqlaydi. Qattiq qotishmaning tuzilishi, o'z navbatida, materialning egilish qarshiligi va qattiqligiga ta'sir qiladi. Eng yaxshi natijalar kichik o'lchamdagi volfram karbid donalari uchun qayd etildi. Volframning nisbatan yuqori narxi tufayli tarkibida volfram bo'lmagan qattiq qotishmalar guruhi ishlab chiqilgan hamda bu guruh kermitlar deb nomlangan. Ushbu qotishmalarda nikel-molibden asosi bilan bog'langan titan karbidlari (TiC), titan karbonitridlari (TiCN) mavjud. Ularni ishlab chiqarish texnologiyasi volframni o'z ichiga olgan qattiq qotishmalarga o'xshaydi. Volfram qattiq qotishmalari bilan solishtirganda, bu qotishmalar pastroq egilish mustahkamligi va zarba bardoshliligi kuchiga ega, past issiqlik o'tkazuvchanligi tufayli harorat o'zgarishiga sezgir, ammo issiqlikka chidamliligi oshishi (1000°C) va ishlov beriladigan materiallar bilan past qirindi yopishish afzalliklariga ega.*

Kalit so'zlar: *volfram, kobalt, reniy, volfram karbidi, qattiq qotishmalar, keklar.*

Аннотация. *Согласно патентной и научной литературе по теме исследования, размер зерна карбида вольфрама определяет режимы обработки материала и наличие ингибиторов роста зерна, содержащих некоторые редкие металлы. Структура твердого сплава, в свою очередь, влияет на сопротивление изгибу и твердость материала. Наилучшие результаты были зафиксированы для зерен карбида вольфрама небольшого размера. В связи с относительно высокой стоимостью вольфрама была разработана группа твердых сплавов, не содержащих вольфрама, получившая название кермитов. Эти сплавы содержат карбиды титана (TiC), карбонитриды титана (TiCN), связанные с никель-молибденовой основой. Технология их производства аналогична твердым сплавам, содержащим вольфрам. По сравнению с вольфрамовыми твердыми сплавами эти сплавы обладают меньшей прочностью на изгиб и ударной вязкостью, чувствительны к изменениям температуры из-за низкой теплопроводности, но обладают преимуществами повышенной жаростойкости (1000°C) и низкой адгезии к заготовкам.*

Ключевые слова: *вольфрам, кобальт, рений, карбид вольфрама, твердые сплавы, кеки.*

Introduction

Classification of hard alloys according to their composition

Annealed solid alloys are divided into the following four main groups according to their composition:

1. WC-Co alloys (some alloy brands of this group contain small amounts of vanadium, niobium, tantalum and chromium carbides).

2. WC-TiC-Co alloys.
3. WC-TiC-TaS (NbC) – Co.
4. Tungsten-free hard alloys TiC (TiN)-Ni-Mo.

The strength of WC-Co alloys is good, but the hardness and abrasion resistance are not sufficient. Industrial brands of alloys of this group differ from each other in terms of cobalt content from 3 to 25% (VK3-VK25).

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Alloys of this group are divided into the following three types according to the content of cobalt:

- low cobalt content (from 3 to 8% So)
- medium cobalt content (from 10 to 15% So)
- high cobalt content (from 20 to 25% So)

Alloys of the first group are somewhat hard, but not strong enough. It is mainly used as a stone cutter for the tips of drills used in the mechanical processing of gray cast iron, non-ferrous materials and some grades of steel, as well as for drilling soft mining layers.

Alloys of the second group are used in the first pass of punching and expansion of high-hardness cast irons, in the mechanical processing of high-temperature alloys, and in the oscillating cutting parts of oscillating tools used in crushing hard layered mining rocks.

Alloys of the third group are used as raw materials for parts that are sufficiently strong, but not sufficiently hard, with a high content of cobalt, used in mechanical processing of stamping tools and in a shock loading environment.

Hard alloys are hard and friction-resistant metallic materials that can maintain these properties up to a temperature of 900-1150°C. They are mainly made of hard and refractory materials with various compositions, based on tungsten, titanium, tantalum, chromium carbides, connected with So or Ni metal compound.

In the production of cutting tools, hard alloys occupy an important place (75% of the world market). They are in the following forms

uncoated alloys;
solid alloys;
super hard alloys.

Uncoated solid alloys are divided into: pure, fine-grained, alloyed types according to their composition, and according to the method of obtaining the alloy: there are found and cast types

The main feature of found hard alloys is that the products made from them are obtained by powder metallurgy methods and they are improved and processed by grinding or physico-chemical processing methods (laser, ultrasound, acid treatment, etc.) and electroerosion method.

A special surface for alloying is provided on the tool on which the hard alloys are installed, and the hard alloys are attached to this surface mechanically or by welding. Hard alloys are installed when the tool is heat treated (forging, tempering, etc.) [1-2].

Materials and methods

Annealed solid alloys are divided into the following four main groups according to their composition:

VK2, VK3, VK3M, VK4V, VK6M, VK6, VK6V, VK8, VK8V, VK10, VK15, VK20, VK25; - tungsten-cobalt;

Ti-W: T30K4, T15K6, T14K8, T5K10, T5K12V; - tungsten-titanium-cobalt;

Ti-Ta-W: TT7K12, TT10K8B; - tungsten-titanium-tantalum-cobalt;

without tungsten: TNM20, TNM25, TNM30.

Due to the relatively high cost of tungsten, a group of hard alloys that do not contain tungsten has been developed and this group is called kermits. These alloys contain titanium carbides (TiC), titanium carbonitrides (TiCN) bonded to a nickel-molybdenum base. Their production technology is similar to hard alloys containing tungsten. Compared to tungsten hard alloys, these alloys have lower bending strength and impact strength, are sensitive to temperature changes due to low thermal conductivity, but have the advantages of increased heat resistance (1000°C) and low adhesion to the workpiece.

The most common alloys of groups VK-6 and VK-8. Table 1 lists their areas of application.

Table 1.

Fields of application in cutting, turning, milling, drilling and other processing methods of VK-6 and VK-8 hard alloys

Brand	Fields of application
VK6	black and semi-black direction; in the initial passage of carving on a lathe cutter; semi-clean milling of flat surfaces; when drilling and expanding the hole; in galvanizing gray cast iron, non-ferrous metals and their alloys, and non-ferrous materials.
VK6C	In the production of matrices used for the synthesis of artificial diamonds.
VK6M	In clean and semi-clean processing of hard, alloyed and whitened cast irons, tempered steels and some stainless, high-strength and refractory steels and alloys, mainly alloys based on titanium, tungsten and molybdenum (forging, broadening, grooving).
VK8	In black grooving of uneven internal surfaces, grooving, black milling, drilling, preliminary pass of grooving, black galvanizing of gray cast iron, non-ferrous metals and their alloys and non-ferrous materials; in the processing of stainless, high-strength and refractory steels and alloys that are difficult to machine, including titanium alloys.

Therefore, they are not prone to the appearance of protrusions of processed material on the tool during cutting, therefore, it is recommended to use them for clean and semi-clean processing [5-6]. According to ISO classification, they belong to group R according to their application.

WC-Co based hard alloys are upgraded according to the Co-binding content. Thus, phase cemented carbides associated with Ni-Co-Cr-Al-W obtained from WC-Ni-Co-Cr_3C_2-$TiAl_3$ powder mixtures are known. Their granulometric measurements showed that the melting and solidification of these materials shifted to higher temperatures with increasing Al content.

Annealing them in argon increases the strength at a low concentration of Al (0.63% by weight), which is explained by its direct direct reaction with $TiAl_3$. As Al content increases, residual porosity is required to be removed after vacuum annealing.

Al additions give rise to two types of additions. The first is the formation of small Al-rich oxides in the metal binder, and the second is the formation of a γ-type cubic internal structure (similar to a Ni superalloy). The TEM-EDS method shows that the binder phase is an alloy of Co, Ni, Cr, W and Al, and the $TiAl_3$ part is an inhibitor of WC grain growth [7-8-9].

Results

Modulus of elasticity. The modulus of elasticity of WC-Co hard alloy is almost 2-3 times larger than that of high-speed steel. The modulus of elasticity decreases with increasing cobalt content in WC-Co solid alloys. Fine-grained alloys [12] has a much larger modulus of elasticity than large-grained alloys [13]. When the temperature increases (starting from 600°C), the modulus of elasticity decreases [14-15-16].

Hardness. Electrodeposited Co (99.5%) hardness (according to Vickers) - 171-216 kg/mm^2 (according to other data - 250 kg/mm^2), powder metallurgical Co - 146-156 kg/mm^2, rolled Co and - 222-264 kg/mm^2. The microhardness of Co in the WC-Co alloy changes dramatically.

The microhardness of the carburizing stage in an alloy with 85-80% Co and 15-20% WC by weight is 370-430 kg/mm^2. With the reduction of Co in the composition, the microhardness of the hard alloy increases due to the increase in stress in the Co layers.

In WC-Co alloys containing 6% Co, the hardness of the Co phase is 825 kg/mm^2. It can be expected that the microhardness of the Co phase in the middle part is different from that of the boundary zones with the WC phase. So - phase grains form a continuous main shape network. The grain diameter of the WC phase is 1-5 μm in fine-grained alloys, 8-30 μm in large-grained alloys. So - phase grains are larger, up to 1 mm.

The temperature dependence of the hardness of such alloys was studied (Table 2).

Table 2.

Temperature dependence of WC-Co hard alloy hardness

Temperature, °C	VK-8	VK-15	VK-20	VK-25	VK-30
	HRB, kg/мм^2				
20	1507	1260	1080	990	820
400	970	956	760	710	640
600	675	620	480	410	346
800	443	410	330	255	191
1000	290	230	170	110	70

Importance of carbon. WC-Co solid alloys consist of the following phases: cementing Co-phase, which determines the strength of WC and QQ. If the amount of carbon in WC increases and exceeds the critical value (6.12% by weight), then the third phase graphite η - phase (W_3Co_3C) can appear

This worsens the cutting properties of WC-Co alloys because carbon affects the composition of the Co-bonding phase. Its excess leads to a decrease in wear resistance of the alloy, and its deficiency leads to the formation of η-phase, which increases wear resistance, but reduces strength

These mean that low-carbon alloys with the same Co content are more wear-resistant than high-carbon ones, but have lower strength [10-11]. The XRD result showed that the more carbon, the longer the grinding time to produce WC powder.

Grinding parameters affect phase formation. In stoichiometric compositions, WC is synthesized faster than in compositions with a high carbon content. Here and in the carbon-deficient composition, the W_2C phase is observed.

Conclusion

Among the annealed hard alloys, a large group consists of alloys based on tungsten and cobalt monocarbide.

These alloys are made by hot pressing rather than melting like other types of annealed hard alloys. At the same time, relatively high temperatures and the presence of a liquid phase during hot pressing allow to consider the state of the resulting alloys as equilibrium or approaching equilibrium in the system of three components - tungsten, carbon, cobalt.

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