MODERN STATE OF SOLID ALLOYS BASED ON TUNGSTEN CARBIDE

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Abstract According to the patent and scientific literature on the subject of research, the grain size of tungsten carbide is responsible for the material processing regimes 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 tungsten carbide grains of small grain size.
Key words: tungsten, cobalt, rhenium, tungsten carbide, hard alloys, cakes.

Annotatsiya. Tadqiqot mavzusi bo’yicha patent va ilmiy adabiyotlardan ko’rinib turibdiki, volьfram karbidining donalar hajmi materialni qayta ishlash rejimlari va ba’zi nodir metallarni o’z ichiga olgan donalar o’sishi ingibitorlarining mavjudligi uchun javobgardir. Qattiq qotishmaning tuzilishi, o’z navbatida, materialning yeyilishga qarshiligi va qattiqligiga ta’sir qiladi. Eng yaxshi natijalar volfram karbidining mayda donador o’lchamdagi donalari uchun qayd etildi.
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.
Ключевые слова: вольфрам, кобальт, рений, карбид вольфрама, твердые сплавы, кеки.

Introduction

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. In this regard, knowledge of the state diagram of the W-C-Co ternary system helps to understand the annealing and structuring processes of tungsten carbide and cobalt-based alloys, and to explain their properties.
At the same time, the compositions of industrial hard alloys often do not fully correspond to the WC-Co system, and the amount of carbon in them is less or more than its stoichiometric amount in the WC compound, so the most complete composition of alloys can be obtained using the phase diagram of the W-C-Co ternary system [1-2].

Materials and Methods

According to the value of the limiting solubility of tungsten carbide in cobalt in the solid state, the data of different authors also differ (from 4 to 22% at 1250-1300°C). Perhaps these inconsistencies are explained by the different conditions of the experiments and changes in the carbon content of the samples. Using microscopic and X-ray analysis methods, it was determined that the solubility of tungsten carbide in cobalt is about 10% at the eutectic melting temperature and varies depending on the annealing environment. When taking alloy samples by heating in vacuum, which does not exclude the possibility

of some decarburization, the solubility was about 15%. Currently, taking into account the available data of various authors, the solubility of tungsten carbide in cobalt for a stoichiometric amount of carbon is 10% at the g + WC eutectic solidification temperature and decreases with decreasing temperature (4% at 1000°C, from 1% at 20°C low) [3-5].
The change in the solubility of WC in Co was considered above without taking into account the presence of two allotropic modifications of cobalt: β-phase with a cubic face-centered lattice and α-phase with a hexagonal lattice.
According to available data, the -phase solubility of tungsten carbide ranges from 14% at 1300°C to 9% at 975°C, and in the α-phase from 14% at 900°C to 11.5% at 750°C. The dissolution of tungsten carbide in cobalt stabilizes the cubic modification, prevents its transformation [6-7].
Cold field emission and high-resolution scanning electron microscopy (SEM) were used in combination with elemental analysis (EDX) to monitor the surface chemical composition of hard alloy VK-6 (fingers) samples. Jeol JSM-6701F brand, supplier - Tokyo Boeki Ltd (Fig. 2.1). Its technical parameters are as follows.

Figure 1. Jeol JSM-6701F high resolution cold field emission scanning electron microscope.

Field emission cold cathode electronic indicator, ultra-high vacuum and digital system provide high-quality, high-resolution images of microstructures. This device increases the beam flux at the output by ten times compared to a conventional laboratory, and also provides high precision even in large samples due to the efficient collection of all electrons. In addition, it became possible to study high-resolution light-sensitive samples with minimal current and/or accelerating voltage [8-9]. At the same time, samples resistant to light damage can work with higher currents, which increases image resolution without compromising resolution. Can work with samples up to 200 mm in diameter in high-quality live images at any scan speed, even in brightly lit rooms. In addition, it became possible to study high-resolution light-sensitive samples with minimal current and/or accelerating voltage. At the same time, samples resistant to light damage can work with higher currents, which increases image resolution without compromising resolution.

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Results

The first information on the study of the W-C-Co system dates back to 1931-32, but it has not been fully studied to date. The W-C-Co system was studied in sufficient detail by X-ray diffraction and partial thermal analysis by P.Rautal and J.Norton, who constructed the isothermal section of the phase diagram at 1400°C. A series of projections to the C concentration triangle and a vertical section along the WC-Co lines are shown [11-12]. The main results of this work are as follows:

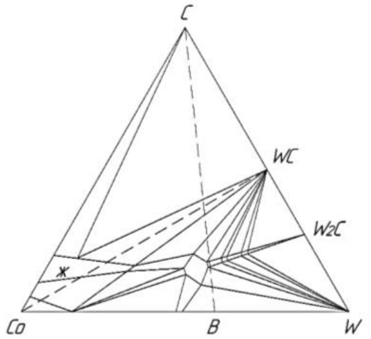

Figure 2. Isothermal section of the state diagram of the W-C-Co system at 1400 ℃.

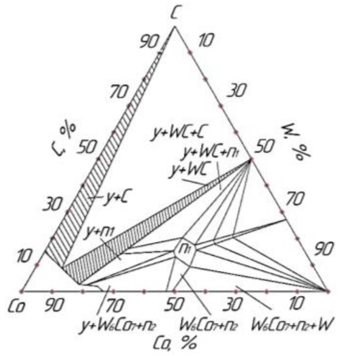

Figure 3. W-C-Co state diagram with phase fields at solidification temperatures of the alloys.

Two types of crystallization were found in the system, one of which is considered by the authors to be stable and the other to be unstable [13-14]. Several peritectic reactions have been identified in the system, leading to the formation of phase equilibria, including the peritectic reaction at 1357°C:

W + η →WC + γ, resulting in solid phase g. In the concentration regions corresponding to the joint, the ternary eutectic g+WC+C exists in the solid state of WC, η phases and partially J, WC and γ phases melt at 1298°C.

The limiting solubility of the tungsten carbide eutectic in cobalt at the melting temperature is about 10% (mol.) or 15% (mass). As the temperature decreases, the solubility of tungsten carbide in cobalt decreases sharply. The solubility of cobalt in tungsten carbide, determined by the X-ray method, was practically not determined. Two and three eutectics are formed in the W-C-Co system [15,16]. The stable binary eutectic WC + γ has a sharp appearance. At high magnification, the tertiary stable eutectic WC + γ structure and a framework-type component characteristic of the η_1 phase can be seen. P. Rautala and J. Norton recommend avoiding slow cooling in the production of hard alloys to avoid the possible appearance of an unconfirmed η phase in further work. It is necessary to know the appearance and properties of the η phase, because it is in equilibrium with the WC and γ phases and can appear in technical alloys. Without disputing the position of J.Gerland, P.Rautal and J.Norton, the greatest expert in the field of hard alloys, about the presence of peritectic reaction: W+ē→WC+ γ, he showed the location of the boundary. A section of the diagram is constructed through the carbon-rich and carbon corner (16% Co) of the W+WC+ē side of the three-phase region.

He showed that in alloys with a carbon content of 6.06-6.12%, only WC and γ phases crystallize during cooling, and in alloys with a low carbon content - 6.00-6.06%, which is low in the equilibrium state. Temperatures should also consist of WC and γ phases, η phase may appear. The alloy is in the state of rapid cooling from the heating temperature of 1350-1400°C

As defined by J. Gerland for each alloy brand, the width of the two-phase region for carbon is determined only by the solubility limit of carbon and tungsten in the γ-phase, since the carbon content does not change in "pure".
The vertical section along the Co-WC line is more interesting from a practical point of view (see Figure 2.). Many authors have studied the W-C-Co diagram, cut along the Co-WC line, typical of the diagrams of binary systems (not taking into account the melting of tungsten carbide with decomposition above ~3000°C peritectic reaction temperature) and covering the following aspects: composition and eutectic melting point γ + WC.
Value of the limiting solubility of tungsten carbide in cobalt in the solid state; changing the solubility of tungsten carbide in the solid state by reducing the temperature to room temperature; the boundary (width) of the two-phase region is WC+ γ.

Conclusion

By choosing the granulometric composition of the WC powder, by using fine-grained WC powders and by further refining the W - raw material, it was possible to obtain a more dense solid alloy before heating. W carbide and cobalt powders have a more perfect structure and higher hardness, and with the help of presslab-heating at high temperature, it was possible to improve the physical and mechanical properties of fingers made of VK-6 hard alloy, and increase the strength by reducing the porosity and increasing the resistance to bending. Compared with imported analogues, the reason for the decrease in the wear resistance of VK hard alloy is due to the defect in its structure, that is, the grain size of tungsten carbide is responsible for the wear resistance and hardness, and its nano-size provides an increase in these indicators. The nanostructure is achieved by inhibiting the growth of WC grains, for example, by introducing 1% rhenium carbide into the alloy.

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