Abstract. The widespread introduction of science into the production around the world, new technologies and devices are entering the industry, and this is the reason for the increase in the volume of mining of underground resources and obtaining new alloys. This article presents the scientific and practical research conducted on the properties of the powders that make up the details of the hard alloy-based device used in crushing and drilling underground resources. The morphology of ultra-disperse titanium carbide powders was studied to strengthen tungsten, carbon, and binder cobalt selected as raw materials. Ultradisperse titanium carbide powders produced at Shanghai Feiyuan Industrial Development Co., Ltd. were selected. Studies conducted on the surface morphology of ultra-disperse titanium carbide powders have shown that ultra-disperse titanium carbide powders have a very uniform and flat structure. Although the surface morphology at x50,000 magnification appears to contain particles approximately 100–150 nm in size, upon closer inspection of x100,000 and x150,000 images, they are monolithic. It can be seen that they are not particles.

1 Introduction

Presently the world's largest enterprises, such as BHP Billiton (Melbourne, Australia), Rio Tinto (London, United Kingdom), China Shenhua Energy Company Limited (Beijing, China), and Caol India Limited (Kolkata, India), produce copper, uranium, aluminium, and iron and are engaged in the mining of underground resources such as tungsten and titanium. In Uzbekistan, large production enterprises NMMC (Navoi) and AMMC (Almalyk) mine rare metals and offer them to the market as finished products [1]. In the process of metal mining, hard alloy details made by the powder metallurgy method are widely used. Hard alloys are divided into two types: those with tungsten carbide and those without. The research was carried out on powders that form the basis of tungsten carbide-hard alloys [2].
In the last 30 years in Uzbekistan, as a result of the introduction of scientific research into production, the extraction of underground resources (gold, silver, copper, uranium, rhenium, tungsten, etc.) has increased dramatically, and this has increased the strength of the equipment used for the extraction of underground resources and created the task of increasing the working time [3-6]. The ground resources attached to water resources or irrigation areas also should be considered [7].

As a raw material for the preparation of tungsten carbide-cobalt-based hard alloy samples, tungsten powders produced at the "SPA for the production of rare metals and hard alloys" under "Almalyk MMC" JSC, to increase the binder's resistance to abrasive wear, are used in China [8-10].

Therefore, the study of the morphology of the powder contained in the solid alloy used in crushing underground resources is not done perfectly and it lacks research. Therefore, this study was planned to identify the morphology of powder contained in the solid alloy used in crushing underground resources. [11-13].

2 Methods

Today's existing methods do not provide complete information about the influence of the quality of metal powders on the quality of hardened alloys [4, 14-16]. The use of the granulometric sedimentation analysis method greatly simplifies the task of determining the quality of large powders [4]. However, such methodologies are not available for production use today. Therefore, it is necessary to develop a method of sedimentation analysis of large grain powders in the laboratories of hard alloy production enterprises and put it into practice to determine the quality of powders. Therefore, it is necessary to use additional methods, such as X-ray phase analysis and electron microscopy [17-18], for the scientific and practical research of the properties of powders used in the sintering of hard alloys. As a raw material for the preparation of tungsten carbide-cobalt-based hard alloy samples, tungsten powders produced at the "SPA for the production of rare metals and hard alloys" under "Almalyk MMC" JSC, to increase the binder's resistance to abrasive wear, are used in China. Ultradisperse titanium carbide powders produced at Shanghai Feiyan Industrial Development Co., Ltd. were selected. The electron microscopic method was used during research, and the JSM-IT200 (JEOL, Japan) scanning electron microscope of the "Uzbekistan-Japan Youth Innovation Center" was used [19-22].

3 Results and Discussion

Morphology of tungsten powders. The chemical composition of the tungsten powder produced at the "SPA for the production of rare metals and hard alloys" at the "Almalyk MMC" JSC, obtained to study the physico-chemical properties and morphology of tungsten powders, is presented in Table 1 and Figure 1. The chemical composition of tungsten powder was determined using a JSM-IT200 (JEOL, Japan) scanning electron microscope.

Table 1. Chemical composition of tungsten powder.

<table>
<thead>
<tr>
<th>W, %</th>
<th>O₂ %</th>
<th>Al %</th>
<th>The amount of additives in the composition, up to %</th>
</tr>
</thead>
<tbody>
<tr>
<td>99.9</td>
<td>0.001</td>
<td>0.001</td>
<td>Mo: 0.03</td>
</tr>
</tbody>
</table>
In the last 30 years in Uzbekistan, as a result of the introduction of scientific research into production, the extraction of underground resources (gold, silver, copper, uranium, rhenium, tungsten, etc.) has increased dramatically, and this has increased the strength of the equipment used for the extraction of underground resources and created the task of increasing the working time [3-6]. The ground resources attached to water resources or irrigation areas also should be considered [7].

As a raw material for the preparation of tungsten carbide-cobalt-based hard alloy samples, tungsten powders produced at the "SPA for the production of rare metals and hard alloys" under "Almalyk MMC" JSC, to increase the binder's resistance to abrasive wear, are used in China [8-10].

Therefore, the study of the morphology of the powder contained in the solid alloy used in crushing underground resources is not done perfectly and it lacks research. Therefore, this study was planned to identify the morphology of powder contained in the solid alloy used in crushing underground resources. [11-13].

2 Methods

Today's existing methods do not provide complete information about the influence of the quality of metal powders on the quality of hardened alloys [4, 14-16]. The use of the granulometric sedimentation analysis method greatly simplifies the task of determining the quality of large powders [4]. However, such methodologies are not available for production use today. Therefore, it is necessary to develop a method of sedimentation analysis of large grain powders in the laboratories of hard alloy production enterprises and put it into practice to determine the quality of powders. Therefore, it is necessary to use additional methods, such as X-ray phase analysis and electron microscopy [17-18], for the scientific and practical research of the properties of powders used in the sintering of hard alloys. As a raw material for the preparation of tungsten carbide-cobalt-based hard alloy samples, tungsten powders produced at the "SPA for the production of rare metals and hard alloys" under "Almalyk MMC" JSC, to increase the binder's resistance to abrasive wear, are used in China. Ultradisperse titanium carbide powders produced at Shanghai Feiyan Industrial Development Co., Ltd. were selected. The electron microscopic method was used during research, and the JSM-IT200 (JEOL, Japan) scanning electron microscope of the "Uzbekistan-Japan Youth Innovation Center" was used [19-22].

3 Results and Discussion

Morphology of tungsten powders. The chemical composition of the tungsten powder produced at the "SPA for the production of rare metals and hard alloys" at the "Almalyk MMC" JSC, obtained to study the physico-chemical properties and morphology of tungsten powders, is presented in Table 1 and Figure 1. The chemical composition of tungsten powder was determined using a JSM-IT200 (JEOL, Japan) scanning electron microscope.

![Fig 1. Chemical composition of tungsten powder.](image1)

The granulometric size of the selected tungsten powder is as follows: ≤0.8 mm - 0.6 percent; 0.8-1 mm - 5.4 percent; 1.2 mm - 12.3 percent. 1.2-2 mm: -80.01 percent; 2≤ mm: -1.69 percent (3; see picture).

The X-ray phase analysis of the tungsten powder produced at the SPA to produce rare metals and hard alloys on a Dron-3.0 diffractometer showed the presence of a cubic tungsten structure in all studied samples. This crystal lattice structure is characteristic of tungsten powders and is used in practice for carbidization. No extraneous additives are other than the elements listed in the chemical composition were found in the tungsten powder.

The surface morphology of tungsten powders was studied using a JSM-IT200 (JEOL, Japan) scanning electron microscope (Figures 3 and 4).

![Fig 2. Arrangement of tungsten powders in the mixture.](image2)

Studies on surface morphology analysis of tungsten powders were carried out at magnifications from x100 to x15,000. The conducted studies revealed that the composition of tungsten powder consists of polydispersed particles and the presence of circular and square particles. 80–85 percent of the total particles are circular particles, and 70–75 percent of them are 1-1.5 μm in size (Figure 3). Rectangular particles make up 20–25 percent.
percent, and the size of 10–15 percent is 1.5–2 μm. The largest square-shaped particles are up to 5 μm and makeup about 0.5 percent of the total amount of powder (Figure 4).

Fig 3. Surface morphology of tungsten powders.

Fig 4. Surface morphology of tungsten powders.
Based on the analysis of literature and scientific and practical research, monodisperse carbide particles have a higher hardness than polydisperse carbide particles, and they can be used in the production of hard alloys widely used in mineral grinding and drilling processes. fit for purpose.

Tungsten powder selected for research is produced according to the requirements of TU 48-4205-62-2000 at the "SPA for the production of rare metals and hard alloys" under the "Almalyk MMC" JSC.

Morphology of carbon powders. The chemical composition of T-900 brand carbon powder produced at the "SPA for the production of rare metals and hard alloys" under "Almalyk MMC" JSC, taken to study the physico-chemical properties and morphology of carbon powders [14-16], is shown in Table 2 and Figure 5.

<table>
<thead>
<tr>
<th>W, %</th>
<th>C_{generalized}, %</th>
<th>Amount of additives in the composition, % max.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>C_{freely}</td>
</tr>
<tr>
<td>93.871</td>
<td>6.006</td>
<td>0.1</td>
</tr>
</tbody>
</table>

The chemical composition of carbon powder was determined using a JSM-IT200 (JEOL, Japan) scanning electron microscope.

Figure 6 shows a photo of an electron microscope with elements such as hydrogen and oxygen turned off when determining the chemical composition of tungsten powders.

The studies conducted on the analysis of the surface morphology of T-900 carbon powders were carried out at magnifications ranging from x100 to x10,000. The conducted studies revealed that the composition of T-900 brand carbon powder consists of monodisperse particles and mainly spherical particles. 98–99 percent of the total particles in the studied area are circular particles; 78–80 percent of them are in the range of 1.2-2 μm, and the remaining 10–12 percent of the particles are in the range of 1-1.2 μm. It was found that in the studied powders there are also nanometer-sized particles, albeit in a small amount (Figure 7). Tungsten powder selected for research is produced by GOST 7885 and requirements at "SPA for the production of rare metals and hard alloys" under "Almalyk MMC" JSC.
Chemical composition and morphology of raw materials reinforcing corrosion-resistant hard alloy binder components in the production of solid alloys resistant to abrasive wear, the use of nano- or ultra-disperse powders of metal carbides with a size of less than 100 nm serves to strengthen the bonding metal in the process of liquid phase quenching [11].

To strengthen the physical and mechanical properties of cobalt, which is a binding component, ultradispersed TiC powder was chosen. The chemical compositions of ultradispersed TiC powder are presented in Table 3 and Figure 8.

Table 3. Results of magnetic separation of ash and slag.

<table>
<thead>
<tr>
<th>TiC, min, %</th>
<th>The amount of additives in the composition, at most, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C_{comm},</td>
</tr>
<tr>
<td>99.5</td>
<td>19.31</td>
</tr>
</tbody>
</table>
Chemical composition and morphology of raw materials reinforcing corrosion-resistant hard alloy binder components in the production of solid alloys resistant to abrasive wear, the use of nano- or ultra-disperse powders of metal carbides with a size of less than 100 nm serves to strengthen the bonding metal in the process of liquid phase quenching [11].

To strengthen the physical and mechanical properties of cobalt, which is a binding component, ultradispersed TiC powder was chosen. The chemical compositions of ultradispersed TiC powder are presented in Table 3 and Figure 8.

**Table 3. Chemical composition of ultradispersed TiC powder.**

<table>
<thead>
<tr>
<th>Element</th>
<th>Min, %</th>
<th>Amount of Additives in the Composition, at Most, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ti</td>
<td>99.5</td>
<td>C, C₃n</td>
</tr>
<tr>
<td>C</td>
<td>19.31</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>0.067</td>
<td></td>
</tr>
<tr>
<td>Al, Ca, Fe, K, Na, Mo, Si, O</td>
<td>0.115</td>
<td></td>
</tr>
</tbody>
</table>

**Fig 8.** Chemical composition of ultradispersed TiC powders.

**Fig 9.** Arrangement of ultradispersed titanium carbide powders in a mixture.

Figure 9 shows the photo of the electron microscope when determining the chemical composition of ultradispersed titanium carbide powders, with elements such as aluminium, iron, molybdenum, silicon, calcium, potassium, sodium, nitrogen, and oxygen turned off. The granulometric size of the selected ultradispersed titanium carbide powder is as follows: ≤10 nm, 6 percent; 10-80 nm, 90 percent; and 80 ≤ nm, 4 percent (see Figure 10).

**Fig. 10.** Surface morphology of ultra-disperse titanium carbide powders.

<table>
<thead>
<tr>
<th>a) x 50 000</th>
<th>b) x 50 000</th>
</tr>
</thead>
<tbody>
<tr>
<td>c) x 100 000</td>
<td>d) x 150 000</td>
</tr>
</tbody>
</table>
Studies conducted on the surface morphology of ultra-disperse titanium carbide powders have shown that ultra-disperse titanium carbide powders have a very uniform and flat structure (see Figure 10). Although the surface morphology at x50,000 magnification appears to contain particles approximately 100–150 nm in size (see Figure 10 a, b), upon closer inspection of x100,000 and x150,000 images, they are monolithic. It can be seen that they are not particles (see pictures 10 c, d). To reduce such a large accumulation of powder particles, additional grinding and sieving processes are carried out before the initial grinding process.

4 Conclusions

The scientific and practical research of tungsten powders selected as the initial raw materials, especially the study of the fraction larger than 16.5 μm, the formation of large particles of about 100 microns after the carbidization process, and the fact that these conglomerates are not completely carbidized during the carbidization process, which was found to result in an excess of free carbon in the extracted tungsten carbide, Depending on the production technology, changes in the amount of free carbon in tungsten powders were determined. A study of the particle surface morphology showed that some tungsten powders have different geometric shapes, which is due to the process used to remove the activating additives in the final stages of tungsten powder production, which causes the separation of the particles stuck together in agglomerates.

References

5. S. Parmonov, Sh. Shakirov, G. Yusuрова, N. Kuchkarova, Sh. Shanazorova, D. Tursunova, A. Kambarov, E3S Web of Conferences, 88, 1010 (2024)
6. O. Moshood, J.A. Adebisi, A.P. Shivute, B. Genc, Resources Policy, 85 (2023)
Studies conducted on the surface morphology of ultra-disperse titanium carbide powders have shown that ultra-disperse titanium carbide powders have a very uniform and flat structure (see Figure 10). Although the surface morphology at x50,000 magnification appears to contain particles approximately 100–150 nm in size (see Figure 10 a, b), upon closer inspection of x100,000 and x150,000 images, they are monolithic. It can be seen that they are not particles (see pictures 10 c, d). To reduce such a large accumulation of powder particles, additional grinding and sieving processes are carried out before the initial grinding process.

4 Conclusions

The scientific and practical research of tungsten powders selected as the initial raw materials, especially the study of the fraction larger than 16.5 μm, the formation of large particles of about 100 microns after the carbidization process, and the fact that these conglomerates are not completely carbidized during the carbidization process, which was found to result in an excess of free carbon in the extracted tungsten carbide, Depending on the production technology, changes in the amount of free carbon in tungsten powders were determined. A study of the particle surface morphology showed that some tungsten powders have different geometric shapes, which is due to the process used to remove the activating additives in the final stages of tungsten powder production, which causes the separation of the particles stuck together in agglomerates.

References

5. S. Parmonov, Sh. Shakirov, G. Yusupova, N. Kuchkarova, Sh. Shanazorova, D. Tursunova, A. Kambarov, E3S Web of Conferences, 88, 1010 (2024)
6. O. Moshood, J.A. Adebisi, A.P. Shivute, B. Genc, Resources Policy, 85 (2023)