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RARE EARTH MATERIALS IN THE INDUSTRY OF UZBEKISTAN AND THEIR APPLICATION IN MECHANICAL ENGINEERING

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Abstract:
The demand for rare metals in high-technology industrial production determines their high cost on the global market. The article presents an example of the possibility of using rare-earth metals for coating cutting tool inserts in order to increase productivity.

Introduction

For the sustainable, dynamic, and balanced development of Uzbekistan's industry, further modernization and diversification are required by transferring it to a qualitatively new level aimed at the advanced development of high - technology manufacturing sectors, primarily the production of finished goods with high added value based on deep processing of local raw materials.

The development of fundamentally new types of products and technologies ensures, on this basis, the competitiveness of domestic products in foreign and domestic markets.

Uzbekistan has a highly developed metallurgical industry based on exceptionally rich natural resources. It is sufficient to note that Uzbekistan ranks fourth in the world in explored gold reserves and seventh in gold production, seventh in uranium reserves, and eleventh – twelfth in copper reserves. The republic also possesses significant reserves of other metals, including precious and rare - earth metals such as silver, molybdenum, bismuth, tungsten, lithium, and others.

Mechanization and automation of production and technological processes should be considered both from the standpoint of improving equipment, technological tooling, and process quality, and from the standpoint of ensuring the technical and economic efficiency of using rare - earth metals.

The specificity of rare metals and, at the same time, their demand in high-technology industrial production determine their high cost on the world market, which is incomparably higher than that of more familiar metals, their alloys, or chemical compounds.

It can be concluded that at present rare metals should be regarded not only as "vitamins of industry" but also as full - fledged factors of innovative industrial development of the country. Therefore, a strategically important state task has arisen - the transformation of the entire production structure.

Rare metals are a historically established term for a large group of elements; this term reflects several of their features to a certain extent:

- Relatively small scales of production and consumption; for example, one of the most well-known rare metals, rubidium, is produced in quantities approximately 130 times smaller than aluminum;
- Low abundance in nature; their Clarke values do not exceed 10^{-9}%; the most abundant rare metal, rubidium, is contained in the Earth's crust in an amount of about 0.015%;
- Most rare metals do not form independent minerals in nature and occur in a dispersed state within the crystal lattices of other minerals; many of them are natural companions of heavy and light non-ferrous metals;
- Very low content in ores and extremely complex composition of such raw materials; no rare metal is obtained by direct reduction from raw material—initially the raw material is enriched, and the resulting rough concentrates and intermediate products are processed into chemical compounds;
- In addition to ore raw materials, sources of rare non-ferrous metals include industrial wastes of non-ferrous and ferrous metallurgy and chemical production.

The use of rare metals began at the end of the 19th century. Tungsten was the first to gain recognition, followed by molybdenum, niobium, tantalum, and then gradually the others. The subsoil of Uzbekistan contains significant reserves of these metals.

Assessment of the application of rare-earth metals in the production of cutting tool inserts.

One of the conditions for the effective operation of automatic lines, CNC machines, and automated complexes controlled by computers, as well as flexible manufacturing systems, is the use of quick-change, non-adjustable tool designs and tool blocks (cutting and auxiliary tools assembled).

Quick tool change is ensured by improving methods of fastening and locating tools, as well as by unifying the connection surfaces of cutting and auxiliary (clamping) tools in order to reduce their assortment.

Cutting tools are an integral part of a complex automated CNC machine system. Particular attention should be paid to the careful selection and preparation of tools for CNC machines and flexible manufacturing systems due to the high cost of this equipment and the need to achieve maximum productivity and higher machining accuracy. To ensure an automatic operating cycle, a higher degree of tool reliability is required.

Cutting tools for CNC machines must meet the following requirements: ensuring high and stable cutting performance; satisfactory chip formation and removal; compliance with specified machining accuracy; versatility for typical machined surfaces of various parts on different machine models; quick change when retooling for another part or replacing a worn tool.

During machining operations such as turning, milling, drilling, and similar processes, cutting tools are used. To guarantee effective chip removal from the workpiece and sufficient tool life, the cutting insert must be both hard and tough.

Hardness, however, may be associated with brittleness. A very popular choice for inserts is composite materials that possess both hardness and toughness, containing hard ceramic particles in a metallic matrix. A number of such metal-ceramic composites, or cermets, have been developed. So-called hard metals or cemented carbides, in particular WC-Co, consisting of tungsten carbide grains in a cobalt matrix, are the materials of choice for cutting tool inserts in many applications.

Inserts remove material and shape the workpiece, but they themselves wear during machining. Wear of cutting tool inserts occurs on their contact surfaces with the workpiece and may mainly be caused by mechanical, chemical, and thermal interactions with the workpiece.

Machine downtime during insert replacement is very costly. Many studies are aimed at improving insert wear resistance through the use of hard coatings. Hardness is a measure of resistance to plastic deformation, and there is a relationship between hardness and wear resistance. Although coatings increase wear resistance, they are often susceptible to catastrophic failure modes such as delamination.

Coatings can be formed on inserts using a number of technologies, mainly classified as PVD (Physical Vapor Deposition) or CVD (Chemical Vapor Deposition).

The PVD process provides coatings with very good properties. The coating is deposited on a surface exposed to irradiation. PVD coatings are characterized by compressive residual stresses generated during deposition. Due to the risk of coating failure caused by delamination with increasing coating thickness, PVD is mainly limited to thin coatings.

CVD coatings are not limited to irradiated surfaces. Moreover, the deposition temperature is usually significantly higher than in PVD technologies, which facilitates the development of a diffusion layer between the coating and the substrate, enabling good adhesion. Good adhesion is one of the most important requirements for insert coatings.

In addition, there are a number of materials and material-substrate combinations that can only be applied using one or the other coating technology.

The use of assembled tools with indexable polygonal inserts makes it possible to improve tool performance and ensures significant savings of scarce cutting materials. At the same time, favorable conditions are created for the wide application of more wear- and heat-resistant cutting materials.

Assembled tools with indexable inserts have found wide application, and their production is constantly increasing both in volume and in assortment. The share of such tools today accounts for 35–40% of the total production of cutting tools.

Fig. 1. Assembled milling cutter using coated inserts.

The choice of cutting tool material is an important factor in planning metal-cutting operations, and the application of coatings on cutting inserts increases productivity.

Tool materials are a variety of alloys with specific properties and may have different combinations of hardness, strength, and wear resistance. As a rule, a tool material that demonstrates good machining performance should possess the following characteristics:

- Hardness to ensure resistance to deformation and flank wear;
- Strength to prevent cutting edge fracture;
- Ability not to react with the workpiece material;
- Chemical stability to resist oxidation and diffusion;
- Resistance to sudden temperature changes.

A coated cemented carbide combines the advantages of the carbide substrate and a special coating. Together they form a material ideally adapted to a particular operation.

Table 1 Advantages of using coated indexable inserts

Features of using indexable inserts	**Technical and economic effect**
Multiple use of the tool holder	Reduction of tool cost; improved quality and reliability
Elimination of regrinding	Improved insert quality; reduction of grinding equipment, space, and workforce; lower operating costs; reduced consumption of abrasive materials
Elimination of brazing	Improved insert quality; reduced manufacturing cost and labor intensity; reduced solder consumption
Reduced tool change time	Shorter economic tool life period; intensified cutting regimes and increased labor productivity
Formation of rake face during insert manufacturing	Stable chip breaking; improved tool quality; reduced operating costs

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If we consider the composition of coatings, a large proportion consists of rare metals mined in Uzbekistan, such as titanium, aluminum, and tungsten.
For example, a cemented carbide with a CVD coating initially had a single-layer titanium carbide (TiC) coating. Later, aluminum oxide (Al_2O_3) and titanium nitride (TiN) coatings appeared. More recently, modern coatings based on titanium carbonitride (MT-Ti (C, N) or MT-TiCN, also referred to as MT-CVD) have been developed, improving material properties due to their ability to maintain interface integrity with the cemented carbide.

a **b**

Fig. 2. Cutting inserts made of: a) cermet; b) coated tungsten-rich cobalt-bonded material.

Cermets have firmly established their position. A cermet is a hard alloy containing high-hardness particles based on titanium. The term “cermet” combines the words ceramic and metal. Initially, cermets consisted of titanium carbides (TiC) and a nickel binder. Modern cermets no longer contain nickel and have a complex structure including titanium carbonitride Ti (C, N), a second hard phase (Ti, Nb, W), (C, N), and cobalt.
Ti (C, N) increases wear resistance, the second hard phase increases resistance to plastic deformation, and the cobalt content determines strength.
Compared to conventional cemented carbides, cermets have higher wear resistance and lower tendency to adhesion. On the other hand, they have lower compressive strength and lower resistance to thermal shock. Cermets can also be combined with PVD coatings to improve wear resistance.
An indexable cemented carbide insert is a tool of a specific geometry, with or without holes; sometimes, to further improve resistance to high temperatures and mechanical loads, inserts are coated with special compounds.
The greater the number of cutting edges an insert has, the longer it can be used by indexing it to a new sharp edge each time.
Multiple cutting edges result in cost savings. The use of coatings applied to cutting surfaces only a few millimeters in size not only improves cutting performance but also leads to savings of rare metals.

The introduction of rare metals into Uzbekistan's industry for domestic needs increases competitiveness and contributes to economic growth.

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