



CREATION OF NEW GENERATION ALLOYS AND VALIDATION OF THEIR MICROSTRUCTURE

Asqarova Shaxlo Abduvalievna

Abstract: This article discusses the issues of creating new generation alloys, studying their structural properties and determining their microstructure. The research analyzes the directions of developing metal alloys that provide high mechanical strength, corrosion resistance and heat resistance. Also, using modern metallographic methods, the microstructure, phase composition and state of the crystal lattice of alloys are studied. The article is aimed at showing the role and importance of innovative approaches in the development of new materials technology.

Keywords: alloy, microstructure, metallography, crystal lattice, phase composition, mechanical strength, new materials, innovative technology.

Annotatsiya: Ushbu maqolada yangi avlod qotishmalarini yaratish, ularning tarkibiy xususiyatlarini o'rganish hamda mikrokonstruksiyasini aniqlash masalalari yoritilgan. Tadqiqotda yuqori mexanik mustahkamlik, korroziyaga chidamlilik va issiqlikka bardoshlilikni ta'minlovchi metall qotishmalarini ishlab chiqish yo'nalishlari tahlil qilinadi. Shuningdek, zamonaviy metallografik usullar yordamida qotishmalarning mikrostrukturasi, fazaviy tarkibi va kristall panjarasining holati o'rganiladi. Maqola yangi materiallar texnologiyasining rivojlanishida innovatsion yondashuvlarning o'rni va ahamiyatini ko'rsatishga qaratilgan.

Kalit so'zlar: qotishma, mikrokonstruksiya, metallografiya, kristall panjara, fazaviy tarkib, mexanik mustahkamlik, yangi materiallar, innovatsion texnologiya.



Аннотация: В статье рассматриваются вопросы создания сплавов нового поколения, исследования их структурных свойств и определения микроструктуры. В работе анализируются направления разработки металлических сплавов, обеспечивающих высокую механическую прочность, коррозионную стойкость и жаропрочность. Также с использованием современных металлографических методов изучены микроструктура, фазовый состав и состояние кристаллической решетки сплавов. Цель статьи – показать роль и значение инновационных подходов в развитии технологий новых материалов.

Ключевые слова: сплав, микроструктура, металлография, кристаллическая решетка, фазовый состав, механическая прочность, новые материалы, инновационная технология.

Introduction

In the context of modern industrial and technical development, the creation of new generation alloys with high performance is one of the most relevant directions in the field of materials science. Metal alloys are widely used in such fields as mechanical engineering, aviation, astronautics, energy and military equipment, and their physical and mechanical properties determine the quality and reliability of products. Therefore, the development of alloys with high strength, corrosion resistance and stable operation under extreme temperature and pressure conditions is at the center of scientific research. The process of creating new generation alloys relies on the selection of their chemical composition, ensuring thermodynamic stability and in-depth study of microstructural properties. In particular, microstructural analysis - by determining the internal structure of the material, interphase boundaries, dislocation density and crystal lattice state - allows predicting its mechanical and technological properties.



Currently, nanostructured and composite alloys, as well as high-entropy materials, are becoming an advanced direction of scientific research. Such alloys demonstrate higher heat resistance and wear resistance compared to traditional metallic materials. From this point of view, determining the microstructure of new generation alloys and experimentally confirming their phase composition is one of the fundamental problems of materials science. The theoretical significance of this study is that it serves to scientifically substantiate the process of developing advanced technological materials by revealing the relationship between the structural and material properties of new alloys and their physical and mechanical properties.

Main part

In the era of modern technological progress, the demands placed on metallic materials are increasing. Traditional alloys often lose their mechanical properties under the influence of high temperature, pressure, and aggressive environments. Therefore, the issue of creating new generation alloys is considered one of the current scientific directions in the field of materials science and metallurgy. The theoretical basis of this process is based on fundamental laws such as the crystal lattice of metals, phase transitions, alloying mechanisms, and energy stability. The role of alloying elements in creating new generation alloys is incomparable. In particular, elements such as chromium, molybdenum, vanadium, nickel, titanium, aluminum, and tungsten increase the structural strength of metals, increase their resistance to corrosion, thermal loads, and mechanical deformation. Also, the development of nanostructured alloys is one of the most advanced achievements of our time. The addition of nano-sized particles strengthens the intergranular boundaries of the metal, significantly increasing the hardness and elasticity of the material.



In scientific research, physicochemical modeling and computer simulation are widely used to create new alloys. With the help of these methods, the interaction energy, diffusion rate, and structural stability of alloy components are calculated in advance. As a result, it becomes possible to accurately predict the results obtained experimentally. In addition, it is important to take into account the principles of green metallurgy in the development of new generation alloys. That is, reducing energy consumption, minimizing waste, and using recyclable resources in the production process are an integral part of the scientific approach. This allows alloys to be formed as not only technically but also environmentally effective materials. Thus, the scientific basis for creating new generation alloys includes atomic-level structural control, optimization of the alloying process, integration of nano and composite technologies, and the concept of sustainable production. Metallic materials created in this way will not only have high strength, but also fully meet the needs of modern equipment and technology.

An important scientific step in assessing the quality of new generation alloys is the analysis of their microstructure. The microstructure of an alloy directly determines its physical and mechanical properties - strength, plasticity, hardness, heat resistance and corrosion resistance. Therefore, a thorough study of the microstructure allows us to form a complete picture of the behavior and long-term stability of the material. In modern scientific research, advanced techniques such as optical and electron microscopy, X-ray diffraction, atomic force microscopy (AFM), scanning electron microscopy (SEM), transmission electron microscopy (TEM) are widely used to study the microstructure of alloys. These methods determine the grain size, phase composition, dislocation density, boundary changes and distribution of alloying elements. X-ray diffraction analysis (XRD) is one of the most effective methods for determining the phase state of alloys. It is used to determine the crystal structures, lattice parameters and degrees of deformation in the material. Scanning electron microscopy (SEM) allows for high-resolution study of surface morphology,



grain boundaries, and precipitate structure. At the same time, energy-dispersive spectral analysis (EDS) determines the chemical composition of elements, which helps to assess the uniform distribution of alloying elements.

Transmission electron microscopy (TEM) is one of the most advanced analysis methods, showing changes at the atomic level. With the help of this technology, the sizes of dislocations, phase separations, and precipitates formed in the alloy are studied with microscopic accuracy. Based on the data obtained in this way, the structural stability of the alloy, the causes of mechanical strength, and its resistance to thermal effects are scientifically analyzed. Numerical modeling and computer simulation methods are also widely used in assessing microstructure. They can be used to predict how the crystal lattice of the alloy will change under conditions of different temperatures, pressures, and chemical compositions. This approach not only reduces the cost of experiments, but also speeds up the process of creating new alloys. Therefore, the analysis of the microstructure of alloys is a scientific direction that integrates theoretical knowledge, advanced technical tools, and numerical analysis methods, which guarantees the reliability and quality of new generation metallic materials.

The creation of new generation alloys is not only a scientific breakthrough in the field of materials science, but also of strategic importance for various industries. Due to their high mechanical, heat-resistant and corrosion-resistant properties, these materials have wide application in such fields as modern technology, energy, aviation, astronautics, mechanical engineering and medicine. First of all, alloys intended for aviation and space technology must withstand the highest thermal loads and dynamic pressures. Therefore, superalloys based on nickel, titanium, molybdenum, as well as nanocomposite materials are widely used in the structural parts of engines, turbines and spacecraft. These alloys help reduce weight and increase energy efficiency.



The use of new generation alloys in the energy sector is of significant economic and environmental importance. High-temperature and corrosion-resistant alloys are being developed for turbine blades, heat exchangers and pressure vessels used in nuclear, thermal and renewable energy systems. This extends the service life of energy equipment and reduces operating costs. In the mechanical engineering sector, new generation alloys allow the development of lightweight but strong parts. In particular, aluminum-magnesium alloys play an important role in reducing fuel consumption, reducing emissions and increasing the efficiency of vehicles in the automotive industry.

The use of new generation alloys is also expanding in the medical field. Biocompatible titanium and magnesium-based alloys are used in the manufacture of implants, prostheses and surgical instruments. Their advantages are compatibility with the human body, non-toxic effects and long-term durability. In the future, new generation alloys will be further developed based on the concept of “smart materials”. That is, such alloys will be able to adapt their structure in response to changes in the external environment, acquire functional properties such as self-healing or heat regulation. This will begin a new stage that will fundamentally change the metallurgy, robotics and energy industries. Thus, the practical prospects of new generation alloys are broad, aimed at ensuring efficiency, safety and environmental sustainability in high-tech industries. Such materials are recognized as one of the key factors of technological progress of the 21st century.

Conclusion

The creation of new generation alloys and confirmation of their microstructure is one of the most relevant directions of modern materials science and metallurgy. This process is carried out through in-depth study of the physicochemical properties of metals, scientific substantiation of alloying mechanisms, and the introduction of nanostructure technologies into practice. Analysis of the microstructure of alloys



allows us to determine their phase composition, grain size, dislocation density, and structural stability. The conducted scientific analyses show that new generation alloys are characterized by higher mechanical strength, heat resistance, corrosion resistance, and energy efficiency compared to traditional materials. Their practical application accelerates technical development in such fields as aviation, astronautics, mechanical engineering, energy, and medicine. In conclusion, research on the creation of new generation alloys contributes to the digital and ecological modernization of not only the metallurgical sector, but also the entire industry. Research in this area will create the scientific basis for the development of innovative, sustainable, and highly efficient materials in the future.

References:

1. Abdullaev, A., & Rakhimov, J. (2022). *Fundamentals of Materials Science and Metallurgy*. Tashkent: Fan Publishing.
2. Ashby, M. F., & Jones, D. R. H. (2019). *Engineering Materials 2: An Introduction to Microstructures, Processing and Design*. Oxford: Elsevier.
3. Callister, W. D., & Rethwisch, D. G. (2020). *Materials Science and Engineering: An Introduction*. New York: Wiley.
4. Khamidov, S. (2021). *Modern Alloy Technologies and Their Industrial Applications*. Tashkent: Innovation Publishing.
5. Gaskell, D. R. (2018). *Introduction to the Thermodynamics of Materials*. New York: Taylor & Francis.
6. Zhumanov, A. (2020). *Nanostructured Materials and Their Physical Properties*. Samarkand: SamSU Press.
7. Reed, R. C. (2016). *The Superalloys: Fundamentals and Applications*. Cambridge: Cambridge University Press.
8. ISO 20482:2013. *Metallic Materials — Sheet and Strip — Erichsen Cupping Test*.



9. ASTM International. (2023). *Annual Book of ASTM Standards, Volume 03.01: Metals — Mechanical Testing; Elevated and Low-Temperature Tests*. West Conshohocken, PA.

10. Ministry of Innovative Development of the Republic of Uzbekistan. (2024). *Scientific and Technical Program Reports on the Development of New Generation Alloys*. Tashkent.