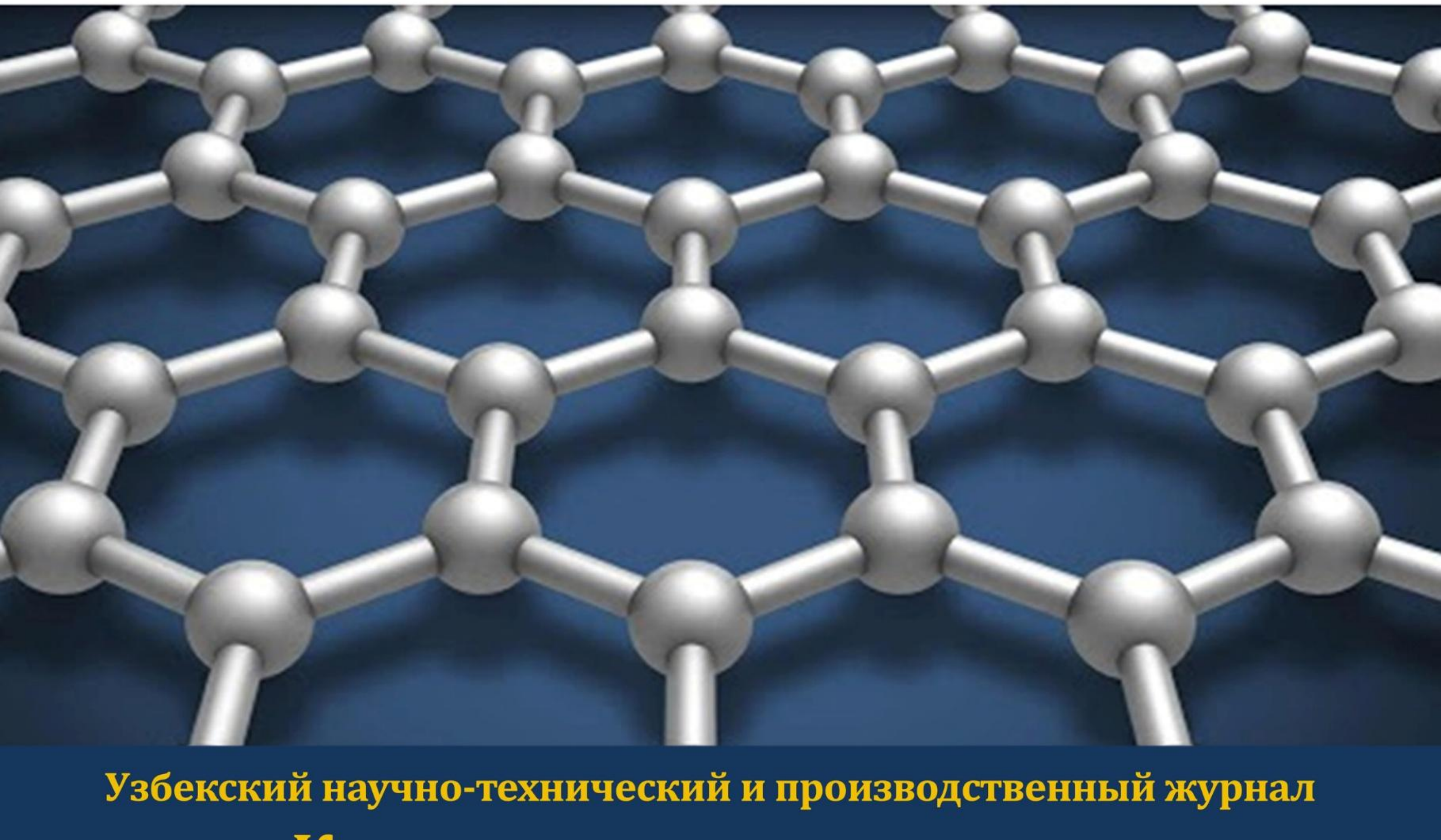
ISSN 2091-5527
№ 1/2026

O‘zbekiston
Kompozitsion **M**ateriallar

Ilmiy-texnikaviy va amaliy jurnali



Узбекский научно-технический и производственный журнал

Композиционные материалы

ANALYSIS OF THE CHEMICAL COMPOSITION OF 300Х28Н2Л WHITE CAST IRON

Abdullayev Farrukhjon Komiljon o‘g‘li, Yuldoshev Omonjon Choriboyevich,
Chorshanbiyev Shukhrat Makhmatmurodovich, To‘rayev Anvar Normamatovich,
Kholmatov Elyor Mavlon o‘g‘li, Abdusamadova Odina Anvar qizi,
Khojimukhamedova Laylo To‘lqin qizi, Suvonova Marjona Yunus qizi

Tashkent State Technical University named after Islam Karimov

Abstract: The study investigates the influence of carbide-forming elements on the structure and mechanical properties of alloys. It was found that a high content of chromium and other carbide-forming elements in the carbide phase positively affects the alloy’s strength, wear resistance, and hardness. Chromium contributes to the stability of carbides, enhancing ductility and overall performance. Conversely, excessive iron content reduces the adaptability of the carbide phase and negatively impacts the alloy’s machinability. Furthermore, low amounts of molybdenum (Mo), titanium (Ti), and nickel (Ni) in the carbide phase adversely affect the alloy’s microstructure and metallic matrix ductility.

Keywords: alloy, carbide phase, chromium, molybdenum, titanium, nickel, silicon, ductility, mechanical properties, wear resistance.

Introduction: It is well established that the microstructure of white cast irons is primarily composed of a metallic matrix and various types of carbides. These structural components play a significant role in determining the mechanical strength of the alloy. However, their influence is not limited only to strength characteristics. The relative distribution of the metallic matrix and carbide phases, as well as the size, morphology, and orientation of carbides within the structure, have a substantial impact on the mechanical behavior and service performance of white cast iron. In particular, changes in carbide shape, size, and alignment can lead to notable variations in hardness, wear resistance, brittleness, and long-term operational durability of the material under different loading conditions. Therefore, a thorough understanding and control of the microstructural features of white cast irons are essential for improving their mechanical and operational properties in practical applications.

In addition to the influence of individual microstructural phases, the overall properties of white cast iron are significantly affected by the spatial distribution of its structural constituents throughout the material volume. The elements forming the structure of white cast iron contribute to its performance not only through their presence as microscopic phases, but also through the uniformity and continuity of their dispersion within the alloy. For instance, a homogeneous composition and well-balanced distribution of carbides and the metallic matrix promote enhanced mechanical strength, durability, and resistance to damage.

Object and Research Methodology: Furthermore, the microstructure of white cast irons, including the distribution and orientation of the constituent phases, plays a crucial role in determining the overall material properties and operational efficiency. A favorable arrangement and alignment of carbides relative to the metallic matrix can improve load-bearing capacity and wear resistance, while an inhomogeneous or anisotropic structure may lead to stress concentration and premature failure. Therefore, careful control and analysis of the microstructural characteristics of white cast irons are essential for achieving optimal performance in practical applications.

Figure 1 shows the distribution of the metallic matrix elements in the microstructure of 300Х28Н2Л cast iron.

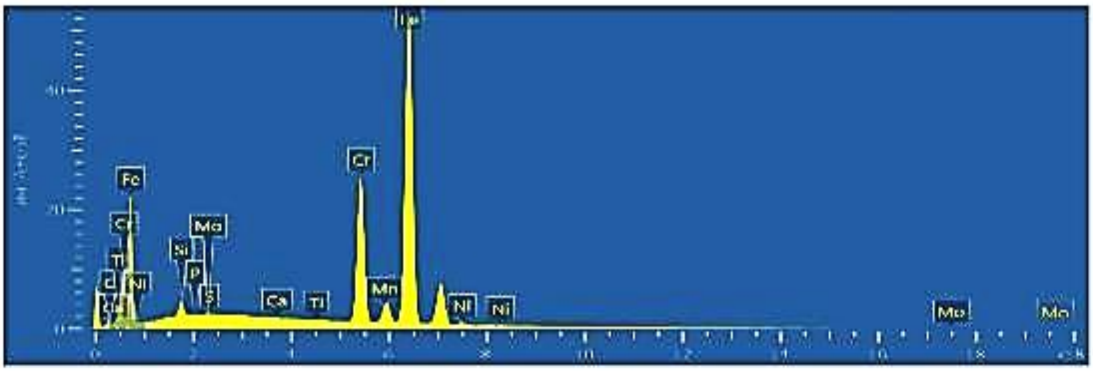


Fig.1. Analysis of the constituent elements of the metallic phase of white cast iron grade 300Х28Н2Л.

The presence of 75.11% iron in the metallic matrix of the alloy does not adversely affect its fluidity or mechanical strength and is therefore considered an acceptable and typical value for this grade of cast iron. Simultaneously, the chromium content, amounting to 28.68%, along with the relatively low concentrations of molybdenum (Mo), titanium (Ti), and nickel (Ni), each present at less than 0.4%, indicates that these elements are insufficient in quantity to promote significant carbide formation. This compositional balance ensures that the metallic matrix retains its desired ductility and toughness, while the limited carbide-promoting elements prevent excessive brittleness, which could otherwise compromise the material's performance under operational conditions. Consequently, understanding the precise distribution and proportion of these alloying elements is essential for predicting and optimizing the mechanical and technological properties of high-chromium white cast iron.

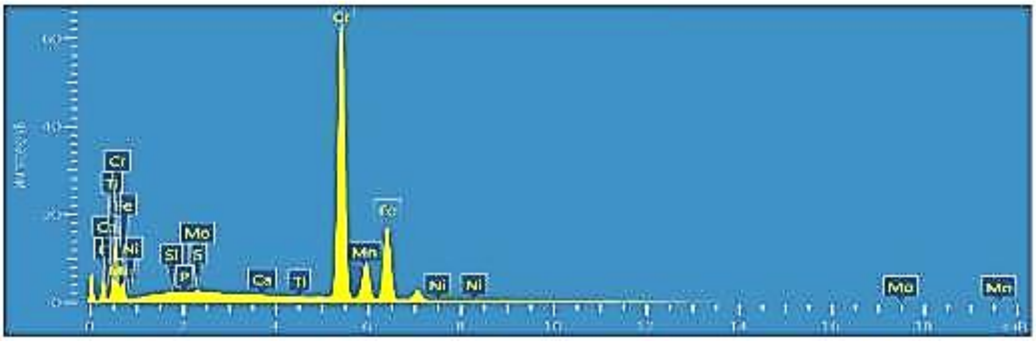


Fig.2. Analysis of the constituent elements of the carbide phase of white cast iron grade 300X28Н2Л.

The presence of a high content of chromium and other carbide-forming elements in the carbide phase has a significant positive impact on the mechanical properties and overall strength of the alloy. Chromium, in particular, enhances the stability of carbide particles, which in turn improves the alloy's wear resistance and hardness, contributing to better durability under mechanical stress. However, an excessively high iron content can have adverse effects. It tends to reduce the adaptability and stability of the carbide phase, which may lead to a decrease in the alloy's ductility and negatively affect its machinability. Therefore, achieving an optimal balance between carbide-forming elements, such as chromium, and iron is crucial for producing alloys that combine high strength, wear resistance, and satisfactory plasticity.

In addition, a low content of carbide-forming elements such as molybdenum (Mo), titanium (Ti), and nickel (Ni) within the carbide phase can negatively affect the alloy's microstructure and the ductility of the metallic matrix. Specifically, the insufficient presence of these elements reduces the stability and uniformity of carbides, which in turn impairs the alloy's ability to deform plastically without fracture. Similarly, a high concentration of silicon (Si) within the carbide phase tends to decrease ductility. However, if silicon is evenly distributed throughout the metallic matrix, it can enhance the alloy's overall ductility, thereby improving the quality of components manufactured from the alloy and increasing their operational efficiency.

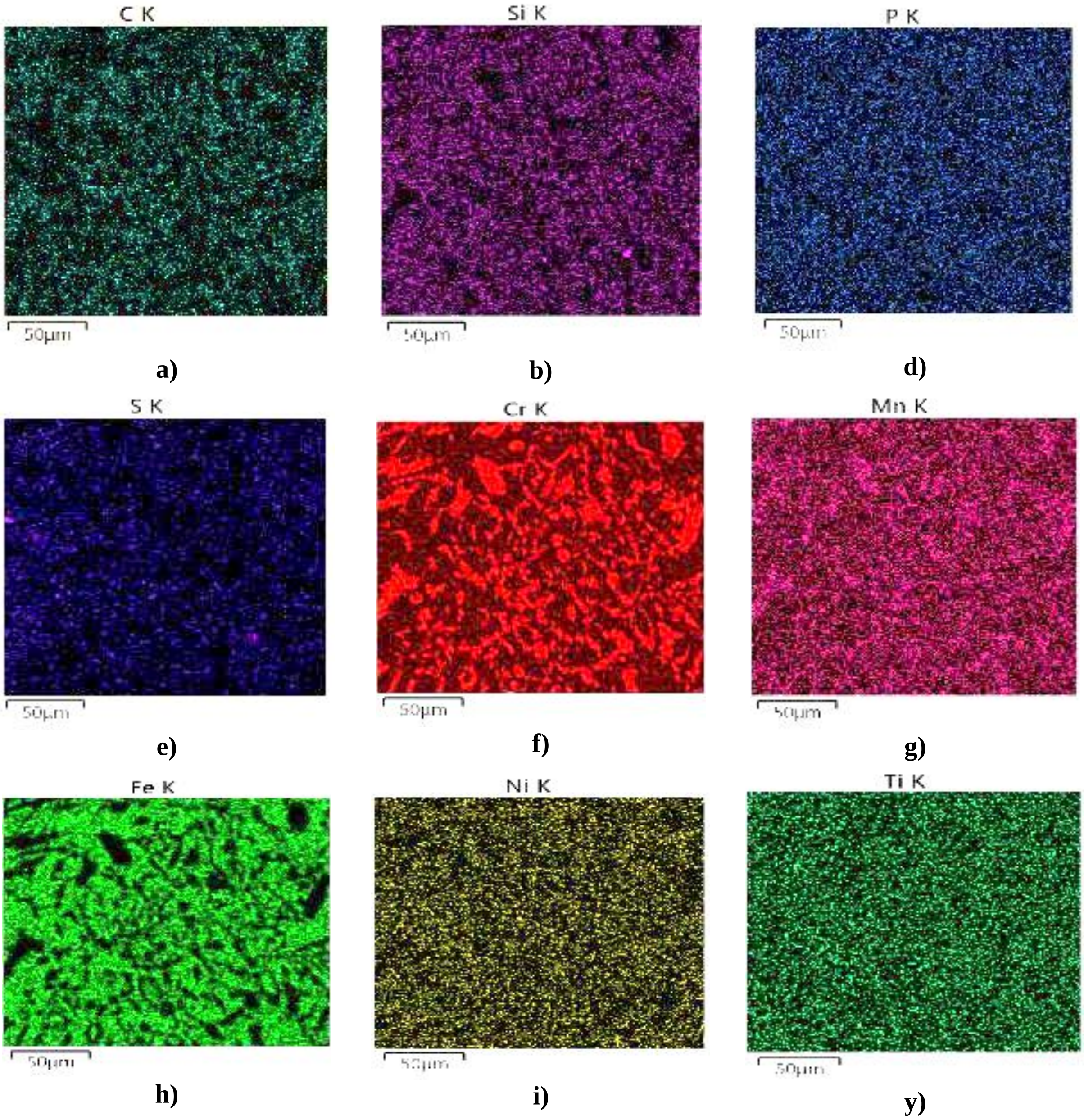
Analysis of the 300X28Н2Л alloy revealed that the alloying elements were not uniformly distributed throughout the structure. Specifically, certain elements were found to be concentrated in localized regions, leading to uneven distribution. In particular, phosphorus (P) and sulfur (S) were not evenly dispersed across the structure, and silicon (Si) was also observed to be distributed non-uniformly. This uneven distribution increases the heterogeneity of the alloy's microstructure and limits the complete interaction between the metallic matrix and carbide phases.

The emergence of the defects described above is believed to be influenced by two primary factors. The first factor is the insufficient content of carbide-forming elements in the alloy, meaning that the components necessary to form a stable carbide phase were not fully present. The second factor is the failure to maintain the required temperature regimes during the heat treatment process, which reduces the activity of chromium and other carbide-forming elements.

As a result, carbides are distributed unevenly within the structure, and their overall quantity is insufficiently developed. Analysis revealed that the degree of carbide phase formation in the alloy reached 25.36%, indicating that the carbide formation process was incomplete and suggesting the need for optimization of modification or heat treatment parameters.

Analysis of the results obtained: During the analysis of the chemical element distribution in gray cast iron samples of the 300X28Н2Л alloy, it was observed that the primary elements — iron (Fe), chromium (Cr), manganese (Mn), sulfur (S), phosphorus (P), silicon (Si), nickel (Ni), titanium (Ti), carbon (C), and molybdenum (Mo) — were distributed almost uniformly and proportionally across the structural surface. This uniform distribution demonstrates good compatibility among the alloying elements and indicates that the modification process was effectively carried out (Figure 3).

The even distribution of elements across the surface promotes structural homogeneity, ensuring the stable formation of austenite and carbide phases. Additionally, this uniformity positively affects the mechanical and operational properties of 300Х28Н2Л gray cast iron, particularly enhancing its wear resistance and thermal stability.



a) b) d)

e) f) g)

h) i) y)

Fig.3. Surface distribution of chemical elements in 300Х28Н2Л cast iron

In the chemical composition of the 300Х28Н2Л alloy, the chromium (Cr) content is 28.6%. Analysis revealed that chromium is distributed uniformly and stably across the structural surface. This indicates a high activity of chromium in the alloy and its ability to interact effectively with iron and carbon.

Iron (Fe), carbon (C), and chromium (Cr) combine to form primarily M_7C_3 and $M_{23}C_6$ types of chromium carbide phases. These carbide compounds play a critical role in the overall microstructure of the alloy, determining its hardness and thermal stability. However, microstructural analysis showed that the formed carbides are not evenly distributed across the structure; rather, they are partially disordered and unevenly dispersed.

Some carbide particles measure approximately 8–11 µm, and their large, irregular distribution can lead to localized stresses within the alloy. This adversely affects operational properties, including strength and thermal stability (Figure 3 f).

Silicon (Si) in the alloy was also observed to be relatively uniformly and stably distributed across the structural surface. Such even distribution of silicon plays an important role in the overall microstructure, enhancing the strength of the metallic matrix and improving its physical and mechanical properties.

Silicon interacts with iron and chromium, stabilizing the austenitic or martensitic structures in the alloy and influencing the accumulation of carbon in the carbide phases. As a result, the metallic matrix becomes denser, stronger, and more ductile. Additionally, silicon enhances adhesion at the interface between carbides and the metallic matrix, strengthening their bonding. This reduces the likelihood of carbide particle detachment and limits the propagation of microcracks (Figure 3 b).

Iron (Fe), the main component of the alloy, comprises 62.2% of its composition. Iron was found to be uniformly and stably distributed across the structural surface, indicating its fundamental role as the matrix-forming element and its contribution to the integrity of the microstructure. Such homogeneous distribution of iron strengthens the metallic matrix, improving overall mechanical stability and resistance to plastic deformation. A strong and stable matrix also positively influences the formation of carbide phases and their interaction with the matrix.

Carbide particles of the M_7C_3 and $M_{23}C_6$ types are relatively stably embedded in the iron-based matrix, exhibiting high adhesion to the metallic matrix. This prevents the detachment of carbides and maintains the stability of the matrix during wear (Figure 3 h).

Manganese (Mn) was observed to be evenly and stably distributed across the structural surface. This uniform distribution is attributed to the stepwise and systematic addition of alloying elements during alloy preparation, as well as continuous mixing at the molten state.

Manganese dissolves well in the iron matrix and partially accumulates in the forming carbide and austenite phases. It thereby influences the distribution of carbon in the microstructure and stabilizes the carbide formation process. Furthermore, manganese reacts with sulfur in the alloy, forming MnS compounds, which reduces sulfide inclusions. This enhances the purity of the metallic matrix, decreases structural defects, and improves the alloy’s plastic properties (Figure 3 g).

Conclusion: The study of the 300Х28Н2Л alloy has demonstrated that the distribution and content of alloying elements significantly influence its microstructure and mechanical properties. Chromium, as the primary carbide-forming element, was found to be uniformly distributed and highly active, contributing to the formation of stable M_7C_3 and $M_{23}C_6$ carbides, which enhance hardness and thermal stability. Iron, silicon, and manganese also exhibited uniform distribution, strengthening the metallic matrix and improving ductility, wear resistance, and operational performance.

However, the presence of sulfur, phosphorus, and unevenly distributed carbide particles was observed to negatively affect the structure, leading to localized stress concentrations and incomplete carbide formation. These findings highlight the critical importance of optimizing the content of carbide-forming elements and controlling heat treatment parameters to ensure a homogeneous microstructure and maximize the alloy’s mechanical and operational properties.

Overall, achieving a balanced distribution of alloying elements and proper heat treatment ensures that 300Х28Н2Л gray cast iron exhibits high structural stability, enhanced wear resistance, and improved performance under operational conditions.

REFERENCES

1. P.Kosasu, S.Inthidech Effect of Carbon on the Hardness during Heat Treatment of 30% Cr cast iron Containing Molybdenum, Nickel and Vanadium. april 2015 materials transactions.

2. Microstructural Characteristics and Mechanical Properties of Heat Treated High-Cr White Cast Iron Alloys Kh. Abdel-Aziz, M. El-Shennawy and Adel A. Omar. International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 14 (2017) pp. 4675-4686

3. Improvement in microstructure and wear-resistance of high chromium cast iron/medium carbon steel bimetal with high vanadium. Li Xuejun, Liu Ying, Zhou Tingchuan. Materials Research Express, Volume 8, Issue 4, id.046512, 9 pp. April 2021

4. Abdujalol Bektemirov, Nodir Turakhodjaev, Khusanboy Makhammadjanov, Sherzod Tashbulatov, Farrukh Abdullaev, Anvarjon Akhunjonov, Abdulkhamid Erkinjonov. “Characteristics of titanium nitride (TiN) in increasing the wear resistance of high-carbon steel alloys” I-CRAFT 4th International Conference on Research of Agricultural and Food Technologies Collection. ISBN: 978-625-99572-2-7 2024/ p.87-89

5. F.K. Abdullayev N.D. Turaxodjayev, Sh.B. Tashbulatov, A.B. Erkinjonov. “300Х28Н2Л markali yeyilishbardosh cho‘yanni molibden bilan modifikatsiyalash” “Quymakorlik va metallarga ishlov berish sohasida energiya va resurslarni tejashga yo‘naltirilgan innovatsiyalar” mavzusidagi xalqaro miqyosidagi ilmiy va ilmiy-texnik anjuman. Toshkent – 2025. b. 79-80

6. Sh. Chorshanbiev, F.Abdullaev, G. Atajanov I. Nasirkhujaev. “Preparation of high-strength details from modified steel alloy 110G13L” I-CRAFT 4th International Conference on Research of Agricultural and Food Technologies Collection. ISBN: 978-625-99572-2-7 2024/ p.235-239

7. Effects of heat treatment and erosion particle size on erosion resistance of a hypereutectic high-chromium cast iron. Alessio Suman, Annalisa Fortini. Coatings 2024, 14, 66. https://doi.org/10.3390/coatings 14010066 https://www.mdpi.com /journal/coatings.

6. Проблемные обзоры

7. Вести из лаборатории