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EFFECTIVE METHODS FOR OBTAINING CHROMIUM-MANGANESE LIGATURE IN LABORATORY CONDITIONS

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Abstract. This article presents the development of the technology for ferrochromium-manganese alloy production in laboratory conditions using domestic raw materials. The primary objective of the research is to optimize the process of obtaining high-quality alloys from chromium and manganese ores and to improve their chemical composition. Ferrochromium-manganese alloy is an essential additive in steel production, enhancing the material's strength, corrosion resistance, and wear resistance.

The study was conducted using a high-temperature Tamm furnace. Chromium and manganese ores were used as raw materials, while ferrosilicoaluminum alloy served as a reducing agent. The chemical composition of the produced alloy was analyzed, and its suitability for industrial applications was assessed. The research identified optimal temperature and time parameters for alloy production, which improved its quality.

The results of this study provide new insights into the effective production of ferrochromium-manganese alloys. Furthermore, the work opens opportunities for achieving new technological advances in Kazakhstan's metallurgy sector by utilizing domestic resources effectively.

Key words: ferrochromium-manganese alloy, ferrosilicoaluminum, reduction, metallurgy, chemical composition, technology.

Introduction. New high-performance alloys are primarily multicomponent or complex ferroalloys containing, along with widely used elements, new components in the most favorable combinations. Their physico-chemical properties should contribute to the necessary effect on the melt at a lower flow rate compared to standard alloys or give a greater effect at the same flow rate. At the same time, it should be possible to: use low-grade and off-balance ores; increase the production of ferroalloys without introducing additional capacities of aggregates; reduce the consumption of alloys by consumers; improve the quality of steel and cast iron [1, 8-15].

In modern metallurgy, various ligatures are widely used for the production of high-quality steel and special alloys. Among them, chromium-manganese ligature holds a special place, as it enhances the strength, wear resistance, and corrosion resistance of steel. Our country is rich in chromium and manganese reserves; however, the optimal technology for their processing has not been fully developed. In this regard, studying effective methods for obtaining chromium-manganese ligature in laboratory conditions is an important scientific and practical issue [2, 2; 3, 18].

The objective of this study is to optimize the technology for obtaining chromium-manganese ligature in laboratory conditions, identify effective methods, and investigate their metallurgical characteristics.

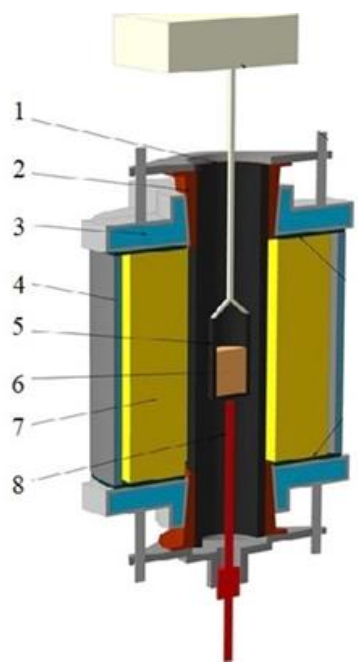
During the research, various raw material sources, reduction methods, and temperature regimes for obtaining chromium-manganese ligature will be examined. In addition, the chemical composition and physical-mechanical properties of the resulting alloy will be analyzed to assess its suitability for industrial application.

The data obtained from laboratory studies will contribute to the development of efficient methods for obtaining chromium-manganese ligature and facilitate its future implementation on an industrial scale.

Materials and methods of research. In this study, domestic chromium and manganese ores were used as the main raw materials, and ferrosilicoaluminum alloy was used as the reducing agent, employing the metallothermic reduction method. This method involves chemical reactions to reduce metal ores into their metallic forms. During the reduction process, the chromium and manganese ores are reduced by the ferrosilicoaluminum alloy to obtain chromium-manganese ligature.

The experiments were conducted in a high-temperature Taman furnace (Figure 1). This furnace is designed for modeling metallurgical processes. Its working area is made of a graphite tube, and the temperature control is achieved using a thyristor voltage regulator. The thyristor regulator is connected to the primary winding of the transformer, allowing for several thousand amperes of current at low voltage (from 0.5 to 15 V). The furnace can reach temperatures of approximately 1700-1800°C, with a maximum heating rate of 25°C/min. The high-temperature capabilities of this furnace make it highly suitable for conducting laboratory experiments at elevated temperatures [4, 89].

Electronic scales are installed at the top of the furnace, allowing for precise measurement of the crucible's mass. To hold the graphite crucible in place inside the furnace chamber, molybdenum (Mo) wire is used, which provides stability at high temperatures [5, 11].. The temperature inside the furnace is measured using a tungsten-rhenium (WR-5/20) thermocouple, which is placed in a corundum casing and is capable of functioning reliably in high-temperature environments.



1 – carbon-graphite tube; 2 – copper crimping ring; 3 – water–cooled lid; 4 – water-cooled body; 5 - crucible; 6 – test charge; 7 – protective lining; 8 – thermocouple
Figure 1 - High-temperature laboratory furnace Tamman (in section)

The chemical composition and physical-mechanical properties of the resulting chromium-manganese ligature were analyzed, and its potential for industrial application was assessed.

Results and their discussion. The experiments conducted to obtain the ferrochrome-manganese alloy were carried out at a temperature of 1650°C. The holding time at this temperature was 20 minutes, and the melting duration was 3 hours. These parameters directly influenced the quality of the alloy and its chemical composition. At a temperature of 1650°C and a holding time of 20 minutes, the chemical composition of the ferrochrome-manganese alloy was optimized.

As a result of chemical analyses, it was found that the ratio of chromium (Cr) and manganese (Mn) in the alloy was maintained, and the reduction process was effectively carried out through the use of ferrosilicoaluminum. The alloy composition contained the required amounts of chromium (Cr) and manganese (Mn), making it suitable for the production of high-quality steel. These results indicate that the ferrochrome-manganese alloy significantly contributes to the quality and efficiency of steel production.

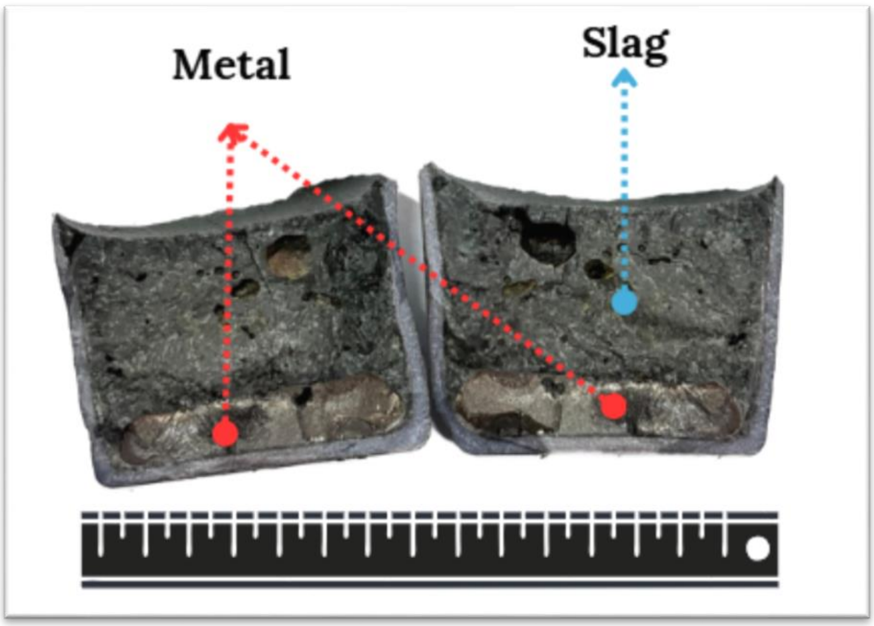


Figure 2 – Appearance of metal and slag obtained in laboratory conditions

To further analyze the results, the obtained metal and slag were examined using an electron microscope. The microscopic analysis revealed the microstructure and phase composition of the alloy. The images obtained through the electron microscope demonstrated that chromium and manganese were evenly distributed in the alloy, confirming the effective implementation of the reduction process. The slag showed the necessary phase changes, indicating that the purification process was well executed. Additionally, the microscopic analysis showed that there were no agglomerated or biphasic regions in the alloy structure, ensuring the high quality and purity of the ligature.

Based on the research results, we analyzed the microstructure and phase composition of both the metal and slag. Through various spectral analyses, it was determined that chromium and manganese are evenly distributed within the metal. This indicates that the reduction process was efficiently and thoroughly carried out.

The main elements in the metal composition – chromium (Cr) and manganese (Mn) – are evenly distributed in the required amounts for high-quality steel production. Consequently, the quality and chemical composition of the ligature were optimized. The slag also exhibited the necessary phase changes, demonstrating that the purification process was successful and that the levels of nitrogen or other harmful elements were minimal.

The research results show that the distribution of the main metals is balanced, and optimal conditions were ensured to maintain the correct ratios in their composition.

Conclusions

The results of the study demonstrated the possibility of effectively optimizing the technology for producing ferrochromium-manganese alloys in laboratory conditions. The chemical composition and physical properties of the obtained alloy met the high-quality standards required for steel production. During the experiments, the use of ferrosilicoaluminum as a reducing agent in the processing of chromium and manganese ores proved to be highly effective. At a temperature of 1650°C and a holding time of 20 minutes, the required ratio of chromium and manganese in the alloy was maintained, which enhances the strength and other properties of the steel.

As a conclusion, the study identified effective methods for producing ferrochromium-manganese alloys that can be applied on an industrial scale. Given Kazakhstan's abundant chromium and manganese reserves, this method plays a crucial role in the development of the domestic metallurgy sector. The production of high-quality ferrochromium-manganese alloys offers the potential for implementing efficient and environmentally friendly technologies in the metallurgical industry.

This research contributes to the introduction of new technological advancements in the metallurgy industry by efficiently utilizing Kazakhstan’s natural resources.

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ЗЕРТХАНАЛЫҚ ЖАҒДАЙДА ХРОММАРГАНЕЦТІ ЛИГАТУРАНЫ АЛУДЫҢ ТИІМДІ ӘДІСТЕРІ

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Аңдатпа. Бұл мақалада отандық шикізаттарды пайдалана отырып, хроммарганецті лигатураның зертханалық жағдайда технологиясын әзірлеу көрсетілген. Зерттеу жұмысының негізгі мақсаты – хром және марганец кендерінен жоғары сапалы лигатура алу процесін оңтайландыру және оның химиялық құрамын жақсарту болып табылады. Хроммарганецті лигатура болат өндірісінде беріктік, коррозияға төзімділік және тозуға қарсы қасиеттерін жақсартатын маңызды қосымша материал ретінде қолданылады.

Зерттеу жұмысы жоғары температуралы Тамман пешінде жүргізілді. Эксперименттерде хром және марганец кендері шикізат ретінде, ал ферросиликоалюминий қорытпасы тотықсыздандырғыш ретінде қолданылды. Алынған лигатураның химиялық құрамы зерттеліп, оның өндірістік мақсаттарға сәйкес келетіндігі анықталды. Зерттеу нәтижелері хроммарганецті лигатураны тиімді алу үшін оңтайлы температуралық және уақыттық параметрлерді белгілеп, оның сапасын арттыруға мүмкіндік берді.

Бұл жұмыс болашақта металлургиялық өндірістерде хроммарганецті лигатураны өндірудің тиімді әдістерін енгізуге мүмкіндік береді. Сонымен қатар, Қазақстанның табиғи қорларын тиімді пайдалану арқылы отандық металлургия саласында жаңа технологиялық жетістіктерге қол жеткізуге жол ашады.
Түйін сөздер: хроммарганецті лигатура, ферросиликоалюминий, тотықсыздандыру, металлургия, химиялық құрам, технология.

ЭФФЕКТИВНЫЕ МЕТОДЫ ПОЛУЧЕНИЯ ХРОММАРГАНЦЕВОЙ ЛИГАТУРЫ В ЛАБОРАТОРНЫХ УСЛОВИЯХ

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Аннотация. В статье представлена разработка технологии получения хроммарганцевой лигатуры в лабораторных условиях с использованием отечественного сырья. Основная цель исследования — оптимизация процесса получения высококачественных лигатур из хромовых и марганцевых руд и улучшение их химического состава. Хроммарганцевая лигатура является важным добавочным материалом в производстве стали, улучшая прочность, коррозионную стойкость и износостойкость.

Исследование проводилось с использованием высокотемпературной печи Таммана. Хромовые и марганцевые руды использовались как сырье, а ферросиликоалюминий – в качестве восстановителя. Анализ химического состава полученной лигатуры показал, что она соответствует промышленным стандартам. В ходе исследования были определены оптимальные температурные и временные параметры для производства лигатуры, что позволило улучшить ее качество.

Результаты исследования открывают новые возможности для эффективного производства хроммарганцевой лигатуры на промышленном уровне, а также способствуют внедрению новых технологических решений в металлургическую отрасль Казахстана с использованием отечественных ресурсов.

Ключевые слова: хромомарганцевая лигатура, ферросиликоалюминий, восстановление, металлургия, химический состав, технология.