IRSTI 53.03.03
UDC 669 **DOI 10.70239/arsu.2024.t78.n4.18**

REVIEW OF THE CHROMIUM-MANGANESE-SILICONCONTAINING COMPLEX FERROALLOY

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Abstract. The relevance of the work lies in the need to develop a comprehensive ferroalloy technology by developing theoretical and technological foundations that contribute to increasing technical and economic indicators, as well as solving the task of attracting poor manganese ores of the Republic of Kazakhstan for metallurgical processing. The ever-high demand for quality steel grades contributes to an increase in the production of ferroalloys, in particular, complex alloys based on three main elements-manganese, silicon and chromium, which are acidifiers of steel. Poor and small ores formed during the enrichment of manganese and chromium ores are completely stored in dumps and do not find use in industry, and their disposal at work is a solution to the problem. There were attempts to agglomerate the small of the bad chromium ores. However, from an economic and technological point of view, they did not give impressive results. In the work, it is proposed to involve low-quality chromium and manganese ores in metallurgical processing to obtain a new multipurpose chromium-manganese-siliconcontaining ferroalloy suitable for steel production or subsequent processing. Purpose of the work a review was carried out in order to lay the scientific basis for the production of a complex chromium-manganese-silicon component ferroalloy using chromium and poor manganese ores of Kazakhstan.

Key words: chromium, manganese, silicon, chromium-manganese-siliconcontaining ferroalloy, steel.

Introduction. The development of the ferroalloy industry in Kazakhstan in modern conditions is very relevant. This applies primarily to the Chromium and manganese industries.

Chrome ores and products made from them are in high demand on the world market. This is due to the possibility of obtaining with their help a wide range of high-quality steels, refractory steels, protective coatings. The undisputed leadership in the volume of consumption of chrome ores belongs to metallurgy. About 80% of the chrome ore mined in the world is used in metallurgy, 10%-in refractory and the remaining 10%-in the chemical industry. Such a high proportion of chromium use in metallurgy is explained by the performance characteristics of chromium-containing steels and alloys. Chromium, as an alloying additive, helps to increase the hardness, strength of steel, increases its elasticity, heat resistance, wear resistance and corrosion resistance.

The demand for the production of manganese alloys is 700 million ton. This is due to the availability of reserves of manganese raw materials up to tons. At the same time, the issue of development of complex ferroalloys based on silicon, aluminum, manganese, etc., based on the presence of huge reserves of natural and man-made raw materials (coal waste, substandard ores, etc.), which are the source of these metals, is relevant in Kazakhstan.

The tendency to deteriorate the quality of manganese ore raises the question of providing ferroalloy plants of Kazakhstan with manganese raw materials in the future. Despite the fact that Kazakhstan has large reserves of manganese-containing raw materials, it is often unsuitable for smelting standard grades of manganese ferroalloys, since the main reserves of ores (about 70%) are iron-manganese species. The remaining 30% are highly enriched oxidized manganese ores [1, 31-32].

In metallurgical production, the use of low-grade raw materials, as described above, will increase the level of production of ferroalloys, including complex ferroalloys. In addition, poor ores solve not only the problem of limiting the resource base, but also a number of environmental problems [2, 3].

One of the main factors contributing to the rational use of raw materials resources is the integrated use of raw materials in order to obtain not only all valuable substances, but also, as far as possible, all the elements that make up the waste rock, based on their modern and promising need for them.

The economic use of material resources and reducing the material capacity of products is one of the most important tasks of increasing the efficiency of social production.

The problem of integrated use of raw materials becomes especially important with an increase in the deficit of certain types of it (for example, high-grade manganese ores and coking coal) and an increase in the number of waste accompanying the processing of low-grade raw materials.

In ferrous metallurgy, it is necessary to use complex ferroalloys to increase production efficiency, improve technologies and improve technical and economic indicators. Currently, the expansion of the range of alloys used in the steel industry requires the search for new, high-quality types of complex ferroalloys [3, 98-100].

Materials and methods of research. Complex (multicomponent) ferroalloys can only be a reducing agent (modifier, alloying alloy) or a combination of the reducing agent and alloying alloy, modifier and reducing agent, etc. The basis of complex alloys is iron, chromium, manganese, silicon, aluminum, etc.

The works of I. P. Kazachkov and N. P. Melikaev are great in the theory and practice of smelting a complex ferroalloy with chromium-manganese-silicon components.

The authors [4, 17-19] argue that in the smelting of a complex ferroalloy with chromium-manganese-silicon components, it is possible to ensure the normal smelting of ore in a reducing electric furnace with a carbothermic process from a mixture of chromium and poor manganese ores. Taking into account the general requirements for the quality of ferroalloys used in the smelting of chromium and manganese ores of Kazakhstan and the needs of the steel industry, the limit of the percentage content of basic elements in the complex ferroalloy with chromium-manganese-silicon components was determined (Table 1).

Table 1 – Chemical composition of the complex ferroalloy with chromium-manganese-siliconcontaining, %.

Cr	Mn	Si	C	P	S
>37	>15	>8	>5.5	>0.1	>0.02

The chemical composition of all raw materials, as well as the technical composition of high ash coal, are determined, the values of which are given in tables 2-3.

Figure 1. Raw composition mix

Table 2. Chemical composition of raw materials for a new complex alloy with chromium and manganese components, %

Material	Components						
	Cr_2O_3	$Mn_{general}$	Fe_2O_3	SiO_2	Al_2O_3	MgO	CaO
Manganese ore	-	17,39	10,06	40,0	7,52	0,74	3,11
Chromium ore	53,40	-	14,03	6,13	10,24	15,05	1,65
High ash coal	-	-	0,35	68,55	19,33	4,24	7,88

Table 3. Technical composition of high ash coal

A, %	W, %	V, %	C_{solid}, %
41,13	1,12	17,31	40,44

Results and their discussion. Smelting using raw materials and high-ash coal as reducing agents, consisting of impurities of chromium and poor manganese ores, showed the possibility of obtaining a new complex alloy of chromium and manganese components [5, p. 1-2]. The chemical composition of the metal and slag was obtained as follows (Tables 4-5).

Table 4. Chemical composition of the metal, %

Cr	Mn	Fe	Si	C
40,80	19,44	25,44	9,75	4,53

Table 5. Chemical composition of slag, %

Cr_2O_3	MnO	FeO	SiO_2	Al_2O_3	CaO	MgO
6,09	1,71	1,03	39,78	26,27	6,14	18,38

The properties of the chromium-manganese-siliconcontaining complex alloy, which is important for steelmaking production, usually exceed those of standard ferroalloys. The melting point of the alloy is 1200-1300°C, the density is about 6.8 g/cm^3. In terms of melting speed in liquid steel, the chromium-manganese-siliconcontaining complex ferroalloy surpasses ferromanganese, ferrochrome and ferrosilicochrome. The thermal effect of the alloy on the steel mixture is almost the same as for standard ferroalloys. The oxidation of the chromium-manganese-siliconcontaining complex ferroalloy is 1400 and 1500°C lower than that of silicomanganese, so it ensures its better assimilation in steel. When deoxygenating steel with the chromium-manganese-siliconcontaining complex ferroalloy, there are fewer non-metallic impurities and allows more complete and faster oxygen removal than when introducing appropriate amounts of silicomanganese, ferrochrome and ferrosilicon. This means that the chromium-manganese-siliconcontaining complex ferroalloy is suitable for deoxygenating and alloying steel.

Conclusions

Chromium and manganese components showed the possibility of smelting a new complex alloy using a raw mixture of chromium and poor manganese ores of Kazakhstan and high ash coal as a reducing agent. The chemical composition of the metal was obtained as follows, %: 40.80 Cr; 19.44 Mn; 9.75 Si; 25.44 Fe; 4.53 C; chemical composition of slag, %: 6.09 Cr_2O_3; 1.71 MnO; 1.03 FeO; 39.78 SiO_2; 26.27 Al_2O_3; 6.14 CaO; 18.38 MgO.

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ХРОМ-МАРГАНЕЦ-КРЕМНИЙ ҚҰРАМДАС ФЕРРОҚОРЫТПАҒА ШОЛУ

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Аңдатпа. Жұмыстың өзектілігі Қазақстан Республикасының кедей марганец кендерін металлургиялық қайта өңдеуге тарту міндетін шешумен қатар техникалық-экономикалық көрсеткіштерді арттыруға ықпал ететін теориялық және технологиялық негіздерді әзірлеу жолымен кешенді ферроқорытпа технологиясын әзірлеу қажеттігінен тұрады. Болаттың сапалы маркаларына үнемі жоғары сұраныс ферроқорытпалар, атап айтқанда, үш негізгі элемент - болатты қышқылдатушы болып табылатын марганец, кремний және хром негізіндегі кешенді қорытпалар өндірісін ұлғайтуға ықпал етеді. Марганец пен хром кендерін байыту кезінде пайда болған нашар және ұсақ кендер толығымен үйінділерде сақталады және өнеркәсіпте пайдаланылмайды, ал оларды жұмыста кәдеге жарату мәселенің шешімі болып табылады. Нашар хром кендерінің аз мөлшерін агломерациялау әрекеттері болды. Алайда, экономикалық және технологиялық тұрғыдан алғанда, олар әсерлі нәтиже берген жоқ. Жұмыста болатты өндіруге немесе одан әрі өңдеуге жарамды жаңа көп мақсатты хром-марганец-кремний құрамдас кешенді ферроқорытпа алу үшін металлургиялық өңдеуге сапасыз хром және марганец кендерін тарту ұсынылады. Жұмыс мақсаты Қазақстанның хром және кедей марганец кендерін қолдана отырып, кешенді хром-марганец-кремний құрамдас ферроқорытпаны алудың ғылыми негізін қалау мақсатында шолу жасалынды.

Түйін сөздер: хром, марганец, кремний, хром-марганец-кремний құрамдас ферроқорытпа, болат.

ОБЗОР КОМПЛЕКСНОГО ФЕРРОСПЛАВА, СОДЕРЖАЩЕГО ХРОМ-МАРГАНЕЦ-КРЕМНИЙ

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Аннотация. Актуальность работы заключается в необходимости разработки комплексной ферросплавной технологии путем разработки теоретических и технологических основ, способствующих повышению технико-экономических показателей, наряду с решением задачи вовлечения Республики Казахстан в металлургическую переработку бедных марганцевых руд. Постоянно высокий спрос на качественные марки стали способствует увеличению производства ферросплавов, в частности, комплексных сплавов на основе марганца, кремния и хрома, которые являются подкислителями трех основных элементов-стали. Бедные и мелкие руды, образующиеся при обогащении марганцевых и хромовых руд, полностью складируются в отвалах и не находят применения в промышленности, и их утилизация на производстве является решением проблемы. Были попытки агломерировать мелкие и некачественные хромовые руды. Однако с экономической и технологической точки зрения они не дали впечатляющих результатов. В работе предлагается вовлекать в металлургическую переработку низкокачественные хромовые и марганцевые руды для получения нового многоцелевого хромомарганцево-кремнийсодержащего ферросплава, пригодного для производства стали или последующей переработки. Целью работы был проведен обзор с целью заложения научной основы получения комплексного хромомарганцево-кремниевого ферросплава с использованием хромовых и бедных марганцевых руд Казахстана.

Ключевые слова: хром, марганец, кремний, хром-марганцево-кремнийсодержащий ферросплав, сталь.