A. ZHUNUSOV, L. TOLYMBEKOVA, YE. ABDULABEKOV
ZH. ZHOLDUBAYEVA, P. BYKOV

ISSN 0543-5846
METABK 60(1-2) 101-103 (2021)
UDC – UDK 669.052: 622.341: 669.1.782.74: 622.7: 479=111

AGGLOMERATION OF MANGANESE ORES AND MANGANESE CONTAINING WASTES OF KAZAKHSTAN

Received – Primljeno: 2020-08-28
Accepted – Prihvaćeno: 2020-11-04
Preliminary Note – Prethodno priopćenje

This article presents the results of a research on the agglomeration of manganese ores and manganese-containing waste in Kazakhstan. In Kazakhstan, there are huge reserves of manganese ores, most of these ores are not suitable for smelting standard grades of manganese alloys. Manganese ores have undergone agglomeration. Laboratory experiments have established that the use of dolomite in the agglomeration of small manganese ores provides for the formation of more refractory final slags for the production of ferro-silicomanganese, considering the fusibility of manganese in Kazakhstan. Industrial tests were carried out at the Aksu Ferroalloy Plant in the sintering plant for sintering manganese ores and smelting ferrosilicon manganese.

Keywords: ore, manganese, ferrosilicomanganese, agglomeration, Kazakhstan

INTRODUCTION

In Kazakhstan, there are huge reserves of manganese ores, most of these ores are not suitable for smelting standard grades of manganese alloys.

Kazakhstan's ferroalloy industry has recently experienced an acute shortage of high-quality manganese ore for the production of manganese alloys.

The needs for ferroalloy plants of manganese ore is provided by the manganese ore industry of Kazakhstan. The fraction of small classes (less than 10 mm) in the ore is 30 % [1-3].

Their use in the metallurgical redistribution is difficult and increases energy costs. A large number of small ores are practically unsuitable for direct use in production processes that require special preparation - agglomeration [2-4].

ANALYSIS OF ACHIEVEMENTS AND PUBLICATIONS

In the world, all three methods of sintering are widely used for sintering ore fines: pellet production, sintering, and briquetting [2-6].

At the «Kobe Steel» plant in the mixture of sinter used for smelting silicomanganese, blast furnace gas cleaning dust containing 50-55 % solid carbon is used, which allows 1,5 times reduction in coke breeze consumption during agglomeration. A feature of the technology at this plant is the crushing of hot sinter. The proportion of hot sinter is 45-70 %, and the temperature of the charge loaded into the furnace is 400-450 °C, which provides energy savings during smelting of 150 kWh/t of alloy [5-8].

In Kazakhstan, numerous researches was focused on agglomeration and fines of manganese ores [2]. Thus, researches in [9] to determine the main technological parameters of agglomeration were directed to Zhezdinsky (fractions 0-2 mm) and Ushkatinsky (fractions 0-2 mm and 0-10 mm) manganese concentrates and ores. The resulting agglomerates had the following chemical composition: manganese – 28,99 %: iron – 9,28-9,86 %; silica – 25,0-27,0 %.

The performed laboratory and industrial tests in [2, 9-10] showed the possibility of producing high-quality manganese agglomerate from ores of Central Kazakhstan. The results of these studies served as the basis for the construction of the sintering shop at the Aksu ferroalloy plant with a capacity of 350 thousand tons of sinter (chromium and manganese) per year [1].

STATEMENT OF MATERIAL AND RESULTS

In the smelting of ferrosilicon manganese, manganese ores and concentrates, quartzite, reducing agents and slag-forming additives – materials containing CaO, MgO, and other components that form the most durable chemical compounds with oxides — products of the reduction reaction, are used as charge materials [1].

The regulation of the slag regime of silicomanganese smelting is one of the urgent directions for increasing the extraction of the leading elements, primarily manganese, and comes down to two aspects: thermodynamic - increasing the activity of manganese oxide, and

A. Zhunusov (zhunusov_ab@mail.ru), L. Tolymbekova, P. Bykov (Bykov_petr@mail.ru), Toraighyrov University, Pavlodar, Kazakhstan
Ye. Abdulabekov, Kazchrome TNC, Aktobe, Kazakhstan
Zh. Zholdubayeva, Karaganda Technical University, Karaganda, Kazakhstan

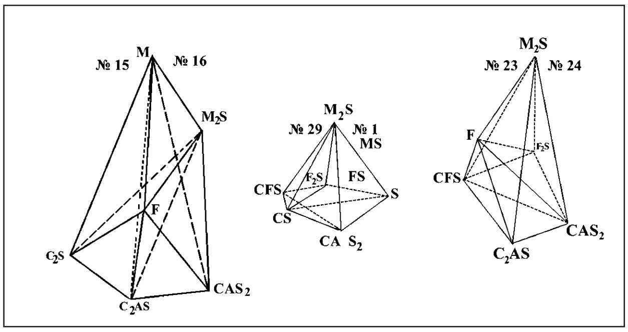

Figure 1 The sequence of transformation of the secondary phases in the melts of the system FeO-MnO-CaO-Al_2O_3-SiO_2 silicomanganese [1]

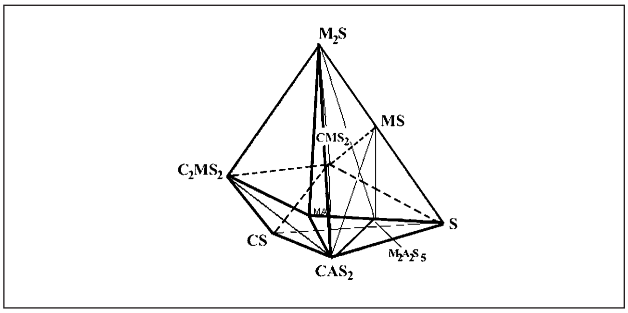

Figure 2 Silica-manganese magnesia slags (phase composition diagrams of the system MgO-CaO-Al_2O_3-SiO_2) acc. to [1]

kinetic - reducing the structurally sensitive properties - viscosity and electrical conductivity of slag. The most commonly used fluxing materials are limestone and dolomite. ($CaCO_3 \cdot MgCO_3$). Especially the use of dolomite provides a lower viscosity of the slag, with a slightly lower amount of flux [1].

Concentrates Tur (Figures 1-2) according to temperature characteristics (softening and melting temperatures) are classified as fusible.

This is caused by the fact that according to the normative phase composition they are located in the area of pentatope No. 16 of the phase diagram of the system FeO-MnO-CaO-Al_2O_3-SiO_2, especially closer to tephroitic ($2MnO \cdot SiO_2$).

According to the works of [1] on diagrams of the phase structure of the system FeO-MnO-CaO-Al_2O_3-SiO_2 it is seen that the ores contained in the pentatopes No. 15 and 16 (the ores of the Tur deposit are located in the pentatope No. 16), as iron and manganese are reduced from them, they move in space to the regions of adjacent pentatopes No. 29, 23, 34 and 1.

If these movements are carried out in the vicinity of the plane Mn_2SiO_4 (tephroite) – $CaO \cdot Al_2O_3 \cdot 2SiO_2$ (anorthitis) – SiO_2 (silica), then the resulting slag will be refractory, less electrically conductive.

For this, dolomite must be added during the agglomeration of small manganese ores. This will ensure the formation of more refractory end slags.

The produced experimental agglomerates were subjected to chemical analysis and on their basis the normative phase compositions in the system were calculated MgO-MnO-CaO-Al_2O_3-SiO_2 (Table 1).

The results showed that the obtained agglomerate with the addition of 10 % dolomite is located in pentatope No. 3 and is characterized by the presence of diopside in its composition CMS_2 (Table 2). This confirms the previously identified thermodynamic-diagram analysis of the phase structure diagram of the system MgO-MnO-CaO-Al_2O_3-SiO_2 [1].

The assumption that the most fusible compound in the spessartine system M_3AS_3, present in the screening of manganese ores and non-fluxed agglomerate, when more than 8 % dolomite is introduced into the sinter charge, a refractory compound diopside will be formed CMS_2. In the presented Table 2, sample No. 1, No. 2 - agglomerate without dolomite, sample No. 3 agglomerate with the addition of 5 % dolomite and sample No. 4 with the addition of dolomite 10 %, respectively.

Industrial tests were carried out at the Aksu Ferroalloy Plant (AFP). At the time of testing in the sinter plant of the AFP, the technical regulations for the production of manganese sinter were developed and approved. During the pilot tests, about 14 thousand tons of manganese sinter were produced.

For the accumulation of 1 000 tons of agglomerate, its test began during the smelting of ferrosilicon manganese in workshop No. 1. Table 3 shows the averaged data for the analysis of agglomerate fractions of 6-100 mm (chemical, drum strength and particle size distribution).

Pilot tests of ferrosilicon manganese production were carried out using fluxed agglomerate in the charge (experimental smelting).

During the tests used lumpy concentrate of manganese ores of the Tur field, the chemical composition of which is shown in Table 4.

The chemical composition of the concentrate is characterized by inconsistency, especially with respect to the Mn / Fe ratio, which varied between 5,86 and 9,35. Dolomite and quartzite were used as fluxing components. The reducing agent was Chinese coke 5-40 mm fraction (14,8 % ash, 2,7 % volatile, 10,6 % moisture) and Ekibastuz coal (42,8 % ash, 15,7 % volatile, 10,6 % moisture).

In the base melts, manganese ore of fractions of 0-10 and 10-80 mm in a ratio of 30:70 was used, which is characteristic of the level of fines in the main stream of raw materials entering the plant. The condition of the furnace was characterized by large fluctuations in the current load on the electrodes and unstable operation of the furnace top (“holes”, collapses and bursts of the charge).

In experimental melts, the charge consisted of manganese ore fraction 20-80 mm, fluxed manganese sinter fraction 10-80 mm, coke, coal and an additional amount of dolomite. The use of manganese sinter allowed withdrawing from the hitch quartzite and reducing the weight of coal to 90 kg, since the required amount of SiO_2 was supplied with the sinter, reducing the amount of solid reducing agent in the sample from 110 kg to 80 kg.

Table 1 **The chemical composition of manganese agglomerates**

Material	MgO	FeO	MnO	CaO	Al_2O_3	SiO_2
Agglomerate without dolomite	1,03	7,57	25,04	3,56	8,13	43,70
Agglomerate without dolomite	1,16	7,57	29,82	4,17	8,64	40,40
Agglomerate with dolomite 5 %	1,92	9,94	20,65	3,06	6,92	44,60
Agglomerate with dolomite 10 %	2,58	10,97	20,78	4,06	6,80	43,00

Table 3 **Averaged agglomerate analysis data**

Material	Chemical analysis content of elements / %					Drum (tech) strength / %		Grading / %	
	Mn_{gen}	Fe_{gen}	SiO_2	C	W	X (impact)	X_1 (abrasion)	-5 mm	+40 mm
Agglomerate	35,9	6,8	28,5	0,27	0,14	73	18	23,6	7,7

Table 2 **Material and regulatory phase states of manganese agglomerates based on the system MgO-MnO-CaO-Al_2O_3-SiO_2**

№ of probe	№ pent	Material composition / %				
		MgO	MnO	CaO	Al_2O_3	SiO_2
1	4	1,26	30,74	4,37	9,98	53,64
2	4	1,38	35,42	4,95	10,26	47,99
3	4	2,49	26,77	3,97	8,97	57,81
4	3	3,34	26,91	5,26	8,81	55,68

№ of probe	№ pent	Regulatory Phase Composition / %					
		CMS_2	CAS_2	M_2S	M_3AS_3	S	M_2S
1	4	-	21,63	37,62	10,01	28,54	2,2
2	4	-	24,50	46,55	6,27	20,27	2,41
3	4	-	19,65	32,79	8,63	34,59	4,35
4	3	1,54	24,07	38,28	-	30,78	5,33

Table 4 **The chemical composition of the manganese concentrate «Tur»**

№ of probe	Mn	Fe	SiO_2	Mn/Fe	Mn/SiO_2
101	43,3	4,91	15,8	8,82	2,74
102	41,8	5,6	16,2	7,46	2,58
108	40,2	6,89	16,5	5,86	2,43
109	42,1	4,5	18,5	9,35	2,28

CONCLUSION

The work proved that the replacement of fine manganese ore with a fluxed agglomerate improved the electrical and technological modes of smelting (the state of the grate of the furnace, uniform release of gases, smooth discharge of the charge, effective assimilation of coke carbon, intensification of the reduction of manganese and silicon from the slag). Based on the research of the chemical composition of furnace slags for smelting silicomanganese, the phase composition of these slags was determined, which lie in the pentatope M-M_2S-Mg_2S-CAS_2-C_2AS, which confirms the results and conclusions of theoretical studies.

REFERENCES

[1] Zhunusov A. K., Tolymbekova L. B. Metallurgical processing of manganese ores from the Tur and Zapadny Kamys – Pavlodar: Kereku, 2016. – 209 p.

[2] Samuratov Ye., Kelamanov B., Akuov A., Zhumagaliyev Ye., Akhmetova M. Smelting standard grades of Manganese ferroalloys from agglomerated thermo-magnetic Manganese concentrates, Metallurgija 59 (2020) 1, 85-88.

[3] Shabanov E., Izbembetov D. D., Baisanov S. O., Shadiev M. F. Technology for the production of high-carbon ferrochromium using mono-briquettes / Izvestiya Ferrous Metallurgy (2018) 9, 702–707).

[4] Tolymbekova L. B., Kim A. S., Zhunusov A. K., Babenko A. A. It has been shown that it is not necessary to take a look at the thermal transformations of manganese / Metallurgist 56 (2013), 919–924.

[5] Koryakova O. F. Preparation of manganese ores for smelting in powerful closed electric furnaces / Ferrous metallurgy. Bulletin of Chermetinformation (1985) 14, 3–16.

[6] Chumarova I. V. Improving the processes of preparing raw materials for ferroalloy production abroad / Surveyinformation: Sb.nauch.tr. Inst. «Chermetinformatsiya», sir. Ferroalloy production (1984) 2, 1–27.

[7] Kitamura M., Morimoto M., Kurita J. Improvement of electric power consumption in silicomanganese smelting / Protise 2-nd International Ferroalloys Congress “INFACON-80”. – Lausanne, 1980. – P 59–72.

[8] Jochikoshi T., Takeuchi O., Miyashits T. et al. Development of a composite cold pellet for silico-manganese production / Trans. ISIJ 24 (1984) 6, 492–497.

[9] Kim V. A., Akberdin A. A., Lee A. M. Development and creation of production technology of manganese sinter in Kazakhstan / Sat. scientific tr. CMI: «Physico-chemical and technological issues of metallurgical production in Kazakhstan»: – Almaty, 2002. – T.30. – P 363–370.

[10] Yessengaliyev D., Baisanov S., Issagulov A., Baisanov A., Zayakin O., Abdrashit A. Thermodynamic diagram analysis (TDA) of MnO–CaO-Al_2O_3-SiO_2 and phase composition of slag in refined ferromanganese production / Metalurgija 58 (2019) 3-4, 291-294.

Note: The responsible for English translate is Almaz Kuandykov, Pavlodar, Kazakhstan