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SMELTING STANDARD GRADES OF MANGANESE FERROALLOYS FROM AGGLOMERATED THERMO-MAGNETIC MANGANESE CONCENTRATES

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Studies have been carried out to investigation the possibility of the agglomeration of thermomagnetic manganese concentrates from the Zhomart and Western Kamys fields (Kazakhstan) with obtaining from them conglomerates suitable for chemical and mechanical properties for subsequent ferroalloy processing. Their metallurgical properties are studied and the principal possibility of obtaining standard grades of manganese alloys from them in laboratory conditions is shown.

Keywords: ferroalloy manganese, thermomagnetic manganese concentrate, reductant, sintering, briquette.

INTRODUCTION

Due to the ever-growing demand for metallurgy in manganese, the use of substandard iron-manganese ores is becoming increasingly important. Preparation for metallurgical processing requires the implementation of complex methods of enrichment with subsequent agglomeration and smelting of the obtained raw materials standard grades of manganese ferroalloys. Preliminary preparation of iron-manganese raw material significantly improves its quality, improves technical and economic indicators of manganese alloys production and allows to expand the raw material base [1].

Kazakhstan has huge reserves of manganese-containing raw materials, but most unsuitable for the production of standard grades of manganese ferroalloys, as the main reserves of ores (up to 70 %) are represented by iron - manganese varieties, and the remaining 30 % - hard-to-rich oxidized and primary manganese ores [2].

At the moment, iron-manganese ores are not involved in ferroalloy production, they are stored on dumps due to the lack of rational technology of their processing [3 - 6]. These varieties include iron-manganese ores of the Western Kamys and Zhomart deposits.

For supplying raw materials for the developing manganese ferroalloy industry, first of all, it is necessary to direct research to create effective technologies for the enrichment of iron-manganese ores in order to involve them in metallurgical processing. One of the options is the roasting-magnetic treatment of iron-manganese ores to produce iron ore and manganese concentrates and the development of technological processes for the production of concentrates in the smelting of electric steel and ferrosilicon manganese [3 - 7].

The Chemical and metallurgical Institute has developed and mastered in large-laboratory conditions the technology of complex processing of iron-manganese ores of the Western Kamys and Zhomart deposits, according to the roasting-magnetic enrichment flow sheet with the production of high-quality manganese concentrate [6]. The resulting manganese concentrates have a size 0 - 5 mm. For using them in ferroalloy production necessary of agglomerating. It should also be noted that the obtained concentrates contain in their composition residual fixed carbon from 11,32 to 12,1 %, which will positively affect the sintering process and the smelting of ferrosilicon manganese from the agglomerated material (for example, from briquettes) containing fixed carbon in its composition, which will partially replace the reducing agent.

RESEARCH METHODOLOGY

When smelting ores in ferroalloy furnaces, a significant amount of fine and fine ore grains are removed by the gases leaving the furnace in the form of so-called furnace dust. This leads to an increased consumption of charge materials for the smelting of 1 ton of alloy and forcing to process top dust. Therefore, it is advisable to feed into the furnace charge materials without a significant amount of fines (at least 5 mm), followed by agglomeration of fines. One of the rational ways of agglomeration of high manganese-containing fines is a method of sintering [8].

Briquetting, as well as sintering, has as its purpose the agglomeration of fine and ultra fine concentrates with a particle size of less than 5 mm through the use of

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interparticle forces, which, when exposed to external forces, lead to the adhesion of individual grains and the formation of briquettes in the form of strong aggregates. The advantage of briquetting is getting lump durable briquette with a relatively large proportion. At small production scales, briquetting with the help of pressing may be justified in some cases [8].

To select the most effective method of agglomeration of the obtained thermomagnetic manganese concentrates, preliminary laboratory studies were carried out using the known agglomeration methods: sintering, briquetting and pelletizing.

RESULTS RESEARCH

As a result of the research, the following conclusions were made:

- For the agglomeration of manganese concentrate from Zhomart field (Table 1) it is more expedient to apply the method of sintering, in view of the high manganese content and low silica content, which made it possible to obtain high-quality manganese agglomerate suitable for smelting high carbon ferromanganese (Table 2). The resulting sintered material in chemical composition (43,06 – 48,23 % manganese) and mechanical properties (strength according to GOST 25471-82-89,7%) is suitable for smelting carbon ferromanganese. It has also been established that the agglomeration of such a concentrate by the method of briquetting is not effective, since the resulting briquettes have low mechanical properties due to poor moistening properties and adhesion of the ore part of the concentrate [9 - 11];

- agglomeration of manganese concentrate obtained from Western Kamys field ferrimanganese ores (Table 1) using known agglomeration methods does not allow to obtain high-quality conglomerate, since the concentrate has an high silica content (up to 41 % SiO2) in relation to the manganese content (up to 20 %). To reduce the silica content, studies have been carried out on the agglomeration of the concentrate mixed with the Zhomart concentrate and it has been established that it is more effective to briquetting the mixture. The chemical composition of the briquettes is given in Table 2. As a result of agglomerating on large-laboratory press-installation were received the cylindrical briquettes with the content of manganese of 27,6 % and residual carbon of 11,98 % which durability on compression makes 80 – 90 kg/briquette. The obtained briquettes are suitable for smelting ferrosilicon manganese from them. The sintering of the mixture using the agglomeration method leads to the formation of the tephroite phase, which reduces the degree of manganese extraction into the metal during smelting in the furnace [9 - 11];

- The agglomeration by the method of pelletizing for thermomagnetic concentrates in this work was not widely used, since there are the following disadvantages: 1) the unsatisfactory fractional composition of roasted concentrates 0 - 5 mm led to the formation of not strong pellets of irregular shape, and to obtain strong pellets you need finely ground concentrate of size particles ≤ 0,07 mm not less than 80 %; 2) the high content of residual carbon in the concentrate (up to 12 % of C_{fix}) does not allow the use of all carbon during pelletizing (up to 50 % of residual carbon is not pelleted). The additional stage of grinding thermomagnetic concentrates to the required fraction and the non-pelletized part of the reducing agent complicates the scheme of their preliminary preparation, and leads to the irrational use of residual carbon. As a consequence, the pelletizing in the present work was not included in the stage of preliminary preparation of the obtained thermomagnetic concentrates.

In order to modelling the process of smelting manganese alloys and establish the optimal technological mode of electric smelting as applied to previously produced manganese briquettes and agglomerate, experimental tests were made at the laboratory high-temperature Tamman furnace to obtain standard ferrosilicon manganese grades from them.

For testing, a chemical analysis of basic charge materials, agglomerate and briquette (Figure 1), the composition of which is given in Table 2, was made.

According to the results of chemical analysis, the charge was calculated for smelting carbonaceous ferromanganese and ferrosilicon manganese in the Tamman furnace, selection of dosage was made and a series of experimental tests were carried out.

The dosage portion of the ore part in all experiments was approximately 150 g. For a starting time, the time

Table 1 **The chemical composition of the investigated thermomagnetic manganese concentrates / wt. %**

№	Concentrate	Mn_{total}	Fe_{total}	C	SiO_2	Mn/Fe
1	Zhomart	39,69	1,65	11,07	11,07	21,63
2	Western Kamys	19,92	2,7	12,1	41,23	7,38

Table 2 **The average chemical composition of charge materials / wt. %**

Material	Mn_{total}	Fe_{total}	MgO	CaO	SiO_2	Al_2O_3	P	S	C_{fix}
Agglomerate	43,06	3,05	0,49	11,54	14,26	-	0,032	0,021	0,32
Briquette	27,6	2,23	2,99	7,57	25,4	3,92	0,034	0,025	11,98
Dolomite	-	0,51	21,22	30,78	1,01	0,47	H.o.	0,11	-
Shubarkol coal	-	5,03	1,77	2,79	56,97	21,3	0,086	0,5	39,35
	W_t^r		A^d		V^{daf}		S_t^d		Q / kal/kg
	4,8		9,85		36,0		0,5		7623

W_t^r - moisture, A^d – ash, V^{daf} - volatile, S_t^d – sulfur, Q / kal/kg - calorific value

Table 3 **The chemical composition of manganese alloys obtained by laboratory testing**

№	Material	Output / %	Content / %				Extraction / %		
			Mn	Fe	Si	C	Mn	Fe	Si
1	Metal	40,2	69,76	2,68	16,95	1,63	84,75	77,94	20,76
	Slag	59,8	8,44	0,51	43,5*	18,61**	15,25	22,06	79,24
	Total	100	-	-	-	-	100	100	100
2	Metal	34,57	66,93	1,46	18,47	1,58	81,51	62,14	21,80
	Slag	65,43	8,02	0,47	35*	21,01**	18,49	37,86	78,20
	Total	100	-	-	-	-	100	100	100
3	Metal	50,16	81,97	4,7	2,55	6,94	90,93	93,48	7,15
	Slag	49,84	8,23	0,33	33,32*	43,04**	9,07	6,52	92,85
	Total	100	-	-	-	-	100	100	100
4	Metal	49,78	80,66	8,97	4,46	6,52	86,53	95,90	11,12
	Slag	50,22	12,45	0,38	35,33*	34,42**	13,47	4,10	88,88
	Total	100	-	-	-	-	100	100	100

Note: * - content of silicon in alloy (SiO2);
** - the content of calcium oxide in the slag (CaO).

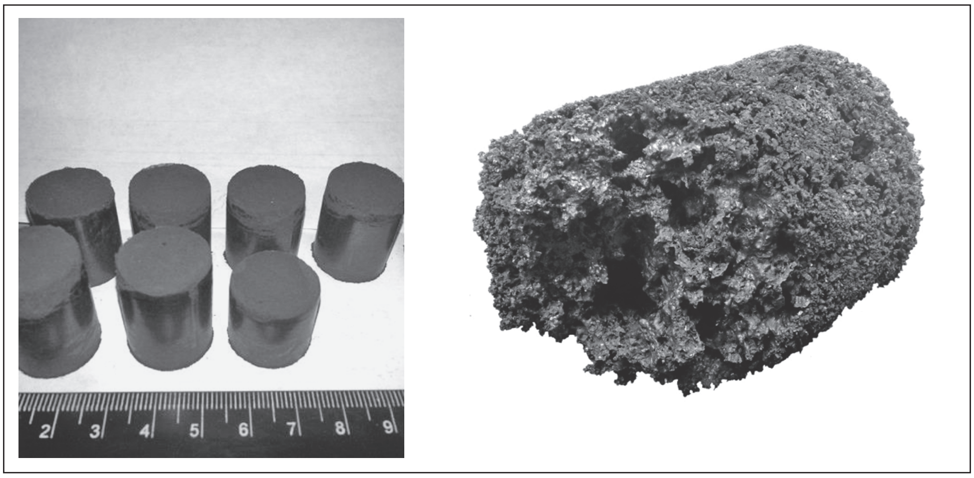

Figure 1 The obtained manganese briquette and agglomerate

when the melt reached a given temperature was accepted. The metal and slag of the experimental tests were kept in graphite crucibles for 1 hour at a constant temperature of 1 500 °C in a weakly reducing atmosphere. The temperature was measured with a VR5-20 thermocouple.

During the experiment, the temperature was kept constant. The temperature fluctuations were 10 °C. After the finish of the experiment, the molten metal and slag were casted into a graphite mold. According to the results of chemical analysis, shown in Table 3, the distribution of manganese, silicon and iron between the metal and slag was determined.

According to the results of experimental tests, it can be concluded that it is preferable to obtain standard grades of ferrosilicon manganese from previously obtained agglomerated material such as a briquette. This is due to the high silica content in the resulting briquettes and the low value of the natural basicity of the original ore. The resulting manganese agglomerate is more rational to use for smelting high-carbon ferromanganese.

The results of laboratory studies conducted in the Tamman furnace, showed the fundamental possibility of smelting carbonaceous ferromanganese and ferrosilicon manganese from agglomerated thermomagnetic manganese concentrates.

CONCLUSIONS

1 Studied the possibility of agglomeration of thermomagnetic manganese concentrate Zhomart (fractions 0 - 5 mm) containing 9 – 12 % residual fixed carbon, by sintering in laboratory conditions suitable for smelting high-carbon ferromanganese.

2 Studied the possibility of agglomeration of roasting manganese concentrate Western Kamys in a mixture with the concentrate Zhomart using the method of briquetting, where the clay component in the amount of 5 % was used as a binder component, it is quite suitable for smelting of ferrosilicon manganese from them.

3 Studies have been conducted to research the possibility of obtaining standard manganese alloys in laboratory from agglomerated manganese concentrates (agglomerate and briquette), depending on the purpose of agglomerated materials. As a result of a metallurgical assessment of conglomerated materials, it was found that ferrosilicon manganese was obtained from briquettes with a content of 66,93 – 69,76 %

Mn and 1,46 – 2,68 % Si (corresponding to GOST 4756-91 of FeSiMn17 grade) - high carbon ferromanganese with a content of 80,66 – 81,97 % Mn, 2,55 – 4,46 % Si and 6,52 – 6,94 % C (corresponding to GOST 4755-70 to FeMn75 grade). The average degree of extraction of manganese and silicon in the smelting of ferrosilicon manganese 83,13 and 21,28 %, respectively, and in obtaining ferromanganese, these values were 88,73 and 9,14 %, respectively.

Thus, according to the results of studies on the possibility of agglomeration of thermomagnetic manganese concentrates suitable for subsequent ferroalloy smelting, it is shown that it is possible in principle to obtain standard grades of manganese alloys from initial roasted manganese concentrates.

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