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Application of the Aluminosilicon Manganese to Obtain Refined Grades of Ferromanganese

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Abstract

This work is dedicated to improving the smelting technology for refined ferromanganese grades through the use of a special complex reducing agent. Laboratory scale experiments were carried out on the smelting of refined ferromanganese using a briquetted charge. Fine fractions (0–5mm) were used for briquetting manganese ore and alumosilicomanganese alloy (AlSiMn). During the experiment were used laboratory installation “HYDROPRESS 50” and coreless induction furnace IUP-25. At the temperature of 1350°C, the beginning of the charge melting was noted, and at the temperature of 1450°C, the formation of a liquid melt. According to the chemical analysis, metal samples fully comply with the requirements of the standard. The progress of process parameters has been achieved: the rate of manganese extraction from ore is 70% (according to the traditional technology, it is 55%); slag/metal ratio is 1.8–2.0 (according to the traditional technology, it is 2.2–2.5); known values of slag basicity are 1.5–1.6. Laboratory melting slags were obtained in a stony state with no signs of breaking. As the outcome of this work, a high efficiency of using the reducing agents based on silicon and aluminum in refined ferromanganese smelting, as well as the use of primary manganese ores from Ushkatyn III deposit for smelting refined ferromanganese, allow reducing the lime consumption up to 40% due to the high content of calcium oxide in ore.

Keywords: refined ferromanganese, alumosilicomanganese alloy, manganese ore, briquette, slag

1. Introduction

To determine the general possibility of the refined ferromanganese smelting using alumosilicomanganese alloy (AlSiMn) as a reducing agent, experiments were carried out in the laboratory conditions.

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During the tests, as the charge material, primary manganese ore from the “Ushkatyn III” deposit (Central Kazakhstan) was used and the reducing agent was the complex alloy AlSiMn, the chemical composition of which is given in Table 1.

Table 1: The chemical composition of initial materials.

Manganese ore, %							AlSiMn, %				
Mn	Fe	SiO_2	Al_2O_3	CaO	P	loss on burning	Mn	Si	Al	C	Fe
29.53	5.79	10.03	1.34	17.03	0.019	18.09	33.9	42.0	12.0	0.5	The rest

The goal of briquetting was the intelligent use of manganese ore and the effective use of elements, involved in the reduction processes during the metallothermic obtaining process for refined ferromanganese. Considering the slaking behavior in the air of the AlSiMn alloy due to the appearance of the unstable compound of aluminum carbide Al_4C_3, which interacts with the atmospheric moisture and forms aluminum hydroxide $Al(OH)_3$ with the release of hydrocarbons [1], it was proposed to briquette it with the commercial manganese ore (fraction 0-5 mm) using a determined ratio. In this case, it is necessary to proceed from the consideration of the recovery process intensification by increasing the contact surface of the reacting phases.

Briquetting was carried out as follows. Initial materials, first in the dry state, and then with the binder were thoroughly mixed. Liquid glass was used as a binder in the amount of 10% of the charge dry mass. The liquid glass density is 1.41 g/cm^3, the silicate module SiO_2/Na_2O = 2.64-2.84. The composition of the monocharged briquettes was as follows:

- manganese ore (0-5 mm) - 56,4%
- aluminum silicomanganese (0-5 mm) - 39.6%.

After mixing, the compound was processed on the “HYDROPRESS 50” installation, where under a pressure of 210 Bar briquettes in the form of cylinders with a diameter of 50 mm and a height of 15–20 mm were obtained at a temperature of 200 ° C and a duration of 50 minutes (Figure 1). The chemical composition of the briquettes is given in Table 2.

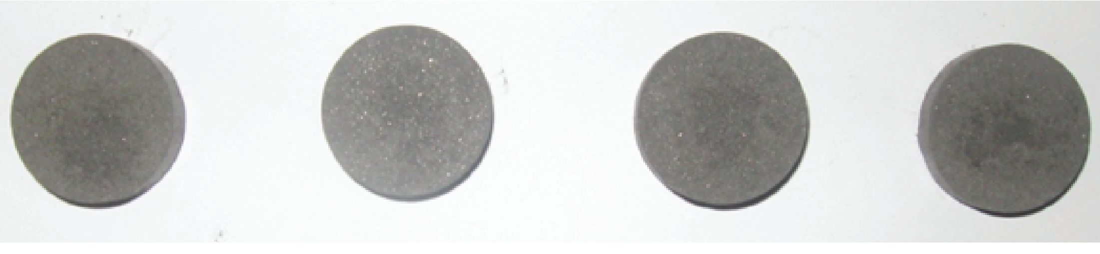

Figure 1: Briquettes made from manganese ore and AlSiMn alloy.

Table 2: The chemical composition of briquettes.

N°.	Chemical composition, %									
	MnO	SiO_2	CaO	Al_2O_3	C	P	Mn	Si	Al	Fe
1	22.52	7.65	12.65	0.55	0.36	0.006	23.36	25.43	4.02	3.21
2	21.36	8.23	11.53	0.32	0.56	0.010	20.65	28.65	5.21	3.02
3	20.65	5.65	15.32	0.28	0.48	0.012	23.85	25.39	4.33	4.05
4	23.37	7.58	13.55	0.39	0.48	0.015	22.89	27.35	3.02	1.02
5	22.05	7.30	13.31	0.41	0.43	0.011	24.02	26.65	3.99	2.06

As the fluxing material used the lime with CaO content$\geq$ 90%.

After all the above operations, the charge materials were loaded into coreless induction furnace (furnace power is 25 kW, inductor voltage is 380-480 V, the inductor current is 200-1800 A) which prevented the alloy pollution with carbon. After the loading of the charge, the furnace was turned on. The temperature was measured with a WRe 5-20 thermocouple. When the temperature reached 900 ° C, all the experimental melting had a gas emission with the specific white deposit on the walls of the furnace body. At a temperature of 1350 ° C, the beginning of charge melting was noted, and at a temperature range of 1430-1450 ° C, a liquid melt appeared, as evidenced by the presence of an alloy adhered to the molybdenum wire. At a temperature of 1500 ° C, in the bath of the furnace, gases were formed and released in the form of bubbles, resembling boiling water. The duration of melting from the start of loading of the first charge portion to the metal and slag tapping for the current melting was 100 minutes. After the melting, the furnace was turned off, then with the aid of a manual drive, the furnace was gently tilted and at the same time, the metal and slag were poured into cast-iron molds. The metal was separated well from the slag. The slag was a stone-like mass of bright green color. The basicity and the ratio of the slag/metal were: $\sim$ 1.75 and 2.0, respectively. The obtained alloy in chemical composition meets the requirements of the standard. The results are presented in Table 3.

Table 3: The chemical composition of smelting products.

N°.	Metal				Slag				
	Mn	Fe	Si	C	MnO	CaO	SiO_2	Al_2O_3	FeO
1	78.60	10.57	3.20	0.65	10.41	39.90	28.30	7.05	1.30
2	80.40	9.60	1.90	0.55	9.15	40.95	26.50	9.55	0.32
3	81.00	7.26	1.97	0.42	9.31	42.22	27.65	6.15	0.55
4	80.65	8.98	2.02	0.32	8.48	44.50	26.56	5.90	1.34
5	82.32	7.03	1.83	0.38	7.65	43.65	28.65	6.23	0.65

During laboratory experiments, it was noted that the reduction process in the furnace was very intensive with throat welding of the entire charge and with a clear separation of metal and slag. The achievement of this effect is provided by the small fraction of the mixture components. The fine fraction of the AlSiMn alloy increases the efficiency of the alloy as a reducing agent due to the more developed surface of the material itself, as well as due to the uniform distribution throughout the volume of briquettes. From Table 3 it can be seen that the use of silicoaluminum reducing agent AlSiMn in the refined ferromanganese metallothermic process leads to the formation of clay-containing slags. The concentration of alumina in them is 6-10%, while according to standard technology it is 2-3% [2]. However, in order to determine the actual technical and economic indices of production for refined ferromanganese grades, it is necessary to conduct further research in the large-scale laboratory and semi-industrial conditions.

2. Conclusions

1. It was established that it is possible in principle to obtain briquettes from primary manganese ore and AlSiMn alloy with a fractional composition of 0-5 mm;

2. The use of primary manganese ores from the “Ushkatyn III” deposit for the smelting of the refined ferromanganese makes it possible to reduce lime consumption up to 40% due to the high content of calcium oxide in the ore;

3. The possibility of the refined ferromanganese smelting using a briquetted monocharge has been proven, and the resulting alloy is of high quality, since the carbon content ranges from 0.4 to 0.65%.

4. An improvement in the technological indicators of the process has been achieved: the degree of manganese extraction in the metal increased to 70%, instead of 55%, the slag/metal ratio was reduced to 2.0, instead of 2.5. The recommended values of slag basicity are 1.75. Laboratory melting slags were obtained in a stony state with no signs of breaking.

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