Conference Paper

Processing and Use of Solid Technogenic Waste - Damping Metallurgical Slags for Producing Calcium-Containing Ferro-Alloys

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Abstract

In the given article there are presented the results of complex calcium-containing ferroalloy from high-ash coals of the Saryadyr deposit, dump blast-furnace slag and slag of refined ferromanganese, which related to technogenic waste. There is established the possibility of smelting calcium-containing ferroalloy, the recovery of basic elements reached 91.56% manganese, 87.75% silicon, 76% aluminum and calcium up to 40%

Keywords: high-ash coals, blast-furnace slag, technogenic waste, calcium ferroalloy, smelting

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1. Intorduction

The depletion of a number of natural mineral resources, and on the other hand the accumulation of huge amounts of technogenic waste, which containing valuable components, can be considered as alternative sources of natural resources, both in color and in ferrous metallurgy. In addition, involvement in the processing of production waste not only solves the problem of the limited resource base, but also becomes a solution to environmental problems in the region.

Domestic and foreign experience of using metallurgical slag does not fully cover the areas of their effective utilization. According to the conclusion of the state ecological expertise of the Aktyubinsk region, the Aktobe ferroalloy plant of the branch of JSC «TNK Kazkhrom» accumulated 1418.802 thousand tons of the slag disposal, the projected volume of disposal of slag in the landfill to 12 million tons [1]. In the process of industrial activity of the enterprises of the Karaganda region have been accumulated 2015, 73369,828 thousand tons of metallurgical slags. The main share of these slags of JSC «ArcelorMittal Temirtau» in the amount of about 24 million tons. The processing of these slags is handled by LLP «AlbastroiDor», which manufacturing crushed stone of

Material	Content of components [%]								
	A	V	W	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	MnO
Manganese slag	-	-	-	20,48	20,44	1,85	36,46	2,62	18,09
Blast-furnace slag	-	-	-	36,65	13,94	-	37,23	11,85	-
High-ash coals	55,92	20,79	0,98	60,86	30,82	1,63	-	-	-

Table 1: Chemical and technical composition of raw materials.

various types for road surfaces. Also, various theoretical and practical research works were carried out in the direction of utilization of waste blast-furnace slags in cement production [2].

At present, the metallurgical slag is of particular interest. The accumulated and newly formed metallurgical slag is a valuable source of a number of components: CaO - 30-45%, Al_2O_3 - 10-20%, SiO_2 - 35-50%, MgO - 6-10% and MnO up to 20% to be recovered.

Also, there was studied the possibility of involving high-ash coals of the Saryadyr deposit as a carbonaceous reductant in the metallurgical redistribution, since according to previous studies [3], these coals are most suitable for ore-thermal melting of complex ferroalloys. At the same time, it is possible to recover silicon and aluminum from the ashes of high-ash coals.

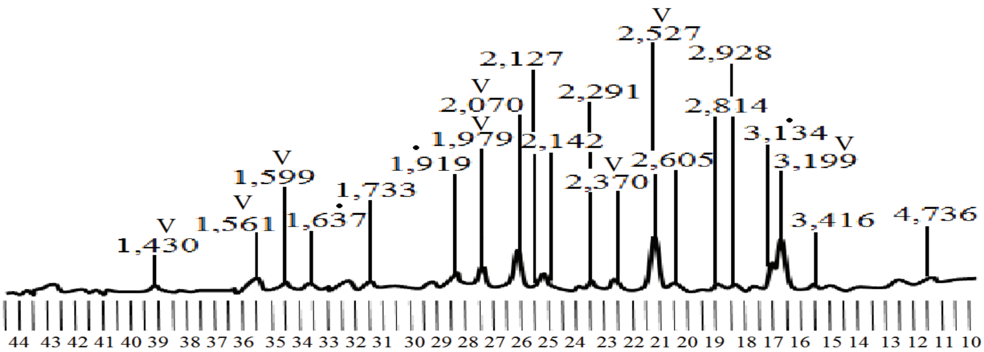
2. Experimental Work

There were carried out technological studies of the process of obtaining a complex calcium-containing ferroalloy from manganese and blast furnace slags using as a reducing agent high-ash coal of the Saryadyr deposit in various ratios in the ore-thermal furnace with a transformer capacity of 200 kVA by a single-stage carbothermic slag-free method in the conditions of the Chemical-Metallurgical Institute named after Zh. Abishev. Smelting was carried out in a continuous manner, with charging of batch in small portions as the top of the shroud was shrunk, with periodic release of the metal every 2 hours into cast iron molds. The chemical composition of the starting charge materials is shown in Table 1.

The main objective of the study was to perform a complete reduction of all oxides, consisting of slag and high-ash coal with a continuous stable, easily regulated slag-free process. The process was characterized by a hot run and a stable regime. Metal went out actively from the furnace, which indicates a high temperature in the cavity of the crucible. After each output of metall, the metal was weighed and then the

Output №	Content of components [%]					
	Mn	Si	Al	Ca	Fe	P
1	12,62	34,59	26,72	3,69	22,19	0,019
2	10,48	43,07	37,81	5,88	2,48	0,028
3	13,88	31,5	29,94	4,62	19,84	0,022
4	11,74	36,19	32,06	5,04	14,73	0,024
5	15,12	37,95	36,53	6,04	4,21	0,015
6	16,34	34,11	34,34	5,71	9,29	0,021
7	16,96	31,54	35,9	6,21	9,16	0,023
8	17,56	33,06	40,06	5,2	3,97	0,015
9	11,74	24,82	25,92	6,21	31,15	0,016
10	17,66	38,18	22,21	6,72	14,28	0,024
11	15,02	41,9	24,54	8,06	9,65	0,019
12	15,94	37,08	29,28	8,73	8,74	0,017
13	15,82	37,35	30,29	9,07	6,87	0,028
14	16,4	48,49	18,3	10,41	5,43	0,024

Table 2: Chemical composition of the alloy obtained from slags produced by refined ferromanganese.



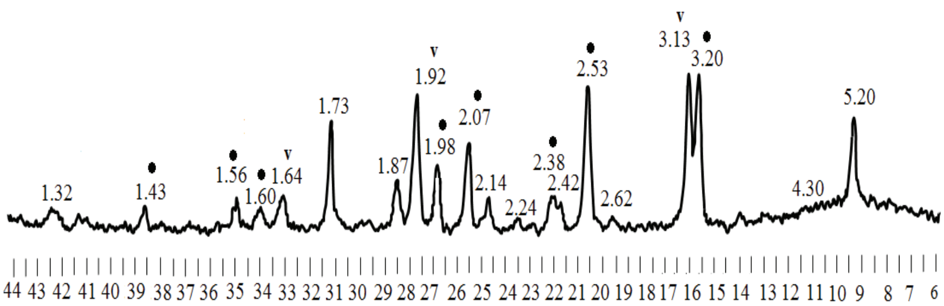
V - $CaAl_2Si_{1,5}$ (1,430; 1,561; 1,599; 1,979; 2,070; 2,370; 2,527; 3,199)
● - Si (1,637; 1,919; 3,134)

Figure 1: X-ray diffraction pattern of metal №4 obtained from slags of ferromanganese.

samples were taken for chemical analysis. The chemical composition of the obtained test samples is given in Tables 2 and 3.

Output №	Content of components [%]						
	Ca	Si	Al	Fe	S	P	C
1	8,12	43,41	23,98	15,24	0,0120	0,027	1,54
2	6,62	43,11	22,12	19,52	0,0130	0,024	0,90
3	13,11	42,33	22,15	9,46	0,0140	0,03	1,57
4	18,22	42,46	25,99	6,97	0,0110	0,029	1,40
5	14,11	43,82	26,79	9,51	0,0068	0,026	1,61
6	11,67	49,74	26,02	8,92	0,0140	0,029	1,01
7	13,69	51,87	22,11	8,97	0,0190	0,023	0,84
8	16,72	50,95	18,22	8,92	0,0180	0,025	0,96
9	14,12	53,89	18,34	11,51	0,0320	0,026	0,95
10	13,20	53,63	13,77	14,32	0,0069	0,03	0,52
11	14,39	53,20	17,83	11,4	0,0250	0,028	0,60
12	13,91	52,27	15,24	8,43	0,0310	0,033	1,52
13	13,14	50,02	15,12	13,57	0,0370	0,033	1,52
14	11,78	45,03	12,73	21,95	0,0098	0,032	0,77
15	7,68	52,13	12,69	20,76	0,0073	0,021	0,73

Table 3: Chemical composition of the alloy obtained from blast furnace slags.



v - Si (1,64; 1,92; 3,13)
• - $CaAl_2Si_{1,5}$ (1,43; 1,56; 1,60; 1,74; 1,98; 2,07; 2,38; 2,53; 3,20)

Figure 2: X-ray diffraction pattern of alloy №12 obtained from blast-furnace slags.

As a result of large-scale tests, a pilot batch of calcium-containing ferroalloy was obtained, the recovery of basic elements reached 91.56% manganese, 87.75% silicon, 76% aluminum and calcium up to 40%. Alloys from slags produced by ferromanganese are characterized by a relatively high content of manganese from 10% to 18%. Experimental alloys have high purity for harmful impurities - sulfur and phosphorus. Low content of phosphorus in the alloy up to 0.03% - due to its low concentration in the starting materials. The carbon content in the alloy is determined by the concentration of silicon in it. Silicon forms a strong silicide with calcium and practically does not dissolve carbon. With a silicon content of 50-54%, the composition of the alloy reduces carbon to 0.9%.

The formation of intermetallic compounds in the alloy is confirmed by X-ray phase analysis. X-ray phase analysis was carried out on a DRON-2 diffractometer. The shooting conditions are filtered Cu radiation, tube voltage 30 kW, tube current 30 mA. The obtained diffractogram of the samples was identified according to the ASTM catalog. X-ray patterns of the obtained metals are shown in Figures 1 and 2.

According to the X-ray diffraction analysis, the calcium-containing ferroalloy is represented by the following phases: $CaAl_2Si_{1.5}$ and unbound structurally-free silicon.

3. Summary

Thus, in large-scale laboratory conditions, it has been established that it is possible in principle to obtain a new type of complex calcium-containing ferroalloy from high-ash coals of the Saryadyr deposit, dump blast-furnace slag and slag of refined ferromanganese, which related to technogenic waste. The obtained data make it possible to develop an integrated and resource-saving technology for smelting a new type of ferroalloy, which can be used in the steelmaking industry in the form of a deoxidizer and a modifier.

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