

Integrated waste-free processing of the electric-arc furnace dust

Mikhail Mikheenkov^{1,*}, *Ilya Nekrasov*^{1,2}, and *Denis Egiazaryan*^{1,2}

¹ Federal State Budgetary Institution of Science Institute of Metallurgy of the Ural Branch of the Russian Academy of Sciences, 620016, Ekaterinburg, Amundsen st, 10, Russia

² Federal State Autonomous Educational Institution of Higher Education «Ural Federal University named after the first President of Russia B.N.Yeltsin», 620002, Ekaterinburg, Mira st., 19, Russia

Abstract. The article deals with issues of integrated waste-free processing of electric arc furnaces dust. It is shown that it is possible to obtain a whole range of valuable commodity products on both metal and non-metal bases as a result of the electric arc furnaces dust complex processing. Integrated waste-free processing reduces the arc furnaces dust impact on the environment and produces a number of valuable commercial products.

Due to increased requirements for the quality of metal products, while simultaneously reducing the quality of raw materials, high-intensity steel melting in high-power electric furnaces has become widespread in the ferrous metallurgy. This entailed a change in the structure of technogenic formations of ferrous metallurgy and their qualitative characteristics. Metallurgical enterprises began to accumulate a significant amount of arc steel-smelting furnaces (ASF) dust. Due to the galvanized scrap use in arc smelting, ASF dust may contain significant amounts of zinc oxide. Recently, the Waelz process in rotating [1] and ring [2] furnaces has become widely used to extract zinc oxide from ASF dust. In addition, ASF dust contains significant amounts of iron oxides and silicate products. Table 1 shows the ASF dust samples chemical composition. That samples should be processed according to the Global Steel Dust technology. Table 2 shows the clinker chemical composition from the Waelz process resulting from the processing of ASF dust using the Global Steel Dust technology.

The chemical analysis data show that the initial ASF dust contains about 28 mass. % iron oxide on average. After Waelz process, Zn and Pb oxides are removed from the ASF dust; at the same time, the content of iron oxide and silicate products increases in the clinker. Silicate products in clinker are represented by oxides of Ca, Si, Al, Mg. Since both iron oxides and silicate oxides are present in the clinker, the technology of converting iron oxides and silicate materials into commercial products will be the most acceptable for processing such clinkers.

We have developed two technological schemes for processing clinker from the Waelz process. The first scheme of processing involves the modernization of the existing Waelz – process. In that way, in a single technological cycle could be obtained zinc oxide, reduced iron and portland cement clinker. To implement this scheme, the raw mix preparation

* Corresponding author: silast@mail.ru

method and heat treatment regimes should be changed. During raw mix preparation, additional carbon-containing materials and corrective silicate additives should be introduced into mix. Carbon-containing materials are necessary for the reduction of iron oxides. Corrective silicate additives allows to form typical portland cement clinker phases during the burning process. The heat treatment regimes are adjusted to obtain during the burning process not only zinc oxide, but also portland cement clinker. The most acceptable thermal regime at the final stage of clinker burning is the regime that provides the complete synthesis of portland cement clinker phases and reduced iron coagulation.

Table 1. Chemical composition of ASF dust samples

№ of sample	Content, mass. %										
	CaO	SiO ₂	Al ₂ O ₃	MgO	Fe ₂ O ₃	ZnO	Na ₂ O	K ₂ O	SO ₃	PbO	Other
№ 1	9,72	5,92	0,73	1,21	36,20	23,80	3,53	0,45	4,60	1,77	12,07
№ 2	20,10	4,34	0,67	0,89	20,10	28,5	3,47	0,42	5,55	2,06	13,90

Table 1. The clinker chemical composition from the Waelz process, mass. %

CaO	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	ZnO	PbO	Na ₂ O	K ₂ O	S
26,63	15,2	4,34	46,13	3,45	0,45	0,05	1,50	0,21	2,04

The second scheme involves the Waelz process clinker processing in separate aggregates. The completeness of aggregates is determined depending on type of initial clinker. If the current production clinker is processed, then it is suitable to realize iron oxides reduction in the Waelz-furnace. If the previously accumulated clinker is processed, then a separate unit will be required for reductive firing. A similar scheme should include:

- clinker reductive firing with the metal shots formation in products;
- magnetic separation or separation melting;
- formation of portland cement clinker phases in the silicate part by additional calcination or in the slag of separation melting.

As a result of the both schemes implementation, two commercial products are formed - metallic iron and portland cement clinker. The verification of the first scheme was carried out by heat treatment of ASF dust samples 1 and 2, the chemical compositions both are given in Table 1. The estimated amount of additives required for reduced iron and portland cement clinker forming were added to the dust. The raw mix was homogenized by co-grinding, mixed with a binder and pressed at the pressure of 50 MPa. Due to the fact that ASF dust contains a significant amount of hydrophobic components, briquettes with the aqueous binder were scattered after briquetting during short storage. It was impossible to obtain necessary synthesis products during firing. The binder selection made it possible to ensure a stable briquette structure and required firing products. Figure 1 shows the general view of water-bonded briquettes (a) and strong briquettes on a special bundle (b) in 24 hours after briquetting. Figure 2 shows the x-ray phase analysis data of ASF dust roasting products based on sample 1 (a) and 2 (b).

Roasting results indicate that it is possible to form the portland cement clinker phases in roasting products, but iron oxide was not fully reduced.



Fig. 1. General view of water-bonded briquettes (a) and strong briquettes with the special binder (b) in 24 hours after briquetting

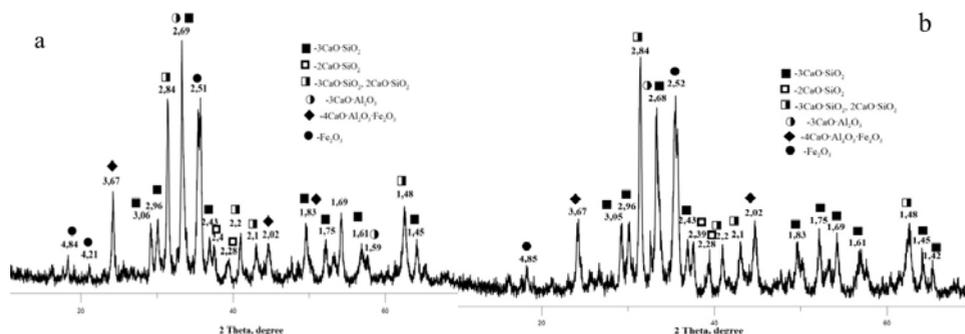


Fig. 2. The x-ray phase analysis data of ASF dust roasting products based on sample 1 (a) and 2 (b)

The second scheme verification was carried out by reductive firing of Waelz process clinker of sample No. 1. Its chemical composition is given in Table 2. The calculated amount of additives for the reduced iron and portland cement clinker formation in products was added to mixture. The mixture was homogenized by co-grinding, mixed with a binder and pressed at a pressure of 50 MPa. Briquettes were subjected to reducing roasting. The x-ray phase analysis data of reduction firing products is shown in Fig. 3.

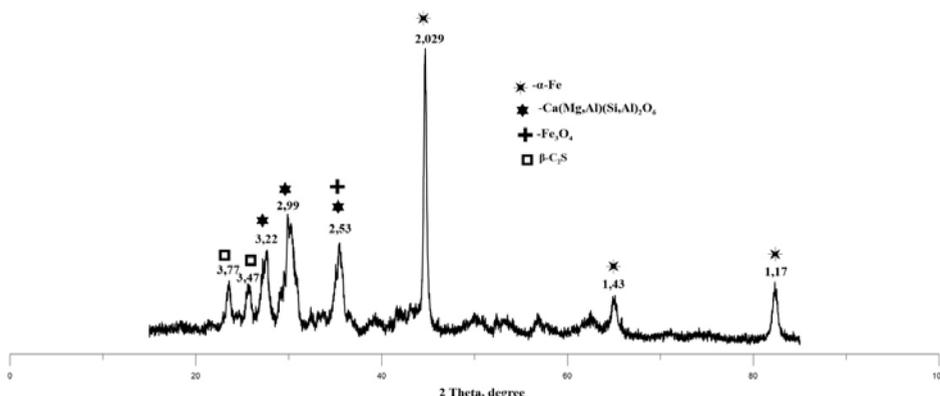


Fig. 3. The x-ray phase analysis data of Waelz-process clinker firing products

In accordance with the phase analysis data, the reduction roasting products consist of reduced iron and aluminat diopside with admixtures of Fe_3O_4 . According to the

quantitative X-ray phase analysis, the reducing firing product contains 42% Fe and 58% aluminate diopside, dicalcium silicate and Fe_3O_4 .

Necessary additives were added to reductive roasting products and separation melting was carried out in the high-temperature laboratory resistance furnace. Pig iron and slag were obtained with a yield of 44.0% pig iron and 56.0% slag as a result. The general view of the obtained iron is shown in fig.4. As a result of separation melting, typical portland cement clinker was obtained in slag, the phase analysis data of it is shown in Fig. 5.



Fig. 4. Pig iron, obtained from reducing firing product

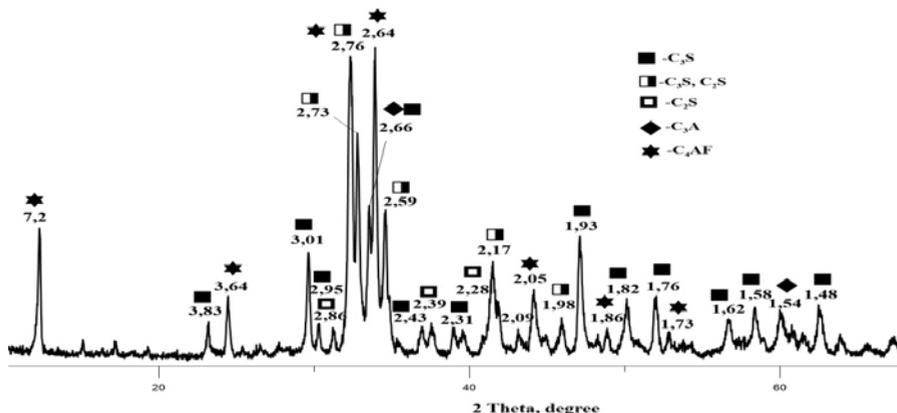


Fig. 5. The x-ray phase analysis data of obtained slag

The resulting portland cement clinker contained about 80% silicate phases ($3\text{CaO}\cdot\text{SiO}_2 + 2\text{CaO}\cdot\text{SiO}_2$) and 20% aluminum-ferrite phases ($3\text{CaO}\cdot\text{Al}_2\text{O}_3 + 4\text{CaO}\cdot\text{Al}_2\text{O}_3\cdot\text{FeO}$). Determination of the physicomechanical properties of portland cement based on the obtained clinker showed that the resulting portland cement meets the requirements of GOST 31108-2003 "General construction cements. Technical specifications " to the grade CEM I 32.5 B.

The test results confirmed the feasibility of the implementation of both clinker processing schemes from the Waelz process of ASF dust.

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