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Technology for producing pure lead-free zinc oxide from electric arc furnace (EAF) dust

G. Koishina[1], N. Dosmukhamedov[1], V. Kaplan[2], I. Nursainov[1], Ye. Zholdasbay[3*]

[1]Satbayev University, Almaty, Kazakhstan
[2]Weizmann Institute of Science, Rehovot, Israel
[3]Zhezkazgan University named after O.A. Baikonurov, Zhezkazgan, Kazakhstan

**Corresponding author: zhte@mail.ru*

Abstract. An economical and environmentally advantageous two stages method with efficient recovery of pure lead-free zinc oxide from electric arc furnace dust in parallel with clinker containing iron and carbon production for easy return to the iron smelting furnace was described. At the first stage, the electric arc furnace dust was mixed with a mixture of chloride salts and sintered at various temperatures to lead removing. In the second stage, the clinker after the first sintering stage was mixed with carbonaceous agent and sintered again to obtain pure lead-free zinc oxide. The clinker after the second sintering stage, containing iron and carbon, can be sent to the main iron production. Laboratory-scale measurements with electric arc furnace dust from one of the Kazakhstan metallurgical ferrous plants show that process allows receive lead-free zinc oxide with the total impurity content is 0.06–0.07 mass%, and the lead content is 0.001 mass%. Based on the laboratory studies carried out, a technological scheme for the two-stage processing of electric arc dust was developed to produce marketable products. The environmental benefit of the method is to reduce emissions of harmful substances into the environment associated with the recycling of electric arc furnace dust. In addition, the process allows to recycle production waste and reduce the consumption of natural resources.

Keywords: *electric arc furnace dust, sintering, zinc oxide lead-free, calcium chloride, carbonaceous agent.*

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1. Introduction

The steady increase in zinc consumption and the long-term development of the global mining and metallurgical complex based on the model of extensive subsoil use inevitably contributed to the depletion of reserves of rich deposits being developed and the formation of significant volumes of technogenic waste. In this regard, the issues of complex processing of man-made raw materials containing zinc, as well as the development of innovative and environmentally friendly technologies for extracting this valuable metal from poor and difficult-to-enrich ores are of particular relevance.

Processing of mining and metallurgical waste, such as slag, gas cleaning dust and leaching cakes, is a promising area that allows not only to involve valuable components in economic circulation, but also to reduce the negative impact on the environment.

Modern methods of extracting zinc from difficult-to-enrich ores include the use of hydrometallurgical processes such as heap leaching, bioleaching and electrowinning, which allow for the efficient extraction of zinc even from ores with a low metal content.

The development and implementation of new technologies aimed at the complex extraction of zinc and other valuable components from various types of raw materials is an important task that requires the consolidation of the efforts of scientists, engineers and industry representatives. Solving this problem will ensure sustainable development of the global zinc industry and minimize its negative impact on the environment.

Ferrous metallurgy processes are characterized by the generation of large amounts of waste. On average, for 1 ton of steel produced in AC furnaces, about 15-25 kg of Electric Arc Furnace dust (EAF dust) is generated [1]. Considering the high productivity of steel plants, the world's dust reserves amount to about 5.6 billion tons. In 2023, Kazakhstan's steel enterprises increased steel production by 16.4% compared to 2022, to 3.92 million tons [2], and the volume of EAF dust generated is approximately 9-11 thousand tons. EAF dust contains both valuable and hazardous metals, including, for example, Fe, Zn, Pb, Cr, Mn, V, Ca, Ti and others. Air pollution and dust accumulation have a negative impact on the environment and the population. Effective disposal of EAF dust is a major challenge in the steel industry: the steel industry generates several million tons of dust each year, which has negative impacts on the environment and human health. The average zinc content in them is about 35-40%, that is, 3-4 thousand tons of zinc are lost in the form of dust. This dust also contains up to 2% lead, >10-20% iron and other heavy

gulzada.koishina@mail.ru; nurdos@bk.ru; valery.kaplan@weizmann.ac.il; ilyasnursainov@gmail.com; zhte@mail.ru

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non-ferrous metals. This amount of valuable raw materials can partially cover the need for raw materials of ferrous and non-ferrous metallurgy enterprises. Of the total volume of material loaded into the furnace, almost 100% zinc, about 10% of manganese, and 40% of lead are transferred into EAF dust [3]. The chemical and phase composition of EAF dust from the steelmaking industry differs depending on the technology used during which it is formed, process temperature, and on the composition of the feedstock.

The main components of EAF dust are iron oxides (mainly magnetite Fe_3O_4), zinc oxide (ZnO), lead oxide (PbO), and franklinite ($ZnFe_2O_4$, $ZnMnFeO_4$) [3]. When galvanized steel is treated, the zinc content in the dust can reach 30% or more [3]. Most of the elements are associated with oxygen in the form of oxides; in addition, chlorides, fluorides, sulfates, and sulfides may also be present.

Currently, various EAF dust pyrometallurgical and hydrometallurgical treatment processes have been proposed and tested. However, more than 95% of EAF dust is processed by pyrometallurgical methods. The most common are Waelz rotary kiln [4, 5, 6], rotary hearth furnace, plasma furnace [7, 8], shaft (OxyCup) furnace [9], [10], microwave heating furnaces [11, 12] and other reducing processes [13-15]. Waelz rotary kilns process 80% of all EAF dust [16].

Unfortunately, in all these processes, only the extraction of zinc and iron was controlled and studied. It is obvious that in the processes of collecting electric arc furnace dust at high temperatures, almost all the lead sublimates together with zinc and contaminates the resulting zinc oxide, which makes it impossible to use.

At the same time, the composition and behavior of other valuable and potentially hazardous elements, such as cadmium, copper, nickel, chromium, remain largely unstudied. This creates serious problems in developing effective strategies for processing and recycling electric arc furnace dust, since without a complete understanding of the behavior of these elements, it is impossible to predict their distribution in different fractions and, therefore, to develop optimal technological solutions.

The need for a comprehensive study of the behavior of the entire spectrum of elements in the processes of collecting electric arc furnace dust is dictated not only by economic considerations related to the possible extraction of valuable components, but also by environmental requirements. Environmental pollution with heavy metals poses a serious threat to human health and ecosystems.

In this regard, it is an urgent task to conduct detailed studies aimed at determining the phase composition and distribution of all significant elements in electric arc furnace dust, as well as studying their behavior at different temperatures and processing conditions. The data obtained will allow developing effective methods for the selective extraction of valuable components and neutralization of hazardous substances, which will contribute to the creation of environmentally friendly and cost-effective technologies for processing electric arc furnace dust.

Such studies should include both experimental works using modern analytical equipment and mathematical modeling of the processes occurring in the electric arc furnace and dust collection system. An integrated approach will provide the most complete understanding of the processes occurring with various elements and develop optimal strategies for managing these processes.

In this paper, an economical and environmentally friendly method is proposed to effectively capture pure lead-free zinc oxide from electric arc furnace dust in parallel with the production of iron-carbon containing clinker for easy return to iron smelting furnace with a detailed study of the behavior of heavy non-ferrous metals.

2. Materials and methods

2.1. Analytical methods

Material composition, prior to and following treatment, was characterized by X-ray fluorescence (XRF) spectroscopy (Niton handheld XRF Analyzers, R.B.M. Control & Mechanization Ltd, Israel). Quantitation and material balance were provided by inductively coupled plasma mass spectroscopy ICP-MS (Agilent 7700s ICP-MS System Technologies) measurements following 24-h dissolution of the EAF dust and clinker powders in aqua regia at room temperature with continuous stirring. Powder X-ray diffraction (XRD) was performed on an Ultima III diffractometer (Rigaku Corporation, USA). Phase identification and quantitative phase analysis were accomplished using Jade Pro (MDI, Cal.) software and the Inorganic Crystal Structure Database (ICSD).

2.2. Materials

The initial samples of Electric Arc Furnace dust (EAF dust) were received from one of the Kazakhstan metallurgical plants. Chemical composition of the initial samples of the EAF dust by ICP-MS measurements are present in Table 1.

Table 1. Chemical composition of the initial material (EAF dust)

Chemical composition (mass%)									
Fe	Zn	Cu	Pb	Cd	As	Sb	Sn	Au	Ag
8.48	37.69	0.2	1.36	0.054	0.004	0.017	0.031	0.008	0.004

Prior to each of the sintering procedures, XRF spectroscopy (Figure 1) and Powder X-ray diffraction (XRD) (Figure 2), were used to determine the contents of basic components in the EAF dust.

Sintering procedures

The experiments were carried out in two stages (Figure 3). At the first stage, the EAF dust was mixed with a mixture of chloride salts and sintered at various temperatures to remove lead as $PbCl_2$. At the second stage, the clinker after the first sintering stage was mixed with carbonaceous agent and sintered again to obtain pure lead-free zinc oxide. The clinker after the second sintering stage, containing iron and carbon, can be sent to the main iron production.

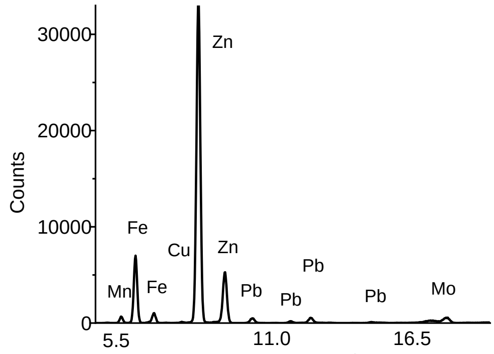


Figure 1. XRF spectra of the EAF dust

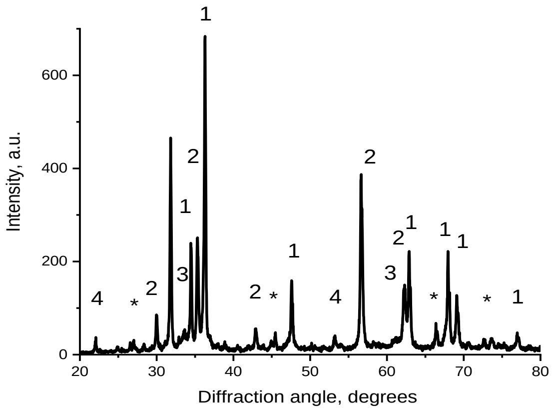


Figure 2. X-ray diffraction (XRD) pattern of the EAF dust: 1 – Zincite, ZnO; 2 – Franklinite, $ZnFe_2O_4$; 3 – Lead, Pb; 4 – Zinc Chloride Hydroxide Hydrate, $Zn_5Cl_2*(OH)_8*H_2O$, * – unidentified peaks

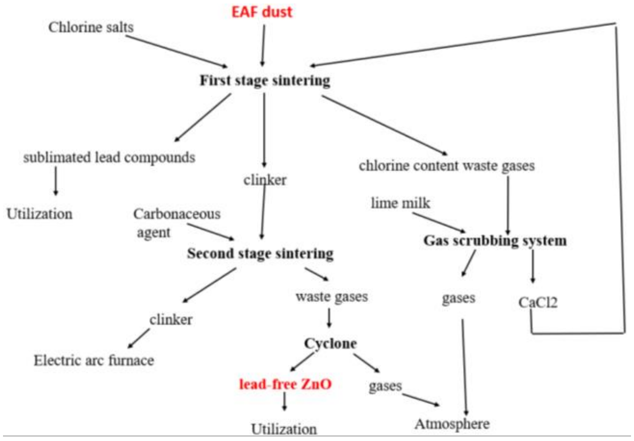


Figure 3. EAF dust treatment process

Reactor furnace

A custom-built, quartz tube reactor placed inside a temperature-controlled laboratory furnace was used for sintering. The accessible temperature range was 973-1373 K. A diagram of the reactor furnace, including placement of the powdered EAF dust initial sample is shown in Figure 4.

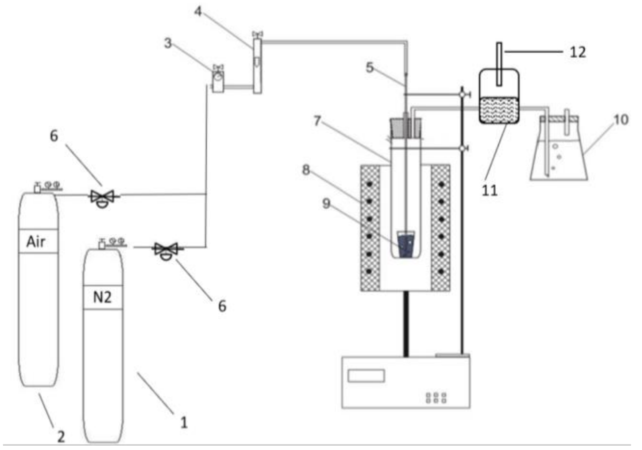


Figure 4. Laboratory reactor: (1) – nitrogen cylinder; (2) – air cylinder; (3) – gas stop; (4) – flowmeter; (5) – tube for gas; (6) – valve; (7) – quartz reactor; (8) – furnace with temperature controller; (9) – alumina crucible with sample; (10) – gas cleaning bottle, (11) – zinc oxide filter and collector; (12) – place for air addition

Mixture of the EAF dust and chloride salts or clinker after the first sintering stage and carbonaceous agent were placed in the furnace in an alumina crucible (total weight approximately 40-50 g).

Prior to heating, the quartz reactor with the mixtures powder was cleaned with a 100 ml/min flow of dry nitrogen gas for 15 min. The furnace was then heated at a uniform rate from room temperature to test temperatures (973-1373K) during 60 min, again in the presence of 100 ml/min nitrogen flow. After the furnace had reached the designated temperature, air was fed into the reactor for 1 h for the first stage sintering. The second stage sintering was carried out in the presence of 100 ml/min nitrogen flow without air flow.

Thermodynamic calculations for chemical reactions of metal oxides with chloride salts and carbon

Calculations were performed using software developed in the framework of Microsoft Excel and based on standard values of enthalpy of compound decomposition (ΔH) and entropy (ΔS) for the pure substances [17] as well as on values from the NIST-JANAF database [18].

3. Results and discussion

3.1 Thermodynamic analysis of the chemical reactions of metal oxides with chloride salts and carbon

The Gibbs energy values for chlorination and reduction reactions within the temperature range 673-1473 K are shown in Table 2.

Group 1 includes chlorination reactions between EAF dust components and calcium chloride. Under sintering conditions, the Gibbs energy of all reactions in Group 1 is strongly negative (–250-450 kJ/mole): thermodynamic calculations predict that the reaction of non-ferrous metals oxides and iron (III) oxide from EAF dust with $CaCl_2$ can result in the formation of metals chloride within a wide temperature range, including the range of interest 1073-1273 K.

Group 2 includes chlorination reactions between EAF dust components and ammonium chloride. The thermodynamic likelihood of reactions in the Group 2 is ensured over the entire temperature range of interest, with the most negative value being for reactions:

$Fe_2O_3 (s) + 6NH_4Cl (s) = 2FeCl_3 (g) + 6NH_3 (g) + 3H_2O (g)$ and $PbO (s)+ 2NH_4Cl (s) = PbCl_2 (g) + 2NH_3 (g) + H_2O (g)$.

The third group of reactions in Table 2 includes the reaction between EAF dust components and calcium chloride in the presence of SiO_2. The Gibbs energy of reactions in the Group 3 under sintering conditions is strongly negative (≈–300-500 kJ/mole).

Group 4 includes reduction reactions between clinker components and carbon. Thermodynamic calculations of the Group 4 reaction predict that that the reaction of non-ferrous metals oxides from second sintering stage clinker with carbon can result in the formation of metals within a wide temperature range, including the range of interest 1273-1473 K. The Gibbs energy of reactions in the Group 4 under sintering conditions is negative (≈–30-100 kJ/mole). This means that if lead and cadmium are not completely removed from the EAF dust in the first sintering stage, then the zinc oxide obtained in the second sintering stage will be contaminated with lead and cadmium.

Table 2. Gibbs energy (ΔG) calculated for chemical reactions of metal oxides with $CaCl_2*2H_2O$ (Group 1), NH_4Cl (Group 2), mixture $CaCl_2*2H_2O+SiO_2$ (Group 3) and for metal oxides with carbon (Group 4) in the temperature region of interest

Reaction	Gibbs Energy, kJ/mole				
	673 K	873 K	1073 K	1273 K	1473 K
Group 1					
$PbO_{(s)} + CaCl_2*2H_2O_{(s)} = PbCl_{2(g)} + CaO_{(s)} + 2H_2O_{(g)}$	-12	-128	-250	-375	-502
$ZnO_{(s)} + CaCl_2*2H_2O_{(s)} = ZnCl_{2(g)} + CaO_{(s)} + 2H_2O_{(g)}$	36	-79	-200	-327	-458
$CuO_{(s)} + CaCl_2*2H_2O_{(s)} = CuCl_{2(g)} + CaO_{(s)} + 2H_2O_{(g)}$	66	-52	-176	-306	-440
$CdO_{(s)} + CaCl_2*2H_2O_{(s)} = CdCl_{2(g)} + CaO_{(s)} + 2H_2O_{(g)}$	20	-94	-215	-341	-472
$ZnFe_2O_{4(s)} + CaCl_2*2H_2O_{(s)} = ZnCl_{2(g)} + Fe_2O_{3(s)} + CaO_{(s)} + 2H_2O_{(g)}$	56	-55	-174	-299	-428
$Fe_2O_{3(s)} + 3CaCl_2*2H_2O_{(s)} = 2FeCl_{3(g)} + 3CaO_{(s)} + 6H_2O_{(g)}$	251	-72	-413	-770	-1141
Group 2					
$PbO_{(s)} + 2NH_4Cl_{(s)} = PbCl_{2(g)} + 2NH_{3(g)} + H_2O_{(g)}$	-71	-179	-283	-378	-465
$ZnO_{(s)} + 2NH_4Cl_{(s)} = ZnCl_{2(g)} + 2NH_{3(g)} + H_2O_{(g)}$	-23	-130	-232	-329	-421
$CuO_{(s)} + 2NH_4Cl_{(s)} = CuCl_{2(g)} + 2NH_{3(g)} + H_2O_{(g)}$	7	-104	-209	-308	-402
$CdO_{(s)} + 2NH_4Cl_{(s)} = CdCl_{2(g)} + 2NH_{3(g)} + H_2O_{(g)}$	-39	-146	-247	-344	-434
$ZnFe_2O_{4(s)} + 2NH_4Cl_{(s)} = ZnCl_{2(g)} + Fe_2O_{3(s)} + 2NH_{3(g)} + H_2O_{(g)}$	-3	-107	-206	-301	-392
$Fe_2O_{3(s)} + 6NH_4Cl_{(s)} = 2FeCl_{3(g)} + 6NH_{3(g)} + 3H_2O_{(g)}$	73	-227	-511	-778	-1030
Group 3					
$PbO_{(s)} + CaCl_2*2H_2O_{(s)} + SiO_{2(s)} = PbCl_{2(g)} + CaSiO_{3(s)} + 2H_2O_{(g)}$	-102	-219	-341	-466	-593
$ZnO_{(s)} + CaCl_2*2H_2O_{(s)} + SiO_{2(s)} = ZnCl_{2(g)} + CaSiO_{3(s)} + 2H_2O_{(g)}$	-54	-169	-291	-417	-549
$CuO_{(s)} + CaCl_2*2H_2O_{(s)} + SiO_{2(s)} = CuCl_{2(g)} + CaSiO_{3(s)} + 2H_2O_{(g)}$	-25	-143	-267	-396	-530
$CdO_{(s)} + CaCl_2*2H_2O_{(s)} + SiO_{2(s)} = CdCl_{2(g)} + CaSiO_{3(s)} + 2H_2O_{(g)}$	-71	-185	-306	-432	-562
$ZnFe_2O_{4(s)} + CaCl_2*2H_2O_{(s)} + SiO_{2(s)} = ZnCl_{2(g)} + Fe_2O_{3(s)} + CaSiO_{3(s)} + 2H_2O_{(g)}$	-34	-146	-265	-389	-518
$Fe_2O_{3(s)} + 3CaCl_2*2H_2O_{(s)} + 3SiO_{2(s)} = 2FeCl_{3(g)} + 3CaSiO_{3(s)} + 6H_2O_{(g)}$	-21	-345	-686	-1042	-1413
Group 4					
$ZnO_{(s)} + 0.5\ C_{(s)} = 0.5\ CO_{2(g)} + Zn_{(g)}$	136	94	52	11	-30
$ZnFe_2O_{4(s)} + C_{(s)} = CO_{2(g)} + Zn_{(g)} + 2FeO_{(s)}$	160	96	33	-30	-91
$PbO_{(s)} + 0.5\ C_{(s)} = 0.5\ CO_{2(g)} + Pb_{(g)}$	77	38	-1	-36	-69
$CdO_{(s)} + 0.5\ C_{(s)} = 0.5\ CO_{2(g)} + Cd_{(g)}$	30	-11	-52	-91	-131
s – solid phase, g – gas phase.					

Thermodynamic calculations predict that the reaction of non-ferrous metals oxides and iron (III) oxide from EAF dust with $CaCl_2$ and NH_4Cl can result in the formation of metal chlorides within a wide temperature range, including the range of interest 1073-1273 K. The addition of silica to the initial mixture leads to a decrease in the Gibbs energy of chlorination reactions and an increase in the thermodynamic probability of these reactions.

3.2 First stage sintering of the EAF dust

Almost all lead at the first stage of sintering with the addition of chloride salts turns into lead chloride, which is removed from the clinker. The effect of sintering temperature on the residual lead content in the clinker and on the degree of its extraction into sublimates is shown in Figure 5.

The addition of ammonium chloride to the chlorinating mixture did not have a significant effect on the degree of lead sublimation. But silica addition increases the degree of lead sublimation by 15-20% and decrease the lead content in the first stage clinker.

The behavior of cadmium during chlorination is similar to that of lead (Figure 6).

All iron, zinc, and a large amount of copper (more than 60-70%) remain almost completely in the clinker. Apparently, this is due to kinetic difficulties during chlorination due to the formation of oxide films on the surface of particles of these metals, which complicate the chlorination process. It is known [19], that ammonium chloride dissolves oxide films on the surface of zinc particles, which promotes the process of zinc chlorination and its sublimation.

It was received that during sintering with the addition of a small amount of ammonium chloride (2% of the weight of the EAF dust), a slight sublimation of zinc to 4-5% was observed.

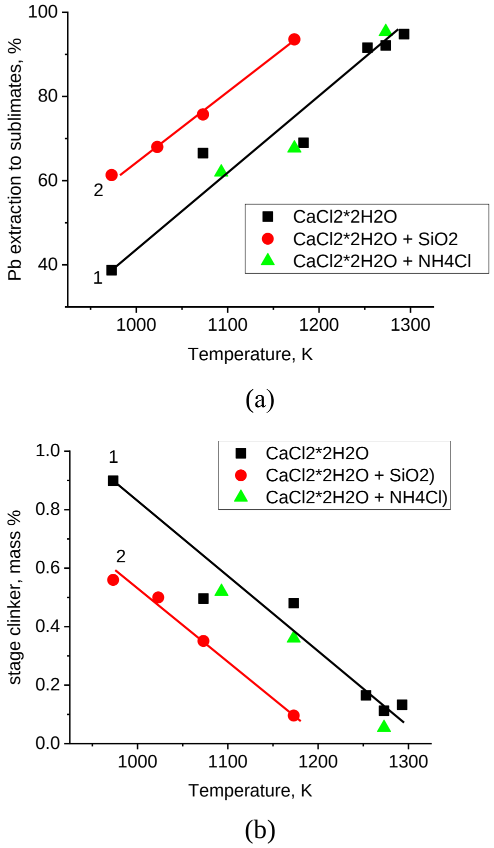
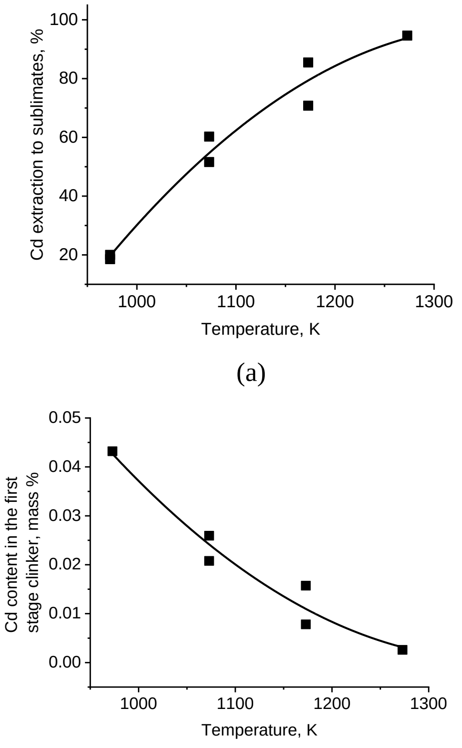


Figure 5. The effect of sintering temperature on the residual lead content in the clinker (a) and on the degree of its extraction into sublimates (b): 1 – EAF dust with $CaCl_2*2H_2O$ and with mixture ($CaCl_2*2H_2O$ + NH_4Cl); 2 – EAF dust with mixture ($CaCl_2*2H_2O$ + SiO_2)



(a)

(b)

Figure 6. The effect of sintering temperature on the degree of cadmium extraction into sublimates (a) and on the residual cadmium content in the clinker (b)

Arsenic, antimony, and tin are also practically not removed from the EAF dust and remain in the clinker, but since their content in the dust is very small (less than 0.02-0.03%), this does not affect the dust processing process. Gold and silver are chlorinated with calcium chloride and their chlorides sublimate at high temperatures by 10-15%, but with their content in the EAF dust are 0.004-0.008%, this also does not have a significant effect on the EAF dust treatment process.

3.3 Second stage sintering of the EAF dust

After lead and cadmium removing through the first stage sintering process, the resulting clinker was sintered again with the addition of a carbonaceous agent to produce pure zinc oxide. Table 3 shows the chemical analysis of the resulting zinc oxide. The total impurity content was 0.06-0.07 mass%, and the lead content was 0.001 mass% when charcoal was used as a reducing agent. In the case of using graphite, the total impurity content was 0.1-0.3 mass%, and the lead content was 0.0015-0.006 mass%. Apparently, this is due to the greater chemical activity of power charcoal compared to compact crystalline graphite.

Table 3. Chemical composition of the Zn oxide after reducing sintering at 1373 K

Reducing agent	Chemical composition				
	Fe	Cu	Zn	Pb	Cd
	mass%	mass%	mass%	mass%	ppm
charcoal	0.06	0.01	80.58	0.0011	0.24
charcoal	0.05	0.01	79.95	0.0012	0.23
graphite	0.09	0.02	72.26	0.0014	0.32
graphite	0.17	0.22	85.81	0.0020	0.38
graphite	0.17	0.08	76.11	0.0057	0.62

Clinker after the second stage of sintering practically does not contain non-ferrous metals (Table 4) and can be used in ferrous metallurgy.

Table 4. Chemical composition of the clinker after reducing sintering at 1373 K

Sample number	Chemical composition				
	Fe	Cu	Zn	Pb	Cd
	mass%	mass%	mass%	mass%	ppm
Sample 1	18.18	0.25	0.65	0.0045	0.96
Sample 2	21.41	0.31	0.31	0.0023	0.58

4. Conclusions

Economical and environmentally advantageous two stages method with efficient recovery of pure lead-free zinc oxide from EAF dust in parallel with clinker containing iron and carbon production for easy return to the iron smelting furnace was proposed. Laboratory-scale measurements with EAF dust from one of the Kazakhstan metallurgical ferrous plants show that process allows receive lead-free zinc oxide with the total impurity content is 0.06-0.07 mass%, and the lead content is 0.001 mass%. The clinker after the second sintering stage, containing iron and carbon and with total content of the non-ferrous metals < 1%, can be sent to the main iron production.

The economic benefit of the method is to reduce the costs of recycling electric arc furnace dust, as well as to obtain a valuable product – pure zinc oxide, which can be used in various industries. In addition, the return of clinker containing iron and carbon to the cast iron smelting furnace allows to reduce the consumption of primary raw materials and material costs for electricity.

The environmental benefit of the method is to reduce emissions of harmful substances into the environment associated with the recycling of electric arc furnace dust. In addition, the process allows to recycle production waste and reduce the consumption of natural resources.

Author contributions

Conceptualization: N.D.; Data curation: N.D., Ye.Zh; Formal analysis: G.K., N.D., V.K.; Funding acquisition: G.K.; Investigation: N.D., I.N.; Methodology: N.D., V.K.; Project administration: Ye.Zh., I.N.; Resources: I.N., V.K.; Software: I.N., V.K.; Supervision: N.D., G.K.; Validation: Ye.Zh., V.K.; Visualization: G.K., Ye.Zh.; Writing – original draft: G.K., N.D.; Writing – review & editing: N.D., V.K. All authors have read and agreed to the published version of the manuscript.

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Conflicts of interest

The authors declare no conflict of interest.

Data availability statement

The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

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Электр доғалы пештердің (ЭДП) шаңынан қорғасынсыз таза мырыш оксидін алу технологиясы

Г. Койшина[1], Н. Досмухамедов[1], В. Каплан[2], И. Нурсаинов[1], Е. Жолдасбай[3*]

[1]*Satbayev University, Алматы, Қазақстан*

[2]*Вейцман ғылыми институты, Реховот, Израиль*

[3]*О.А. Байқоңыров атындағы Жезқазған университеті, Жезқазған, Қазақстан*

**Корреспонденция үшін автор:* *zhte@mail.ru*

Аңдатпа. Шойын балқыту пешіне қайта оңай оралатын құрамында темір мен көміртегі бар клинкерді алатын, электр доғалы пеш шаңынан таза қорғасынсыз мырыш оксидін тиімді алу арқылы үнемді және экологиялық тиімді екі сатылы әдіс сипатталған. Бірінші кезеңде электр доғалы пештердің шаңы хлорид тұздарының қоспасымен араластырылып, қорғасынды бөліп алу үшін әртүрлі температурада күйдіріледі. Екінші кезеңде күйдірудің бірінші кезеңінен өткен клинкер құрамында көміртегі бар реагентпен араластырылып, қорғасынсыз таза мырыш оксидін алу үшін қайтадан күйдіріледі. Құрамында темір мен көміртегі бар күйдірудің екінші кезеңінен кейінгі клинкер шойынның негізгі өндірісіне бағытталуы мүмкін. Қазақстанның қара металлургия зауыттарының бірінен электр доғалы пештердің шаңын пайдалана отырып жүргізілген зертханалық нәтижелер құрамында 0.06-0.07 мас.% қоспалары бар қорғасынсыз мырыш оксидін алуға мүмкіндік беретінін көрсетті және қорғасын мөлшері 0.001 мас.% құрады. Жүргізілген зертханалық зерттеулер негізінде тауарлық өнімді ала отырып, электр доғаларының шаңын екі сатылы өңдеудің технологиялық схемасы жасалды. Әдістің экологиялық пайдасы электр доғалы пештердің шаңын жоюға байланысты қоршаған ортаға зиянды заттардың шығарындыларын азайту болып табылады. Сонымен қатар, процесс өндіріс қалдықтарын қайта өңдеуге және табиғи ресурстарды тұтынуды азайтуға мүмкіндік береді.

Негізгі сөздер: *электр доғалы пештердің шаңы, күйдіру, қорғасынсыз мырыш оксиді, кальций хлориді, көміртегі бар реагент.*

Технология получения чистого оксида цинка, не содержащего свинца, из пыли электродуговых печей (ЭДП)

Г. Койшина[1], Н. Досмухамедов[1], В. Каплан[2], И. Нурсаинов[1], Е. Жолдасбай[3]*

[1]*Satbayev University, Алматы, Казахстан*
[2]*Научный институт Вейцмана, Реховот, Израиль*
[3]*Жезказганский университет имени О.А. Байконурова, Алматы, Казахстан*

**Автор для корреспонденции: zhte@mail.ru*

Аннотация. Описан экономичный и экологически выгодный двухэтапный метод с эффективным извлечением чистого оксида цинка, не содержащего свинца, из пыли электродуговых печей параллельно с получением клинкера, содержащего железо и углерод, для легкого возврата в чугуноплавильную печь. На первом этапе - пыль электродуговых печей смешивали со смесью хлоридных солей и спекали при различных температурах для удаления свинца. На втором этапе клинкер, прошедший первую стадию спекания, смешивали с углеродсодержащим веществом и снова спекали для получения чистого оксида цинка, не содержащего свинца. Клинкер после второй стадии спекания, содержащий железо и углерод, может быть направлен на основное производство чугуна. Лабораторные результаты с использованием – пыли электродуговых печей с одного из казахстанских металлургических заводов черной металлургии показали, что процесс позволяет получать оксид цинка, не содержащий свинец, с общим содержанием примесей 0.06-0.07 мас.% и содержанием свинца 0.001 мас.%. На основе проведённых лабораторных исследований была разработана технологическая схема двухэтапной переработки пыли электродуговых с получением товарной продукции. Экологическая выгода метода заключается в снижении выбросов вредных веществ в окружающую среду, связанных с утилизацией пыли электродуговых печей. Кроме того, процесс позволяет перерабатывать отходы производства и сокращать потребление природных ресурсов.

Ключевые слова: *пыль электродуговых печей, спекание, не содержащий свинца оксид цинка, хлорид кальция, углеродсодержащий реагент.*

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