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RESEARCH ON REDUCTIVE BURNING STEEL MELTING DUST

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Abstract

The present paper is based on experimental data obtained by the author and represents the results of a comprehensive experimental and theoretical investigation into the phase composition, microstructure, and physicochemical properties of steel melting dust formed during steelmaking processes. The study considers steelmaking dust generated in electric arc furnace (EAF) operations as a representative case. Samples of dust were collected from various stages of the technological cycle, including dust collection systems and post-treatment residues, and were analyzed using modern analytical techniques. The objectives of this study are twofold: first, to investigate the phase distribution of valuable components such as iron and zinc in steel melting dust; and second, to elucidate the mechanisms governing metal recovery and losses during reductive burning. The obtained results provide a scientific basis for developing effective technologies aimed at improving the utilization of steelmaking dust through optimized reductive burning conditions, thereby enhancing metal recovery and reducing environmental impact. The findings are of interest to researchers and industrial specialists engaged in secondary raw material recycling, metallurgical waste processing, and the development of sustainable steel production technologies.

Keywords: Steel melting dust, reductive burning, iron oxides, zinc, phase composition, thermodynamic modeling, metal recovery, secondary raw materials.

Introduction

Implementation of modern technologies aimed at: increasing the complexity of raw material use, resource- and energy-saving technologies, utilization of all valuable components, waste and semi-finished products of metallurgical production reduction of metal content in processed ores, depletion rich and easily excavated ore deposits and increased requirements for environmental protection.

The ferrous metallurgy of the Republic of Uzbekistan is represented as follows: enterprise as JSC "Uzmetkombinat." The main source of raw materials for steelmaking is an iron-containing scrap of various compositions. Steel smelting at the enterprise is carried out in an arc steel mill. furnaces. During melting, a large amount of dust is formed and carried away. exhaust gases. In the dust of steelmaking furnaces, except containing a significant amount of iron-containing components zinc as zinc oxide (ZnO up to 17%).

Scrap metal is the main source of inflow to steel-smelting aggregates of such impurities as Zn and Pb (entering the charge zinc-plated iron, brass and bronze parts, shells electrical cables, etc.).

The composition significantly influences the composition of the removed dust. shifts. This effect is especially noticeable when smelting steel in arc furnaces. steelmaking furnaces . Processing such dust requires special attention, since, firstly, they can simply be used as a supplement to shixta is not allowed (this will worsen the quality of the steel); secondly, it is not allowed to be buried in the ground, as soil contamination is possible (burial in is prohibited in a number of countries); thirdly, it is advisable to use such dust extract its valuable components (except iron).

Materials and Methods of Research

Object of research dust from the steel smelting furnaces of JSC "Uzmetkombinat." On to date, more than 60,000 tons have accumulated in special warehouses. zinc-containing dust of gas cleaning ESPC. Annually generated additionally 12000 - 13000 tons of zinc-containing dust . Chemical composition of steel-smelting dust obtained from AO "Uzmetkombinat" is presented in Table 1.

Table 1. Chemical composition of steel-melting dust

Compounds	Content, %
$Fe_{general}$	31,2
Fe_2O_3	41,6
FeO	4,6
P_2O_5	0,2
SO_3	0,9
SiO_2	3,4
ZnO	16,2
PbO	1,36
CuO	0,36
C	2,4
CaO	3,4
Al_2O_3	0,9
MnO	3,7
MgO -	
Cr_2O_3	0,6
NiO	0,03
TiO_2	0,14
Na_2O	10,4

As reducing agents of zinc oxide and iron oxides, the oil coke contained in the steel smelting dust was selected. Fergana Oil Refinery (FNPZ).

Oil coke is a complex dispersed system in which the dispersed phase consists of crystalline formations (crystallites). of different sizes and order in the mutual arrangement of molecules and porus, and dispersion medium - the filling porus of crystallites, continuous. gaseous or liquid phase from which adsorption-Solvate layers, or solvate complexes. Despite the differences conditions of obtaining, the crystallites have similar sizes and represent a package of parallel layers (planes). Crystallite sizes (v nm): length of the planes a = 2.4-3.3, package thickness c = 1.5-2.0, interplanar distance 0.345 - 0.347 [8].

Results and their Discussion

To determine the optimal and its cost, experiments were conducted with using Fergana oil coke as a reducing agent oil refinery (FNPZ) and bury coal of the Angren field.

Based on industrial experience in the process of zinc welding Kekov and information obtained during the analysis of literary sources, a decision was made on the quantity of coke from the FNPZ loaded into the charge. taken equal to 40% of the pili mass (average carbon content in the coke) 95%).

When used as a reducing agent of brown coal Angren section, the lower carbon content in it was taken into account (73.44%) compared to coke, based on the amount of carbon increased to 52% of the pili mass (95:73.44·40 = 52).

The suspension was made for preparing the charge with petroleum coke. 20 g., and the amount of added coke is 8 g.

The hanging of the pulley for preparing the charge with burning coal was also made. 20 g, and the amount of added carbon was 10.4 g.

The prepared charge was loaded into the chamotte crucible and were installed in a preheated to 1200°C shaft furnace and were burned for 90 minutes. Upon expiration of the specified time, the crucibles the hangers were removed from the furnace and cooled to room temperature.

Residual zinc content in clinker and degree of reduction iron oxides were analyzed on an atomic absorption analyzer in laboratories "Physicochemical Research Methods" GP "Institute" "mineral resources." The results of the analyses are presented in Table. 2.

Table 2. Zinc content in the initial probe and after burning

№	Sample Name	Moderate Zn content, %
1	Initial battery suspension	16.78
2	Clinker (batch: pill 20 g + petroleum coke 8 g)	14.5
3	Clinker (batch: pill 20 g + carbon 10.4 g)	13.4

From the data presented in the table, it can be seen that when used in as a reducing agent of carbon, the zinc content in clinker is lower than in use of petroleum coke. Based on the obtained results, and also taking into account the cost of petroleum coke (about 2.4 million soums per ton), over the cost of coal (about 0.5 million soums per ton) and high the presence of sulfur in the coke, which is a harmful impurity for steel, was a decision was made to use the angren burial mound as a restorer angle.

From the results of the experiment, it can be seen that the zinc content in clinker remains high, this can be explained by many reasons. the main ones are the deficiency and insufficiency of the reducing agent. The temperature is high.

To determine the optimal amount of reducing agent, it was a decision was made to increase the cost of the reducer (coal). Knowledge three signs have been prepared with coal content in charge of 65, 80, and 90% of masses of pili All three suspensions were fired under the same conditions (1200°C, 90°F). min). The results of the study are presented in Table 3 and Figure 1.

Table 3. Zinc content in clinker depending on the amount of reducing agent in the charge

№	Quantity Restorer in shifts % of battery weight	Residual contents zinc in clinker, %
1	52	13,4
2	65	10,56
3	80	7,98
4	90	7,98

From the research results presented in Table 3 and Figure 1, it is evident that with an increase in the amount of coal in the charge to 80-90% of the pill mass, zinc content in clinker decreased to 7.98%. Extraction of zinc in is 52.4% (16.78 - 7.98): 16.78 = 52.4).

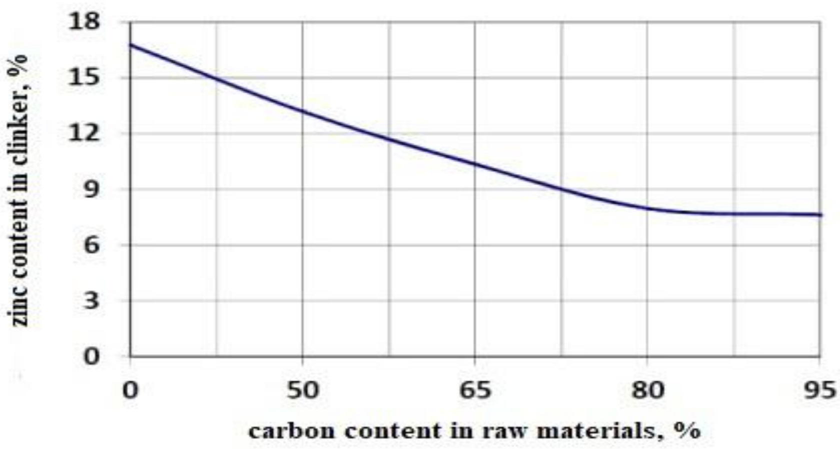

Fig. 1. Dependence of zinc content in clinker on consumption restorative

The choice of the optimal temperature of 1200°C is explained by the fact that at The degree of reduction of zinc at this temperature is determined by the reaction $ZnO + Fe = FeO + Zn$ (g) has large values (table. 4.).

Table 4. Vapor pressure of zinc upon its rise

Temperature, °	Zinc vapor pressure, mm.
1000	85
1100	363
1200	1260

Based on the data presented in the table, it can be concluded that that the further increase in temperature will have a favorable effect on Distillation of zinc, however, limitation of temperature regime is caused the presence of easily melted components, which cover during melting pores of solid particles, causing an obstacle to the distillation of zinc into the gas phase. Iron present in steel smelting dust during the process reducing roasting, also reduced from oxides compounds to metal. Reduction of iron oxides with carbon is described by the reactions:

$3Fe_2O_3 + C = 2Fe_3O_4 + CO$

$Fe_3O_4 + C = 3FeO + CO$

$FeO + C = Fe + CO$

Metallic iron formed during reduction annealing steel-melting saw will contribute to an increase in zinc extraction. zinc will be reduced from the oxide in volcanic form according to the reaction:

$ZnO + Fe = Zn + FeO$

In addition, due to the carbonization of iron at a temperature of 1150 ^{0}C cast iron will be formed. As a result of restorative annealing zinc content in the dust will be reduced due to the distillation of zinc into gas. and a solid product called "clinker" was obtained, in which the main part of the iron will be in metallic form, which allow, without preliminary preparation, to melt it into steel-smelting furnaces

Results of iron oxide reduction during reducing roasting with coal as a reducing agent, reduced to Table 5.

Table 5. Iron oxide reduction indicators

№	Sample name	Fe,%	FeO, %
	Initial steel-melting dust	31,3	2,54
	Clinker after restorative annealing	31,8-34	< 0,02

The zinc content was determined by atomic absorption analysis. Vozgonax. The zinc content in volcanoes is 64.41%.

Conclusion

Problem of involvement in steelmaking production piles are especially sharp nowadays, when enterprises are black. metallurgists of the Republic are experiencing a shortage of raw materials. Currently at 60 thousand tons have already been accumulated in the warehouses of JSC "Uzmetkombinat" and are formed annually. 10 thousand tons of steel-melting saw with a ZnO content of up to 17%.

One of the solutions to this problem may be reduction the amount of zinc loaded into the steel furnace together with the raw material.

The conducted research established that the reduction of zinc and iron oxides can be reduced by reducing Objiga. The use of brown coal was proposed as a reducing agent. angren deposit For the practical implementation of the proposed technology it is proposed to use the existing technology and equipment.

Processing of zinc cakes used at a zinc plant Almalyk Mining and Metallurgical Combine.

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