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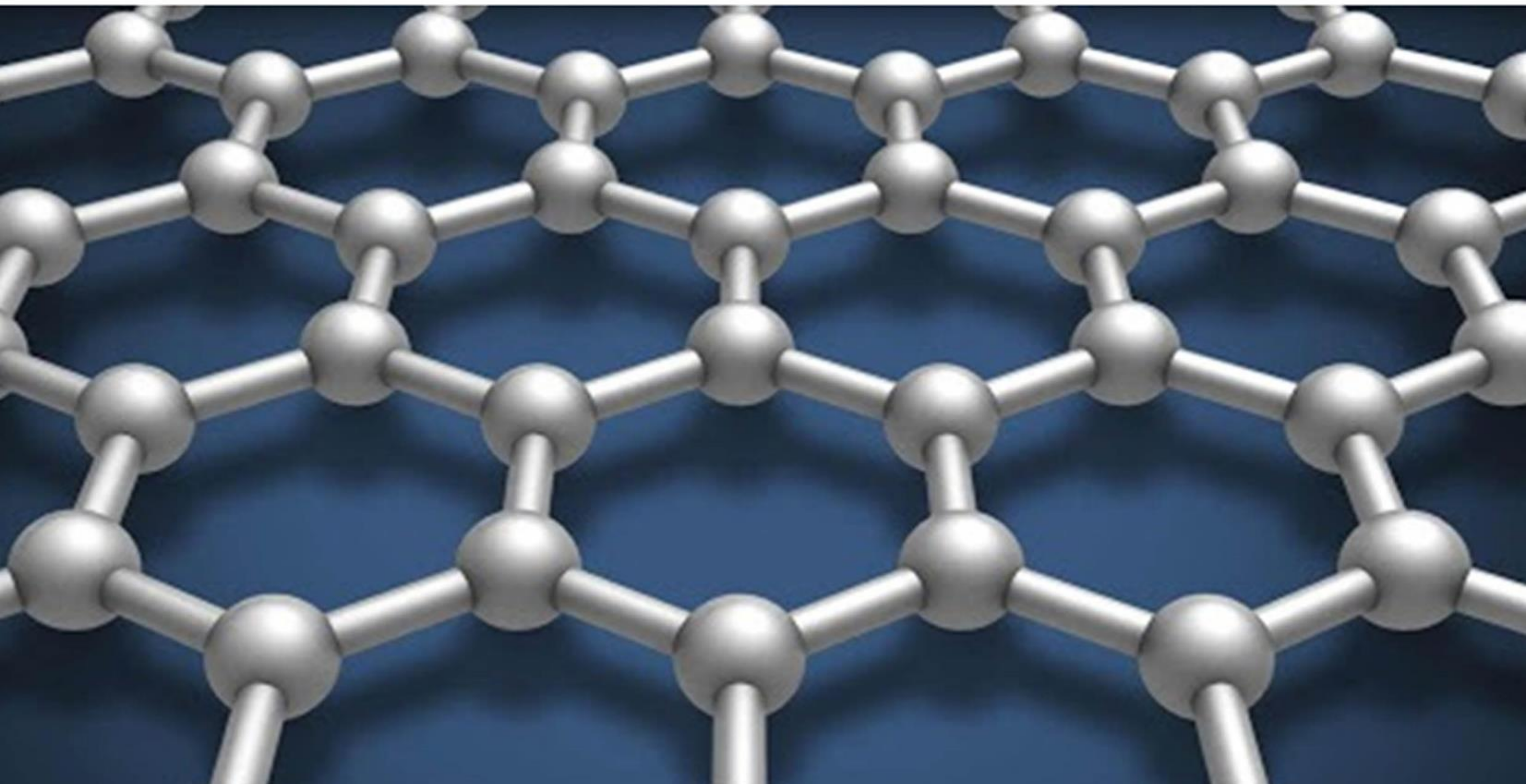

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Композиционные материалы

Ключевые слова: пемзовидный, стекловидный, плавленый флюс, шлаковая система, прокалка, параметры термообработки.

Аннотация. В статье рассмотрены исследование влияния параметров режима прокалки плавленого флюса ФЦ-18М в стационарных электрических печах на его влажность и количество водорода в наплавленном металле. Приведены оптимальные параметры термообработки и рекомендации по оборудованию для высокотемпературной прокалки флюса ФЦ-18М.

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DEVELOPMENT OF TECHNOLOGY FOR REDUCING FERRITES AND ZINC SILICATES WHEN RINGING ZINC CONCENTRATES IN ROAST FURNACES

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Introduction. Zinc production plays an important role in the Uzbekistan economy and is aimed at providing other industries with zinc-containing products, including mechanical engineering, chemical and construction industries, which together account for more than 60% of the total amount of zinc consumed.

The process of oxidative roasting of zinc concentrates in FBR furnaces, being one of the important production cycles of zinc production, makes it possible to determine the technical and economic indicators of subsequent processing and production in general. According to the type of source of thermal energy of the kiln, FBRs are classified as units that operate using the energy of only sulfide-containing materials. Sulfide materials, consisting mainly of sphalerite minerals (ZnS - more than 95% of zinc consists of these minerals), contained in the charge, interacting with oxygen in the air, are completely or partially oxidized, and the sulfur found in the charge concentrates turns into sulfur dioxide into the gas phase.

As a result, the purpose of the roasting stage is related to the maximum conversion into metal oxides in sulfide form. The resulting cinder must have a large reaction surface with a limited content of compounds in the resulting product, such as ferrites and silicates of zinc and lead, and also provide the possibility of producing roasting gases with the maximum possible concentration of sulfur dioxide [1].

Physico-chemical studies of the processes of roasting zinc concentrate in FBR using classical firing technology have shown results that determine the possibility of the formation of metal ferrites. Ferrite formation is because zinc oxides interact with hematite (reaction 1) to form the compound zinc meta ferrite $ZnO{\cdot}Fe_2O_3$ [2-3].

$$ZnO + Fe_2O_3 = ZnO{\cdot}Fe_2O_3 \quad (1)$$

During the firing of zinc concentrates at a temperature of 650ºC, continuous ferrite formation was observed, and the results of further research into the firing process by increasing the temperature to 700-750ºC also did not exclude the possibility of ferrite formation.

It is known that direct losses of zinc are associated with the fact that a significant amount of them can be in the residual masses during the leaching process of zinc cinders because these compounds cannot dissolve in weak sulfuric acid, which leads to significant losses of zinc. Preventing the formation of metal ferrites, including zinc ferrites, during roasting processes is impossible in cases where zinc concentrates contain iron [4].

In addition to zinc ferrites, zinc silicates are also formed during the firing process (reaction 2).

$$ZnO + SiO_2 = ZnO{\cdot}SiO_2 \quad (2)$$

Silicates can be decomposed by sulfuric acid to produce colloidal silicon dioxide in the pulp when leaching calcined concentrates. The formation of silicates is the result of the interaction of silica-containing non-metallic mineral mass with oxides of heavy non-ferrous metals obtained during the roasting of sulfide concentrates. If the firing temperature of the fluidized bed reaches 950ºC, then the possibility of the formation of roasting silicates can increase up to 60% [5].

In the processes of the hydrometallurgical method of zinc production, sufficient attention is paid to the processes of silicate formation during the roasting of concentrates. Zinc and lead silicates in the form of $ZnO{\cdot}SiO_2$, and $PbO{\cdot}SiO_2$, which can decompose in H_2SO_4 solutions, can serve as a source of the formation of colloidal silica, which prevents the filtration of solutions. The source of the formation of silicates during the roasting of zinc concentrates is the process of interaction of waste rock containing silicon with metal oxides. In addition, an increase in the degree of silicate formation by 32% was observed under conditions of increasing temperature and a decrease in the granulometric composition of the substances entering the reaction [6].

From the above, it follows that ferrite and silicate formation is inevitable during the roasting of zinc sulfide concentrate. This may explain the fact that during leaching, in any case, loss of zinc will occur. In addition, it can be noted that with an increase in the iron content in the concentrate, the likelihood of the formation of zinc ferrite increases, which is the most harmful [7].

The above compounds are very slightly soluble in solutions of sulfuric acid and are largely transferred to cakes. The yield of cakes depends on the composition of the feedstock and when processing a concentrate of average quality, it is 40-45% of the weight of the original charge [8-9].

From these data it is clear that a significant amount of zinc is lost in technogenic waste and significantly affects the technical and economic indicators of the process. In the context of declining zinc ore reserves and increasing metal prices on the world market, the issue of improving technology and significantly reducing losses from industrial waste is being raised. [10].

In this regard, it is considered important to improve the technology for processing zinc concentrates during their roasting using oxygen-enriched air, as well as the development of the optimal composition of the charge and technology to reduce ferrite and silicate formation.

Selection of research objects. The objects of research were zinc sulfide concentrate with charge prepared for roasting at the zinc plant of “Almalyk MMC” JSC. Before conducting the research, 100 kg of zinc sulfide concentrate, limestone, calcium oxide, and charge were selected.

The selected samples were subjected to chemical and phase analysis. The results are shown in table 1.

Table 1.

Chemical composition of selected samples of zinc concentrate

Sample number	Content, %					
	Zn	Fe	S	SiO_2	Pb	Cu
№1	38-50	5-8	29-31	0-4	4-4,6	2,2-2,3
№2	45-46	8-9	29-31	1,5-3,0		
№3	50,8	3,77	31,19	6,08	4,34	0,67
№4	47,69	4,46	28,83	7,76	2,29	0,87

To study and study the reasons for reducing the formation of ferrites and zinc silicates during the firing process, additional additives of CaO and $CaCO_3$ oxides were introduced into the charge.

Discussion of the research results. The authors were faced with the question of completely converting all sulfide-containing compounds into an oxide or water-soluble form, i.e. into sulfate. At the same time, the issue of reducing dust removal should be resolved, because cyclones trap dust consisting of oxides, i.e. The cinder consists partly of unburnt concentrate. In the oven, after drying to a moisture content of W=0.1-1%, small particles of the concentrate fly into the cyclone in the air stream.

In a laboratory installation of a calcination furnace, the air in the chamber is enriched with oxygen from 21% to 28% and mixed, then fed into the furnace with the charge by a specially prepared burner. A mixture of air with oxygen or oxygen separately was purged in an amount of 1.2-1.4 m^3 per 1 kg of sulfide concentrate. In this case, the blast speed was 3-5 m/s [11].

The use of lime as an additional additive to the firing charge is justified by the fact that at firing temperatures, calcium carbonate decomposes to form calcium oxide and carbon dioxide, which are directly involved in the processes of preventing the formation of ferrites and zinc silicates [12].

Table 2.

Results of tests of roasting zinc concentrates with the addition of lime

№	Blend composition		Technological process		Results			
	Initial concentrate, g	Lime, %	τ, burning hour	T, °C	S in the cinder %	Degree $ZnO{\cdot}Fe_2O_3$%	Degree Zn_2SiO_4%	ε, soluble Zn %
1	100	-	0,5	900	6,8	14,4	8,3	56,9
2	100	-	1,0	1000	5,7	13,7	8,7	57,5
3	100	3	1,0	1000	3,1	6,3	6,8	71,3
4	100	3	1,5	950	2,2	7,6	7,2	68,2
5	100	3	2,0	900	1,7	7,2	7,0	69,8
6	100	5	1,0	950	3,4	6,9	6,4	74,3
7	100	5	1,5	950	1,8	6,2	6,1	75,6
8	100	5	2,0	950	0,4	5,7	5,8	78,5

9	100	7	1,0	950	0,7	7,3	6,2	74,1
10	100	7	1,5	950	0,3	6,2	5,4	79,2
11	100	10	1,0	900	2,6	5,8	5,7	76,7
12	100	10	1,5	900	2,3	5,4	4,3	78,6
13	100	10	2,0	900	1,7	4,2	2,2	85,3
14	100	12	1,0	950	2,2	2,0	2,4	86,2
15	100	12	1,5	900	1,4	1,7	1,7	88,9
16	**100**	**12**	**2,0**	**900**	**0,4**	**1,3**	**1,2**	**91,2**
17	100	15	1,0	950	2,2	2,4	2,1	92,6
18	**100**	**15**	**1,5**	**900**	**0,4**	**0,6**	**1,2**	**97,5**

During the laboratory study, as can be seen from Table 2, during the roasting of zinc concentrates, the best results were obtained by adding lime to the charge in the amount of 12% and 15% (Table 3. point 16, 18). The firing processes were carried out at a temperature of 900 °C, but the firing time was different, that is with 12% lime added, the firing time extended to 2 hours, and with the addition of 15% lime, the firing time took 1,5 hours. Comparing these results from the table, we can say that the minimum degree of ferrite and silicate formation occurs at point 18 with the use of 15% lime. At the same time, the degree of ferrite formation decreased to 0,6%, and the degree of silicate formation decreased to 1,2%.

Table 3 shows the dependence of the completeness of sulfide oxidation during firing of concentrates on the amount of air supplied to the furnace, while the temperature in the main zone of the fluidized bed increases with increasing oxygen concentration in the blast from 25% to 28%. At the same time, the temperature of the exhaust gases increases.

Blowing in ordinary air, if the temperature is 372°C, with the addition of technical oxygen with enriched air up to 28%, the temperature of the exhaust gases in the flue rises to 416°C (Table 3, point 15). But to ensure the complete and rapid occurrence of oxidation reactions during firing, an excess of air is needed compared to the required amount by 20%. According to practical data at the zinc plant of "Almalyk MMC" JSC, the excess air coefficient in the fluidized bed kiln used is α = 1.2-1.3. In practice, the temperature in the furnace is adjusted by changing the loading of the charge into the furnace, i.e. sulfur and sulfur-containing materials were loaded with the loading of the charge.

Table 3.

Results of a laboratory study using oxygen in blast for firing zinc concentrates in a FRR

№	O_2 content in the blast	Increase in T in the furnace °C	T – in the gas duct °C	*a*, specific productivity kg/cm2 h	S content in cinder, %	Content in exhaust gases and dusts, %			
						SO_2	Ss	O_2	Dust output
1	20,0	920	372	2,7	4,9	9,1	2,1	0,20	32,5
2	21,0	920	374	2,7	4,8	9,3	2,0	0,18	31,4
3	22,0	931	376	2,7	4,5	9,8	1,5	0,75	30,6
4	22,0	933	378	2,7	4,2	10,1	1,5	0,74	30,8
5	23,0	963	389	2,9	1,5	11,4	0,7	1,3	28,7
6	23,0	960	390	2,9	1,4	11,6	0,6	1,3	28,9
7	24,0	982	397	3,1	1,2	11,7	0,64	1,7	27,2
8	24,0	986	398	3,2	1,2	11,4	0,59	1,6	27,3
9	25,0	988	398	3,4	1,0	11,7	0,44	1,8	27,4
10	25,0	990	403	3,4	0,9	11,8	0,51	2,2	27,3
11	26,0	994	407	3,6	0,4	11,6	0,28	2,7	25,2
12	26,0	994	405	3,6	0,5	12,2	0,27	2,8	26,4
13	27,0	1020	412	3,6	0,6	12,6	0,25	3,1	26,3
14	27,0	1020	412	3,6	0,8	12,7	0,27	3,2	26,5
15	28,0	1034	416	3,8	0,4	12,9	0,26	4,2	25,4
16	28,0	1038	415	3,8	0,3	13,2	0,20	4,1	26,1

When sulfur burns, the temperature in the furnace is reduced by water cooling, i.e. cooling coils. Cooling elements, coils, are installed in the fluidized bed zone and are determined by the productivity of the furnace, the firing temperature, and the cooling system. In laboratory conditions, the temperature was regulated using a gas burner with a change in the humidity of the mixture, which ranges from W from 5 to 8%.

The use of firing with blast enriched with oxygen up to 28% made it possible to significantly increase the productivity of the furnace with a duration of 1.5 hours instead of two hours. The most important aspects of improving the quality of the roasted concentrate during roasting is an increase in the content of sulfur dioxide from 9.1% to 13.9% (Table 4, paragraph 16) and a decrease in free sulfur to 0.3%. Adding technical oxygen to the blast will not lead to an increase in the cost of cinder and zinc metal in general due to the difference in the price of ordinary air and oxygen.

If 140-160 m^3 of air were consumed per 100 kg of concentrate, then when enriched with oxygen, about 100 m3 is consumed, but at the same time dust removal decreases from 32.5% to 25.4%. One of the economic advantages of using oxygen is its intensifying effect on sulfide compounds. The rate of the main reaction of sulfide roasting is positively influenced by the concentration of oxygen in the gas phase and temperature.

During oxidation, it was revealed that the firing process depends on the temperature in the KS furnace, and is determined by the amount of burned cinder, as well as the amount and temperature of incoming air. With a small amount of air, the cinder is not completely burned and, therefore, this leads to a decrease in the productivity of the process.

Conclusion: Based on the conducted research, we can conclude that an increase in the oxygen content in the blast when firing zinc concentrates in FBR furnaces leads to a reduction in the formation of undesirable compounds of ferrites and zinc silicates, increases the degree of desulfurization, and reduces the firing time. In this case, it becomes possible to load concentrate with high humidity into the oven, which will save costs on drying the starting materials.

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