

Possibilities for improving the technology of roasting zinc concentrates

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Abstract. The paper presents an investigation into the oxidation process of zinc sulfide concentrate. A common challenge encountered during the fluidized calcination process is the high concentration of sulfide sulfur in the condensed products, such as the mixture collected at the furnace threshold and in the dust. This scientific work reports the results of laboratory studies aimed at improving the technology of roasting zinc concentrates. The study's objective was to obtain zinc cinders with increased solubility in aqueous solutions by roasting sulfide zinc concentrates. The results show that the optimal composition of the charge for roasting was determined using limestone and wastewater from the processing plant, which contains alkaline earth metal oxides. This composition helped reduce the formation of ferrites and silicates by 1.5-1.7 times.

1 Introduction

The initial step in the hydro-electrometallurgical process for zinc production involves the oxidative calcination of sulfide concentrates. Reducing the amount of zinc in zinc cakes produced by hydrometallurgical processes while also saving additional carbon-containing fuel is of particular importance. In this regard, studying the physicochemical processes that occur during the classical process of roasting zinc concentrates in fluidized bed furnaces is important. Calcination carried out in a fluidized state within the furnace guarantees a rapid process rate, energy self-sufficiency, and yields a finely grained product that is advantageous for the following stages of the hydro-metallurgical process. In this vein, many developed countries, including the USA, Germany, and England, and at the same time, leading countries for processing zinc raw materials, such as China, Australia, India and others, have paid special attention to preventing the formation of undesirable compounds during the processing of zinc concentrates [1].

Examining the observed phenomena indicates that excessively high temperatures in the fluidized bed may contribute to the elevated sulphide sulphur content in condensed roasted products. All over the world, targeted research is being carried out to develop technologies for processing zinc concentrates, allowing for the reduction of energy resource materials. In these areas, the development of technology to prevent the formation of sparingly soluble and insoluble zinc compounds during the firing of sulfide zinc concentrates in fluidized bed

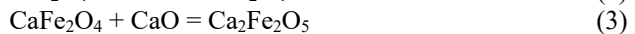
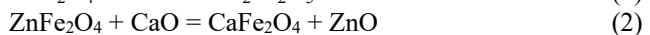
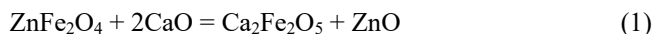
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furnaces is of particular importance. Among other things, improving the processing of zinc concentrates is considered important for ensuring resource conservation [2].

In the Republic of Uzbekistan, measures are being developed to organize modern zinc production; these measures are necessary for processing a large assortment of concentrates from various deposits with high contents of iron and silicon, which can occur unevenly in time and quantity. Additionally, under the influence of external conditions, there is an uncontrolled change in the duration of the polymetallic processing of zinc sulfide raw materials. If zinc concentrates contain the mineral marmatite or iron sulfides, the roasting process leads to the formation of zinc metaferrite ($ZnFe_2O_4$), which is insoluble in weak sulfuric acid. This compound remains unchanged in the residue after leaching the cinder, thereby hindering the direct extraction of zinc into the solution. Silica is a harmful impurity in zinc concentrates and we strive to reduce its content in them to a minimum. During the firing process, silica forms low-melting compounds with oxides of heavy non-ferrous metals (zinc, lead) - silicates, which cause melting of the material in the furnace [3]. The authors of this work were faced with the task of conducting a study to improve the technological regime for processing zinc sulfide concentrates by introducing production waste from processing plants containing alkaline earth metals and containing a sufficiently high amount of iron and silicon with the further development and implementation of the roasting process to obtain zinc crystals soluble in aqueous solutions [4]. The significance of the results of laboratory studies carried out by the authors is due to the influence of the content of limestone and alkaline earth compounds on firing, as well as the influence of natural minerals on the formation of the structural-phase composition and distribution of zinc in other compounds, especially with iron and silicon, leading to the formation of compounds such as ferrites and silicate zinc and the acceleration of the rate of oxidative reactions of sulfide compounds [5].

2 Materials and methods

For this purpose, we propose to introduce into the firing charge some quantities of such compounds (Na_2O , K_2O , CaO , MgO , and BaO), which would have greater chemical affinity for FeO and SiO_2 than zinc oxide. The decomposition of zinc ferrite with calcium oxide occurs according to reactions



This will make it possible, even at moderate temperatures and at a much higher speed, to bind iron and silicon oxide into strong compounds and create conditions under which zinc oxide remains in a free state, which will significantly increase the degree of transition of zinc into solution during leaching and reduce the zinc content in the cake, increasing the end-to-end extraction of zinc into finished products [6,7].

The objects of experimental research were zinc sulfide concentrate and charge prepared for firing in a fluidized bed furnace (FB) at the AMMK zinc plant, limestone and technical oxygen.

Additional additives were introduced into the firing charge in three ways: 1) additional additives were thoroughly mixed dry until a homogeneous mass was formed; 2) to ensure good contact between the components of the charge and the introduced additional additives, the charge prepared according to the first method was wetted with water, and granules were prepared; and 3) to ensure complete contact of the charge components with the introduced additives, an aqueous suspension of the added component was prepared and mixed with zinc concentrate. The resulting pulp was ground in a porcelain mortar and dried. The dried mixture was crushed and fired.

In addition to the addition of chemically pure oxides of alkali and alkaline earth metals, the roasting charge was prepared by mixing zinc concentrate with wastewater from the AMMK processing plant, which contains a significant amount of oxides of alkali and alkaline earth metals (in the form of a suspension and ions). Like in the case of batch preparation according to Method 3, the pulp was dried, crushed and roasted.

In order to determine the optimal amount of limestone added to the charge material, according to the results of the research with the addition of different amounts of CaCO_3 , it was determined that the optimal amount of limestone added to the charge depends on the amount of iron and silicon oxide, which is calculated according to the following equation.

$$P_{\text{CaCO}_3} = \frac{(0,72 \cdot C_{\text{Fe}} + 0,5 \cdot C_{\text{SiO}_2}) \cdot 56}{X} \quad (4)$$

Here, C_{Fe} – is the amount of iron in enrichment, % (mass);

C_{SiO_2} – amount of silicon oxide in enrichment, % (mass);

X – is the amount of CaO in CaCO_3 , % (mass).

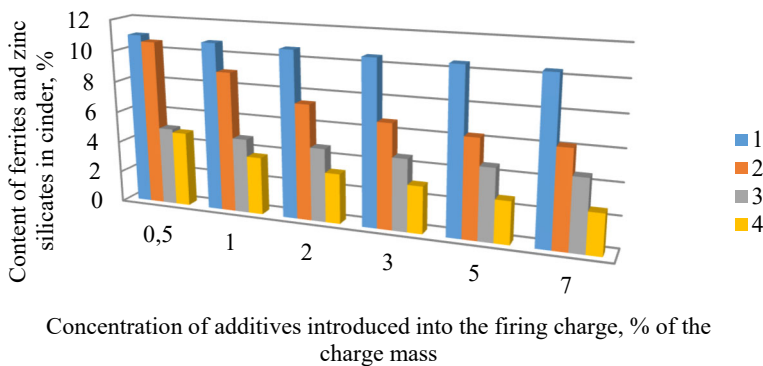
Under laboratory conditions, a zinc charge containing 50.88% zinc, 7.21% iron, and 4.13% silicon dioxide was applied. The amount of added limestone varied from 0.5 to 7% by weight of the charge. For this purpose, 100 kg of zinc sulfide concentrate, limestone and charge were selected.

According to the results of the study, the minimum amount of zinc ferrites and silicates was formed when the amount of CaCO_3 was 7% of the charge weight. This amount of CaCO_3 corresponds to the data obtained by calculation according to equation 4.

To study the reasons for the reduced formation of ferrites and zinc silicates, zinc concentrates were roasted in stationary mode in a muffle furnace and in dynamic mode during LPKS installation, which consisted of a laboratory shaft furnace of the SNOL 1.6/11-IZ type. Firing was carried out by preheating to 950°C.

3 Results and discussion

The results of experiments on studying ferrite and silicate formation during firing showed that the addition of even a small amount of alkali and alkaline earth metal oxides to the charge causes a noticeable decrease in ferrite and zinc silicate in the cinder (Figure 1, lines 2, 4).



1-ferrite content in the cinder during firing at the LPKS installation; 2- ferrite content in the cinder during firing in a laboratory muffle furnace; 3- silicate content in the cinder during firing in the LPKS installation; 4-silicate content in the cinder when fired in a laboratory muffle furnace.

Fig. 1. The influence of additional additives introduced into the firing charge on ferrite and silicate formation during firing.

The best indicators for reducing the content of ferrites and zinc silicates in the cinder were obtained by firing the charge prepared using the third method. This can be explained by the fact that with the wet method of batch preparation, almost complete envelopment of zinc concentrate particles with oxides of alkali and alkaline earth metals occurs.

The use of CaCO_3 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 preventing the formation of ferrites and zinc silicates.

When firing the charge in a dynamic mode on the laboratory installation "LPKS", a decrease in the content of ferrites and zinc silicates was not observed (Figure 1, lines 1, 3); this is explained by the fact that when firing in a fluidized bed, complete contact between concentrate particles and oxides is not achieved between alkali and alkaline earth metals.

4 Conclusion

According to the results obtained experimentally, the addition of oxides of alkali and alkaline earth metals leads to a 1.5-1.7-fold reduction in the formation of ferrites and silicates, and when limestone is used as an additive, the best results are obtained.

The optimal amount of additive, i.e., limestone, depends on the silica content, as well as the amount of iron in the concentrate. Based on this, it was determined that the optimal way to prepare a charge for firing is to mix an aqueous suspension of introduced additional additives (CaCO_3 , Na_2CO_3) with a zinc concentrate (wet charge preparation), which ensures almost complete envelopment of zinc concentrate particles by oxides of alkali and alkaline earth metals.

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