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The aim of the study is possibility of processing the Khandiza deposit's zinc concentrate into zinc chloride. It has been shown that the extraction of zinc from the concentrate must be carried out in an autoclave, after preliminary calcining the zinc concentrate at a temperature of 500 °C, followed by purification of the zinc chloride solution and further evaporation. A technological scheme of production has been developed and a scheme of material flows has been drawn up.

Keywords: zinc chloride, acid decomposition, hydrochloric acid, zinc-containing concentrate, autoclave

ИССЛЕДОВАНИЕ ТЕХНОЛОГИЧЕСКИХ ПОКАЗАТЕЛЕЙ ПРОЦЕССА ПЕРЕРАБОТКИ ЦИНКОВОГО КОНЦЕНТРАТА НА ХЛОРИСТЫЙ ЦИНК

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Целью исследования было изучение возможности переработки цинкового концентрата месторождения Хандиза на хлористый цинк. Показано, что извлечение цинка из концентрата необходимо проводить в автоклаве, предварительно прокалив цинковый концентрат при температуре 500 °С с последующей очисткой раствора хлорида цинка и дальнейшей выпаркой. Разработана технологическая схема производства и составлена схема материальных потоков.

Ключевые слова: хлористый цинк, кислотное разложение, соляная кислота, цинксодердащий концентрат, автоклав

RUX KONSERTATINI RUX XLORIDIGA QAYTA ISHLASH JARAYONINING TEXNOLOGIK KO'RSATKICHILARINI TADQIQ ETISH SINTEZI

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Tadqiqotning maqsadi Xondiza konidan rux konsentratini rux xloridga qayta ishlash imkoniyatlarini o'rganish edi. Ruxni kontsentratdan ajratib olish avtoklavda, sink konsentratini 500 °C haroratda oldindan kalsifikatsiya qilgandan so'ng, sink xlorid eritmasini tozalash va keyinchalik bug'lanishdan so'ng amalga oshirilishi kerakligi ko'rsatilgan. Ishlab chiqarishning texnologik sxemasi ishlab chiqilgan va moddiy oqimlarning sxemasi tuzilgan.

Kalit so'zlar: rux xlorid, kislotali parchalash, xlorid kislotasi, rux konsentrati, avtoklav

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Introduction

Zinc chloride has a fairly wide range of applications. Zinc chloride ($ZnCl_2$) is white crystals or flakes, sometimes with a yellowish, capable of absorbing water vapor from the environment [1].

Zinc chloride is an important component of the flux for soldering metals and fibers [2-3]. Zinc chloride is used as a component for the production of fiber, as an antiseptic impregnation of wood, in particular sleepers, in the manufacture of dental cements, and for refining zinc alloy melts. Zinc chloride is used in fire-resistant foam or for impregnation of fabrics and cardboard. In addition, zinc chloride is used in calico printing, the production of dyes, aluminum, zinc cyanide and vanillin, in galvanic batteries, in oil refining, for fractional analysis of coal samples, and for many other purposes [4–5].

At the present stage of economic development, increasing the efficiency of the use of natural resources has become one of the most important scientific, technical and economic problems.

Special scientific and practical interest is the problem of economic efficiency of the integrated use of zinc raw materials. The solution to the problem of the integrated use of raw materials in zinc production is due to the fact that it is necessary to significantly increase the production of non-ferrous, noble and rare metals, as well as the production of sulfuric acid. The degree of complexity is characterized by the number of extractable components in relation to their total number in the ore (concentrate) and is expressed as a percentage [6-8].

The complexity of using zinc concentrates ranges from 70 to 93%. Increasing the degree of complexity of the use of raw materials leads to a significant expansion of raw materials for zinc production, due to the possibility of using ores poor in base metal, reduces the cost of production, helps to increase labor productivity, increases the profitability of enterprises, makes it possible to significantly reduce hazardous production waste [9-11].

In the production of zinc for the processing of concentrates in world practice, at present, pyrometallurgical and hydrometallurgical methods are used.

The study of the behavior of rare elements and other zinc companions during the processing of concentrates according to the above schemes made it possible to draw some conclusions given below.

At hydrometallurgical zinc plants, during the roasting of zinc concentrates at a temperature of 950–980 °C, most of the indium and germanium remain in the cinder, thallium sublimes by 60–70% and concentrates in dust, selenium and tellurium in the form of oxides (SeO_2 and TeO_2) sublimate to a significant degree, partially condense in dust, and most of it, together with the gas phase, enters the sulfuric acid production. Cadmium in the bulk remains in the cinder in the form of oxide and complex compounds (ferrites, silicates, aluminates) [12 –17].

During the processing of zinc concentrates according to pyrometallurgical technology in the process of agglomerating roasting, the following are sublimated: cadmium by 80–90%, thallium by 70–80%, germanium partially volatilizes in the form of chloride and oxides, most of the selenium and tellurium is sublimated, 90% of lead is sublimated from the concentrate. These metals are concentrated in dust [18–20].

The most important property of non-ferrous metallurgy raw materials is the ability to significantly release heat during its processing. A huge amount of energy is hidden and released in the process of pyrometallurgical processing of various sulfide raw materials, which include sulfide zinc concentrates, as well as copper, nickel sulfide concentrates and intermediate products of their processing. This energy forms a significant part of secondary energy resources. It is more than 30% of the total amount of secondary energy resources in non-ferrous metallurgy [21-25].

Research methods

The objects of study were zinc-containing ores of the Khandiza deposit, located in the Surkhandarya region, in the southwestern spurs of the Gissar Range of Central Asia [26-28].

In this work, zinc concentrates obtained at the Khandiza deposit were studied. In Uzbekistan, the “Almalyk Mining and Metallurgical Combine” JST is processing polymetallic ores from the Khandiza deposit [29].

Zinc was determined by the X-ray fluorescence method [30-31]. The method is based on the collection and subsequent analysis of the spectrum that occurs when the material under study is irradiated with X-rays - this is a fast, non-destructive and environmentally friendly analysis method with high accuracy and reproducibility of results. The method allows qualitative, semi-quantitative and quantitative determination of all elements from beryllium to uranium in powder, solid and liquid samples.

The density of solutions and pulps was determined using a PZh-2 pycnometer with a measurement accuracy of 0.05 rel.%. The kinematic viscosity of solutions and pulps was measured with glass capillary viscometers VPZh-1 and VPZh-2 with an error of 0.2% [32-33].

The density value was calculated by the formula

$$\rho = m/v ;$$

where m is the mass of the pulp, g; v is the capacity of the pycnometer, cm^3.

Viscosity was determined according to the following formula

$$\eta = \kappa \cdot \rho \cdot \tau ;$$

where κ is the viscometer constant and is equal to 0.3262 and 3.404, respectively, for VPZH-1 and VPZH-2 with a capillary diameter of 1.31 mm; ρ is the pulp density in g/cm^3; τ is the time of passage of the pulp through the capillary of the viscometer, s.

Plasma Atomic Emission Spectrometer ICPE-9000. The method of atomic emission spectrometry using inductively coupled plasma (ICP) as a source of excitation of atoms. Which is a highly ionized inert gas (argon) with the same number of electrons and ions supported by an RF (radio frequency) field. The temperature obtained in the plasma desolvates, converts into vapor and ionizes the atoms of the sample under study by mass spectrometry (MS) and atomic emission spectrometry

(AES). Typically, detection limits range from less than - nanogram (ICP-MS) to less than - microgram (ICP-AES) per liter [34].

Results and Discussion

Previously, studies were carried out on the extraction of zinc in a solution with hydrochloric acid, it was found that at atmospheric pressure, the degree of extraction of zinc from the zinc concentrate of the Khandiza deposit does not exceed 50-55%, regardless of other technological parameters of the process. Preliminary calcination of the zinc concentrate makes it possible to raise the degree of decomposition to 90,05%. The optimal technological parameters of autoclave extraction of zinc into solution were established: calcination temperature 500°C, hydrochloric acid concentration 28%, molar ratio Zn:HCI=1:1.1, T:L=1:2, temperature 80-85 °C, pressure 17 atm and process duration 10 hours. It is shown that the processes of purification of solutions of zinc chloride with calcium hypochloride at a stoichiometric ratio of $Fe:Ca(ClO)_2$ and $CaO:Zn(OH)_2=1:(1-1.1)$ make it possible to purify the solution from iron up to 98,25%, and its content does not exceed 0,012% [35]. The results obtained in the laboratory served as the basis for the development of a technological scheme for obtaining zinc chloride from the zinc-containing concentrate of the Khandiza deposit, as well as the calculation of material flows and the preparation of a material balance.

The essence of the technology lies in the acid decomposition of zinc-containing concentrates with a hydrochloric acid solution, followed by separation of the solid phase, obtaining a solution of zinc chloride, cleaning the solution from impurities and further evaporation of the liquid phase to obtain a salt precipitate of zinc chloride.

When conducting research, we used zinc concentrate of the Khandiza deposit of composition (wt.%): Zn – 39,45-40,50; Si – 13,10-13,50; Fe – 1,60-1,65; Pb – 3,01-3,06.

The process of processing zinc concentrate for zinc chloride consists of the following stages:

- calcination of zinc concentrate at 500 °C;
- hydrochloric acid decomposition of the zinc concentrate of the Khandiza deposit in a high-pressure autoclave at t = 80 °C;
- separation of zinc chloride solution and purification from associated impurities;
- evaporation of the purified zinc chloride solution to obtain industrial zinc chloride;
- packaging and storage of the finished product.

Zinc-containing concentrate was fed into the autoclave reactor, and then hydrochloric acid solution was added. The reaction takes place in a tightly closed autoclave reactor; the gas released during the decomposition of zinc concentrate with hydrochloric acid creates a high pressure inside the reactor and at the same time increases the temperature. The reaction was carried out for 10 hours, after the end of the reaction pulp from the autoclave was sent to the filter unit. After filtration, the liquid phase was purified from accompanying impurities by sedimentation, then zinc chloride was separated by evaporation.

The developed technology for the processing of zinc-containing concentrate with the production of zinc chloride differs significantly from the known production of zinc chloride and the processing of zinc-containing waste.

The main parameters of the technological mode of processing zinc-containing concentrates for zinc chloride are: calcination of the concentrate at 500 °C, molar ratio Zn:HCI = 1:1.1, at the ratio T:L=1:2, temperature 80 °C, pressure 17 atm., residence time in the reactor 10 hours, pulp density 1,676-1,651 g/cm^3.

Metal impurities present in the resulting zinc chloride solution were removed by sedimentation.

In table shows the technological parameters for the production of commercial zinc chloride from zinc concentrates from the Khandiza deposit.

The resulting product is characterized by the following quality indicators (wt.%): $ZnCl_2$ – 98,27; Ca – 0,0143; Fe – 0,027; Cu – 0,0018; Cd – 0,0009; Pb – 0,0015; K – 0,00088; H_2O – 1,623. The samples were transferred to Avtotractorradiator JSC for the possible use of technical $ZnCl_2$ obtained from zinc concentrates.

During the test period, 1000 kg of zinc chloride were obtained for a total amount of more than 18 million soums, which meets the requirements for technical zinc chloride in accordance with GOST 7345-78 grade A and contains, on average (wt.%): $ZnCl_2$- 97,7-98,0; Fe-0,1-00,1; SO4-0,01-0,05; н.о.-0,01, NH_3-0,5.

As the test results showed, the technology for processing zinc concentrates into zinc chloride is technologically simple, does not require special

Production parameters of zinc chloride

Name of parameters	Meaning
Calcination of zinc concentrate	
Temperature, °C	450-500
Acid decomposition of the concentrate in an autoclave	
Temperature, °C	80
Molar ratio Zn:HCI	1:1,1
Pressure, Atm	17
Process duration, hour	10
S:L ratio	1:2
Separation of liquid and solid phases	
Temperature, °C	40-60
Process duration, min	20-40
S:L ratio	1:1,5-2
Purification of zinc chloride solution	
Temperature, °C	20-40
$Fe:Ca(ClO)_2$ ratio	1:1
HCI:CaO ratio	1:1
$CaO:Zn(OH)_2$ ratio	1:1-1,1
Residue of purified zinc chloride solution to obtain zinc chloride	
Temperature, °C	100-120

equipment, energy-, resource- and material-saving.

A complete technological scheme for the processing of zinc-containing concentrates from the Khandiza deposit into zinc chloride has also been developed. This scheme makes it possible to obtain technical $ZnCl_2$ grade “A” with a $ZnCl_2$ content of at least 97.7%.

On figure 1 shows the material flows of processing zinc-containing concentrates for zinc chloride based on 1000 kg of technical salt.

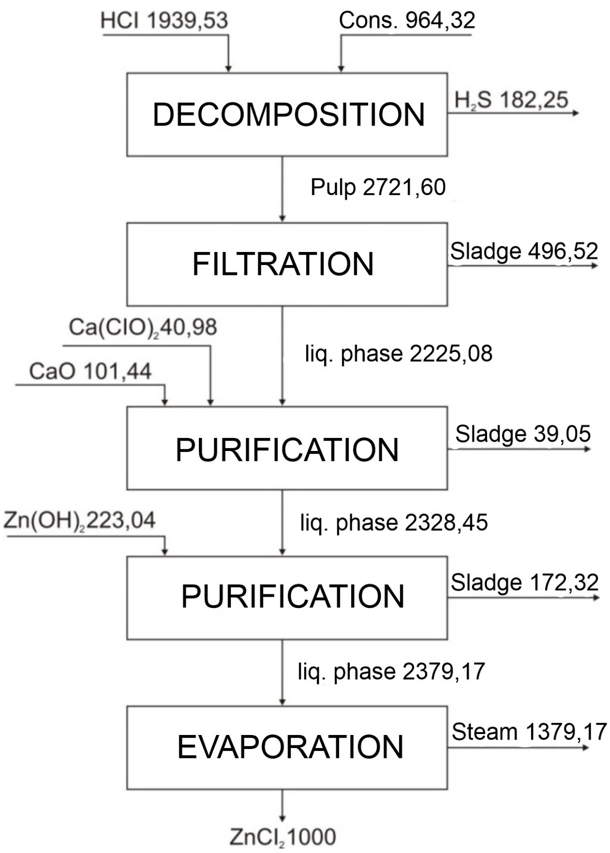

Figure 1. Block diagram of material flows and material balance of processing zinc-containing concentrates for zinc chloride.

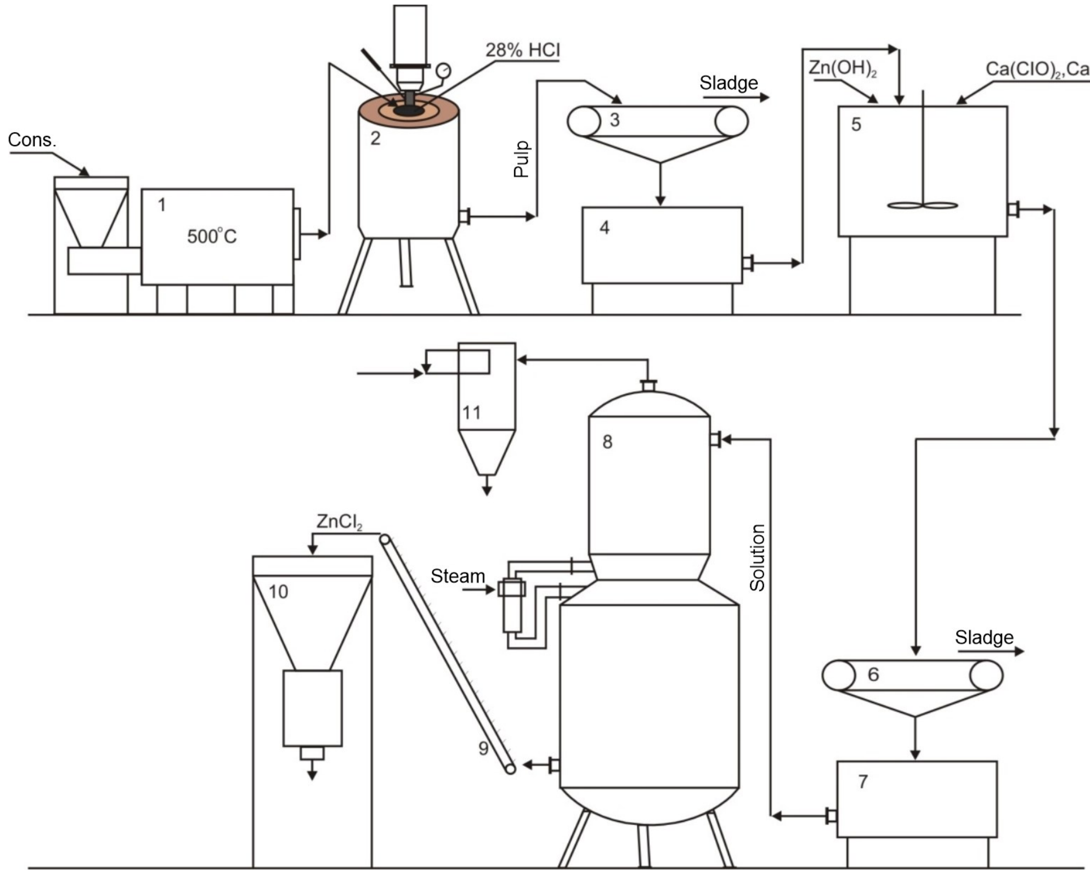

Figure 2. Technological scheme of a pilot plant for the processing of zinc concentrates into commercial zinc chloride:
1 – calcining furnace; 2 – autoclave reactor; 3, 6 – filters; 4, 7 – tanks; 5 – mixing tank; 8 – vacuum evaporator with a crystallizer; 9 – conveyor; 10 – packaging unit; 11 – distiller.

The technological scheme for obtaining commercial zinc chloride from zinc-containing concentrates is shown in Figure 2.

The results of testing the technology for processing zinc-containing concentrates into zinc chloride using an autoclave and an evaporator showed the fundamental possibility of processing zinc-containing concentrates. The technology has been tested in industrial conditions and accepted for implementation at “Almalyk Mining and Metallurgical Combine” JSC.

The technological scheme for obtaining commercial zinc chloride from zinc-containing concentrates is shown in Figure 2.

The zinc-containing concentrate is fed into the calcination furnace (pos. 1) for thermal treatment, and then the calcined concentrate is fed into the autoclave reactor (pos. 2), equipped with a stirrer, thermometer and pressure gauge for acid decomposition with hydrochloric acid, and then the reaction mass is fed to filters (pos. 3) for separation of solid and liquid phases. The filtered solution of zinc chloride from the tank (pos. 4) enters the mixing tank (pos. 5) to separate impurities that pollute the zinc chloride solution, the solution is fed to the filter (pos. 6) to separate sedimentary impurities, then the purified solution from the tank (pos. 7) is fed into a vacuum evaporator with a crystallizer (pos. 8). The resulting zinc chloride is fed by a conveyor (pos. 9) to a packaging plant (pos. 10).

Conclusion

The research on autoclave extraction of zinc from the zinc concentrate of the Khandiza deposit made it possible to develop a technological scheme for processing zinc concentrate into zinc chloride, to draw up a scheme of material flows. The data indicate the possibility of obtaining zinc chloride and local raw materials.

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