STUDY OF THE PROCESS OF PRODUCING ZINC SULFATE SOLUTION FROM ZINC-CONTAINING CONCENTRATE OF THE KHANDIZA DEPOSIT

[1]Davlatov F., [2]Togaev E.,[3]Makhmayorov J.,[4]TalipovaKh, [5]Samadiy M.
[1,2,5]Karshi Engineering-Economics Institute, Karshi, Uzbekistan
[3]University of Economics and Pedagogy, Karshi, Uzbekistan
[4]Tashkent Chemical Technological Institute, Tashkent, Uzbekistan
https://doi.org/10.5281/zenodo.11650741

Abstract. *The aim of the study is to study the effect of the process of calcining zinc concentrate from the Khandiza deposit on the degree of zinc extraction and fractional composition. For this, the chemical composition of the concentrate was established and it was shown that the main components are zinc, silicon, potassium, calcium, iron, copper, cadmium, and lead. Titanium, manganese, cobalt, and molybdenum are also contained in small amounts. Extraction of zinc from a concentrate, calcined at 900°C for 90 minutes with sulfuric acid with concentration of 18-25% in an autoclave at a temperature of 75°C, a ratio of Zn:H_2SO_4=1:1.05 and process duration of 90 minutes allows achieving the degree of extraction 91%. The optimum roasting temperature of the concentrate is 900°C and the duration of calcination is 90 minutes. The main share of 92.1% zinc-containing concentrate calcined under optimal conditions is a fraction of -0.140 mm and 3.6% a fraction of -0.165 - + 0.140 mm. The possibility of obtaining zinc sulfate from the zinc-containing concentrate of the Khandiza deposit is shown. To do this, the calcination process must be carried out at a temperature of 900°C and a process duration of 90 minutes. The degree of extraction of zinc increases from 71% to 91%.*

Keywords*: processed meat, nitrites, natural replacement, health problems.*

INTRODUCTION

Zinc compounds, as a mineral additive, are used in various industries, including the chemical industry (production of mineral paints, paper brighteners, fertilizers), as well as in metallurgy, paper, leather and food industries. In this regard, zinc sulfate ($ZnSO_4 \cdot 7H_2O$) and zinc sulfate play an irreplaceable role [1].

Zinc sulfate is produced in combination with processes for the production of other zinc products. It is obtained by treating mineral ores, zinc ash and processed products containing zinc metal or zinc oxide with sulfuric acid, followed by filtration, crystallization, grinding and bagging [Morse et al. 1998].

On an industrial scale, zinc sulfate is produced from zinc ore mined in underground or open pits. Zinc ore deposits are widespread throughout the world. Zinc is usually associated with lead and other metals and minerals, including barium, bismuth, cadmium, calcium, copper, magnesium, tin, gold and silver [Li et al., 2010]. In some areas, zinc is naturally concentrated to much higher levels by geological and geochemical processes (5-15% or 50-150 g/kg). The zinc containing fraction is fired or sintered at >900°C to produce zinc ash, rich in zinc oxide. In the hydrometallurgical process - one of two industrial processes for the production of zinc sulfate - zinc ash is mixed with sulfuric acid, which is diluted with water to 65-70%. Zinc dissolves in sulfuric acid, while impurities such as iron, lead and silver remain partially or completely undissolved. The zinc sulfate solution is filtered and electrolyzed to produce zinc metal, or crystallized, processed, and packaged for sale and distribution [2].

STUDY OF THE PROCESS OF OBTAINING ZINC SULFATE SOLUTION

The essence of the method for obtaining a solution of zinc sulfate is to treat the zinc concentrate with solutions of sulfuric acid. The processing was carried out in an autoclave reactor, into which zinc concentrate was loaded and acid was poured. Mixing was carried out using an electric stirrer. The $ZnSO_4$ concentration gradually increases to 44% at 70°C. The amount of acid was taken based on the production of a $ZnSO_4$ solution.

The influence of the $Zn:H_2SO_4$ ratio from 1:0.8 to 1:1.5 on the chemical composition of the liquid and solid phases using 30% sulfuric acid and a process duration of 90 minutes was studied. The obtained data are presented in table. 1.

Table 1. The influence of the $Zn:H_2SO_4$ ratio on the chemical composition of the liquid and solid phases of the process of obtaining a solution of zinc sulfate at a H_2SO_4 concentration of 30%, a process duration of 90 minutes

№	*$Zn:H_2SO_4$*	Chemical composition of the liquid phase, mass. %										Free H_2SO_4	Degree of transition of Zn into solution, %
		Zn	Ca	Fe	Cu	Cd	Pb	Co	Mo	SO_4^{2-}	H_2O		
1	1:0,8	15,17	0,184	0,55	0,270	0,134	1,015	0,0047	0,0150	25,46	55,56	2,89	51,15
2	1:1,0	15,07	0,182	0,54	0,267	0,132	1,008	0,0040	0,0128	25,78	56,36	2,98	53,60
3	1:1,05	14,88	0,180	0,53	0,260	0,130	0,995	0,0036	0,0114	25,95	57,04	3,04	55,10
4	1:1,2	13,40	0,170	0,51	0,246	0,121	0,930	0,0032	0,0100	26,10	58,00	3,31	56,70
5	1:1,3	12,11	0,158	0,47	0,231	0,112	0,864	0,0029	0,0091	26,25	59,30	3,70	58,60
6	1:1,4	11,26	0,147	0,44	0,217	0,108	0,814	0,0027	0,0086	26,39	60,61	4,06	60,70
7	1:1,5	11,12	0,141	0,42	0,210	0,107	0,811	0,0026	0,0085	26,41	60,73	4,08	61,00

№	*$Zn:H_2SO_4$*	Chemical composition of the solid phase, mass. %									
		Si	Zn	Ca	Fe	Cu	Cd	Pb	K	Mo	SO_4^{2-}
1	1:0,80	26,06	9,66	0,12	0,34	0,18	0,088	0,64	0,086	0,016	0,06
2	1:1,00	26,20	9,40	0,11	0,33	0,17	0,085	0,63	0,084	0,015	0,062
3	1:1,05	26,31	9,20	0,1	0,32	0,17	0,083	0,61	0,082	0,015	0,064

				1							
4	1:1,20	27,00	8,30	0,10	0,30	0,16	0,078	0,54	0,077	0,014	0,070
5	1:1,30	30,05	7,50	0,09	0,27	0,14	0,071	0,49	0,068	0,012	0,077
6	1:1,40	35,10	6,90	0,08	0,25	0,13	0,063	0,46	0,062	0,011	0,084
7	1:1,50	35,50	6,60	0,07	0,24	0,12	0,061	0,45	0,061	0,010	0,086

With a decrease in the stoichiometric ratio of Zn:H_2SO_4 from 1:0.8 to 1:1.5, the content of all components in the liquid phase decreases. Thus, the zinc content decreases from 15.07% to 11.12%, Ca from 0.184% to 0.141%, iron from 0.55 to 0.42%, and so on for the remaining components. At the same time, the content of sulfate ion increases slightly from 25.46% to 26.41%, the content of free sulfuric acid from 2.89 to 4.08%, the degree of zinc extraction from 51.15% increases to 61.00%.

The solid phase is enriched with silicon. At a ratio of 1:0.8, the Si content is 26.06%, at 1:1.5 it reaches 35.50%. The remaining components in the composition of the solid phase decrease monotonically, including the sulfate ion.

From the data given in the table it is clear that the direct use of zinc concentrate in the process of conversion of zinc sulfate does not give the desired result. It is necessary to take measures to increase the conversion rate.

STUDY OF THE INFLUENCE OF PRELIMINARY CALCINATION OF ZINC CONCENTRATE ON THE FRACTIONAL, CHEMICAL COMPOSITIONS AND DEGREE OF ZINC EXTRACTION INTO SOLUTION

Due to the low degree of zinc extraction into solution from zinc concentrate with sulfuric acid, in order to increase this indicator, the influence of pre-roasting on the technological parameters of zinc extraction was studied.

The impurities of lead compounds, SiO_2 and other metals found in the raw materials, when dissolved in sulfuric acid, form sediments that form on the particles of the dissolving material containing zinc in the form of an impenetrable crust.

To prevent this phenomenon, studies have been carried out on the effect of pre-roasting of zinc concentrate. The process was carried out in a muffle furnace at temperatures of 400-1000°C and a calcination duration of 30-180 minutes.

When roasting and processing zinc concentrate, the base metals and sulfur are transferred from sulfide compounds to oxidized forms.

The studies were carried out with zinc-containing concentrate from the Khandiza deposit.

For the experiments, we used a zinc-containing concentrate from the Khandiza deposit with the following chemical composition (wt. %): Zn - 45.15-45.45, Si - 12.90-13.30, Mn - 0.1, Fe - 1.57-1, 64, Mo – 0.031-0.033, Pb – 3.01-3.05 and technical sulfuric acid with a concentration of 92.5%.

In table Table 2 shows the influence of the temperature of preliminary calcination of the Handiz concentrate at a ratio of Zn:H_2SO_4 = 1:1.05, a sulfuric acid concentration of 30% and a process duration of 90 minutes. Increasing the calcination temperature from 400 to 900°C increases the zinc content in the liquid phase from 11.52% to 14.88% and has virtually no effect on the degree of extraction. Calcination reduces the content of Pb, K, Mo and increases the content of iron from 0.30% to 0.53%, calcium from 0.10% to 0.18%, copper from 0.14% to 0.26%, cadmium from 0 .07% to 0.13%.

Calcination has a more significant effect on the change in the composition of the solid phase. An increase in temperature contributes to a change in the content of calcium, iron, copper, cadmium, lead, potassium, molybdenum and an increase in the silicon content from 13.14% to 26.31%, and a decrease in the zinc content from 20.8 to 9.2%. The content of sulfate ions decreases from 0.071% to 0.064%.

The dissolution reactions of zinc and zinc oxide in sulfuric acid are exothermic and proceed very vigorously, but the total duration of the process reaches 90 minutes. and more, since towards the end of the process it slows down. When dissolved, a large amount of hydrogen is released:

$$Zn + H_2SO_4 = ZnSO_4 + H_2$$

During pilot tests, reaction tanks were installed outside the building, under a canopy, and hydrogen was released into the atmosphere [3].

Conducted studies on the production of zinc sulfate from concentrate by decomposition with sulfuric acid in an autoclave mode showed that the degree of zinc extraction with a leaching process duration of up to 10 minutes does not exceed 65%. The maximum degree of zinc extraction into solution reaches 91.7% at a temperature of 75°C, a process duration of 90 minutes and a ratio of $Zn:H_2SO_4$=1:1.05.

Table 2. The influence of the process of calcination of the concentrate from the Khandiza deposit on the chemical composition of the liquid and solid phases when producing zinc sulfate

№	Calcination temperature, °C	Chemical composition of the liquid phase, mass.%										Degree of transition of Zn into solution, %
		Zn	Ca	Fe	Cu	Cd	Pb	K	Mo	SO_4^{2-}	H_2O	
1	0	8,94	0,10	0,30	0,14	0,07	0,55	0,185	0,006	19,66	43,76	55,10
2	400	11,52	0,12	0,38	0,18	0,09	0,24	0,060	-	22,30	50,1	71,05
3	500	12,18	0,13	0,40	0,19	0,09	0,16	0,034	-	23,20	52,5	75,10
4	700	13,50	0,15	0,45	0,21	0,10	0,023	0,001	-	24,90	57,0	83,25
5	900	14,88	0,18	0,53	0,26	0,13	0,0006	0,0004	-	26,39	60,61	91,70
6	1000	14,88	0,18	0,53	0,26	0,13	0,0006	0,0004	-	26,39	60,61	91,75

№	Calcination temperature, °C	Chemical composition of the solid phase, mass. %									
		Si	Zn	Ca	Fe	Cu	Cd	Pb	K	Mo	SO_4^{2-}
1	0	13,14	20,8	0,30	0,90	0,44	0,21	1,68	0,51	0,018	0,071
2	400	18,3	16,	0,23	0,6	0,3	0,16	1,64	0,39	0,026	0,068

		0	1		9	4					
3	500	19,90	15,2	0,22	0,66	0,32	0,15	1,63	0,37	0,026	0,067
4	700	23,20	13,7	0,19	0,59	0,29	0,13	1,61	0,33	0,026	0,065
5	900	26,31	9,2	0,14	0,32	0,17	0,08	1,60	0,08	0,026	0,064
6	1000	26,31	9,2	0,14	0,32	0,17	0,08	1,60	0,08	0,026	0,064

To clarify the distribution of zinc depending on the size of the fraction, the fractional and chemical compositions of the zinc-containing concentrate from the Khandiza deposit, calcined at 900°C and a process duration of 90 minutes, were studied (Table 3).

Table 3. Fractional and chemical composition of zinc-containing concentrate from the Khandiza deposit after roasting

№	Grainsize, mm	Contentsoffactions, %	Chemicalcomposition, mass. %		
			Zn	Si	H_2O
Zn content in concentrate 45.45% and Si 13.10%					
1	+0,90	0,2	45,05	15,65	0,47
2	-0,90 ÷ +0,65	0,3	45,14	14,81	0,48
3	-0,65 ÷ +0,50	0,5	45,31	14,11	0,47
4	-0,50 ÷ +0,25	1,2	45,39	13,25	0,49
5	-0,25 ÷ +0,165	2,1	45,54	12,47	0,51
6	-0,165 ÷ +0,140	3,6	45,67	11,28	0,48
7	-0,140	92,1	46,11	10,15	0,49

The table shows that the main share of the zinc-containing concentrate of the Khandiza deposit is the -0.140 mm fraction, which, with a decrease in its size, increases from 0.2% to 92.1% for a concentrate containing 45.45% Zn and 13.10% Si.

The increase in zinc content is due to a decrease in the silicon content in the concentrate from 15.65% in the +0.90 mm fraction to 10.15 in the -0.140 mm fraction. The main silicon content is observed in fractions from +0.90 mm to +0.25 mm.

Figure 1 shows the results of the influence of the temperature of preliminary calcination of zinc concentrate on the degree of zinc extraction at Zn:H_2SO_4 = 1:1.05, a temperature of 75°C and the duration of the autoclave leaching process - 90 minutes.

Increasing the calcination temperature of zinc concentrate from 400°C to 900°C helps to increase the degree of zinc extraction into the sulfuric acid solution from 71 to 90%. Further increase in temperature does not affect the degree of extraction. Experiments show that the optimal firing temperature is 900°C [4].

With an increase in the duration of the calcination process from 10 to 90 minutes, the degree of zinc extraction increases from 65 to 90%. A further increase in temperature does not affect the degree of zinc extraction from the zinc-containing concentrate. The experiments carried out show that the optimal firing time is 90 minutes (Fig. 2).

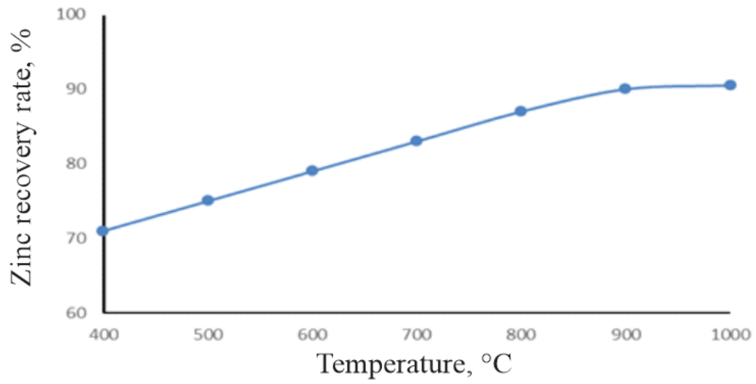

Figure.1. The influence of pre-roasting of zinc-containing concentrate on the degree of zinc extraction

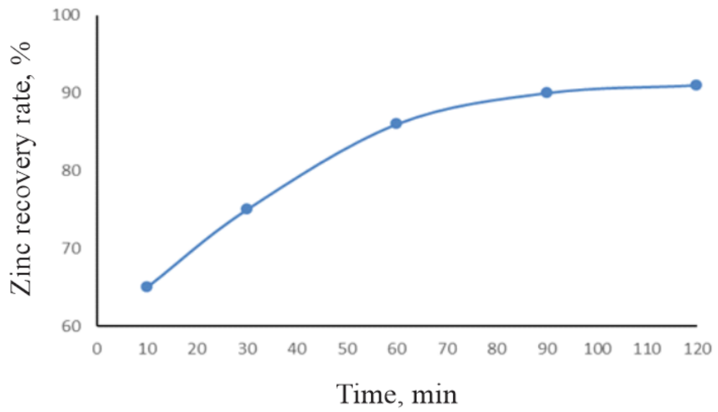

Figure.2. Influence of the duration of the calcination process of zinc-containing concentrate on the degree of zinc extraction

From Figure 3 it is clear that with a decrease in the size of the fractions of the zinc-containing concentrate from the Khandiza deposit, the degree of extraction increases and is 91.7% for the -0.140 mm fraction. As the particle size increases to 0.90 mm, the recovery rate decreases to 78.0%.

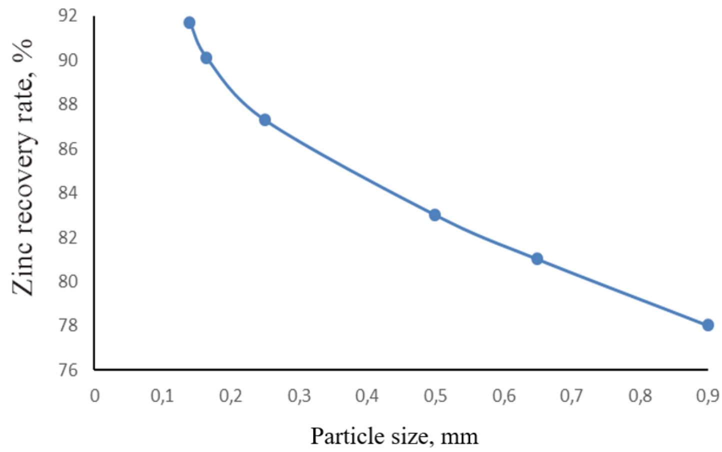

Figure.3. Influence of particle size of zinc-containing concentrate on the degree of zinc extraction

The conducted studies show that with a decrease in the particle size of the zinc-containing concentrate from the Khandiza deposit, the degree of extraction increases. This is due to the fact that the smaller the particle size, the greater the degree of contact of the acid with zinc in the concentrate and, accordingly, the higher the reaction indicators.

CONCLUSION

A series of experiments have proven the possibility of producing zinc sulfate with sulfuric acid in an autoclave. To do this, it is necessary to pre-calcinate the zinc concentrate at 900°C for 90 minutes and leach the zinc with sulfuric acid from the fine (-0.140 mm) fraction. At the same time, the degree of zinc extraction reaches 91.7%.

The effect of calcination of zinc-containing concentrate with sulfuric acid solutions was studied depending on T:L, pressure, temperature and duration of autoclave leaching.

The optimal conditions for obtaining a solution of zinc sulfate is the ratio T:L = 1:2.36. In this case, the solution contains 14.88% zinc and 26.96% sulfate ion, which corresponds to a zinc sulfate concentration of 36.85%.

The optimal duration of the process of obtaining a solution of zinc sulfate from a calcined concentrate is 90 minutes, at which the maximum extraction of zinc from the concentrate is achieved. In this case, the zinc content in the solution reaches 14.88%, which corresponds to the content of 22.43% zinc sulfate.

The optimal temperature for obtaining zinc sulfate from concentrate is 75°C. When the process is carried out at this temperature, the zinc content in the solution reaches 14.88%, as in processes under optimal conditions of the influence of T:L and the duration of the process.

REFERENCES

1. Absattorov D., Makhmayorov J., Abdullayev B., Qodirov Sh., Davlatov F., Usmanov I., Samadiy M. (2023). Study on the Process of Purification of Zinc Sulfate Solutions from Impurities and Their Rheological Properties. *IOP Conf. Ser.: EarthEnviron. Sci.* 1281 012004
2. Baek, K.S., Kim, B.H., Park, S.B., Park, S.J., Kim, H.S., Lee, W.S., Ki, K.S., Jeon, B.S., Ahn, B.S., Kang, S.J., andSuh, G.H. (2006).Effect of new foot-bath facility and solution on foot health in lactating cows, J. Lives. Hous.&Env., 12:3, pp. 107-114.
3. MakhmayorovJ., РосиловМ.,Самадий М. (2019).Получение сульфата цинка на основе местных сульфидных руд// Universum: Технические науки: электрон.научн. журн. № 3(60). URL: http://7universum.com/ru/tech/archive/item/7076.
4. Makhmayorov J., Makhkamov B., Samadiy M. (2022).Investigations of roasting process and fractional composition of zinc concentrate of Khandiza deposit // *Chemistry And Chemical Engineering*: Vol. 2022: No. 1, P. 11-15.
5. Morse, G., Brett, S., Guy, J. & Lester, J. (1998). Review: phosphorus removal and recovery technologies. Sci. Total. Environ. 212, 69–81.
6. Li Cunxiong, Wei Chang, Xu Hong-sheng, Li Minting, Li Xingbin, Deng Zhigan, Fan Gang. (2010). Oxidative pressure leaching of sphalerite concentrate with high indium and iron content in sulfuric acid medium.Hydrometallurgy. 102, № 1-4, P. 91-94.