

# Extraction of copper from copper processing plant waste by leaching

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**Abstract.** On the territory of Uzbekistan, copper is mainly found in chalcopyrite's and chalcocite's, the enrichment of copper minerals results in waste and tailings as a result of technological processing. The processes of copper processing plants are complex and are constantly characterized by gradual technological processes. The technology of ore enrichment in its initial state can be enriched in several stages: grinding and crushing, flotation processes, gravitational methods, magnetic separation methods. As a result of technological processes, waste and tailings are formed, i.e. they are very poor and unsuitable for the recycling process. And these wastes harm the environment, accumulate and occupy large areas. An effective technology for extracting metals from waste is the process of leaching in the dump, and the ratio of leaching of sulfuric acid with tailings corresponds according to the technological scheme, that is,  $T : W = 1 : 15; 1 : 10; 1 : 7,5$ . The tail analysis was studied, which has a copper content of 0.534%, conducted by experiment after leaching, the amount of copper in the solution formed 1.66%. The copper in the solution turned into a solution 3 times more than in its original form.

## 1 Introduction

When developing a technology for the associated extraction of precious and non-ferrous metals from waste from a copper processing plant, two options were considered: the first is the leaching of heavy and foreign metals directly from tailings; the second is the leaching of gold, silver and copper from cakes by bacterial leaching. Waste (tailings) are by-products formed during the production of basic types of products, and are characterized by certain physico-chemical properties [1].

In this article, the extraction of copper from waste is one of the main problems in the conditions of the Republic of Uzbekistan. It should be noted that industrial waste from the Almalyk Mining and Metallurgical Combine occupies a large area and is also dangerous from an environmental point of view. Waste is a resource that is part of the base of secondary raw materials in production and products suitable for processing into metal, which is currently considered the most demanding metal. In quarries like Kalmakyr, Sarychek, after long extraction, runs out of a sufficient amount of copper [2].

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The article gives the percentage of elements contained in the tailings of a copper processing plant which contains copper, zinc, iron, calcium, silicon, aluminum, magnesium, etc.

In the process of flotation enrichment of ores, together with the extraction of metals, a certain number of necessary elements remain in their composition. Extraction of the necessary elements from the tailings by firing and hydrometallurgical method solves economic and environmental problems.

## 2 Materials and methods

The tailings dumps of waste № 1 of the copper processing plant in the lower hundred-meter zone have accumulated an average amount of useful components - about 500 million tons of waste, which have the following amounts: copper 0.18 – 0.20%, 0.0029 – 0.0033% molybdenum, 0.3 – 0.4 g/t gold, 1.0 – 1.8 g/t silver [3,4].

To carry out theoretical and practical processes to reduce waste and extract metals from their composition, a sample was taken (CPP waste from Sarychek and Kalmakyr) and the chemical and granulometric composition of the waste was determined using a scanning electron microscope (SEM) analysis: Mg – 0.87%; Al – 4.00%; Si – 18.22%; Ca – 0.83 %; Fe – 2.98 %; Cu – 0.536 %; Zn – 0.96%. Theoretically, after determining the initial composition of the tailings, the expediency of using an oxidative roasting process, in which S, Si in the tailings are reduced, as well as selective leaching of waste using acids, was studied.

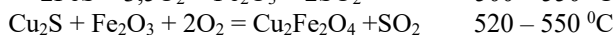
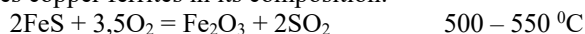
In order to analyze the waste from the copper processing plant in the laboratory of the Uzbek-Japanese Youth Innovation Center, scanning electron microscope SEM analyses (JEOL JSM-IT200 (Japan) were performed, the results

**Table 1.** The result of the analysis of waste from the copper processing plant.

Elements	Mass %	Atom %	Elements	Mass %	Atom %
C	20.42±0.11	30.71±0.16	Si	18.22±0.08	11.20±0.05
O	47.50±0.17	51.09±0.19	S	1.06±0.02	0.57±0.01
Na	0.32±0.02	0.24±0.01	K	2.30±0.03	1.01±0.01
Mg	0.87±0.02	0.62±0.01	Ca	0.83±0.02	0.36±0.01
Al	4.00±0.04	2.45±0.02	Fe	2.98±0.05	0.92±0.01
Cu	0.536±0.01	0.11±0.01	Zn	0.96±0.03	0.72±0.01
Total	100.00	100.00			

## 3 Results and discussion

The thermal decomposition of Cu<sub>2</sub>S copper mineral ranges from 300-350°C to 500-700°C [5]. During the process at 3-stage temperatures at low temperatures, CuS is not able to decompose, and when decomposed at high temperatures, it forms bonds with FeO (reactions are given) and creates copper ferrites in its composition.



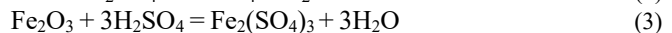
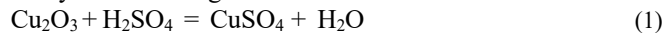
Theoretically, after determining the mineral parameters, the pyrite mineral decomposes in 3 stages at temperatures of 491 – 549°C, 450 – 590°C and 582 – 645°C. The decomposition of pyrite and the desulfurization process make it possible to selectively dissolve oxidized substances using acid. According to the results, the fayalite compound was formed in copper at a temperature above 800°C. The formation of fayalite and magnetite at high temperatures leads to the condensation of their crystal lattices and the loss of copper.

The most effective temperature turned out to be 650°C, which was proved based on the conclusion of the analysis of samples obtained as a result of experimental work. The decomposition temperature of MgCO<sub>3</sub> continues to a temperature index of 350-900°C. The decomposition of carbonate compounds is also very effective. In this case, MgO is taken as a flux.

To decompose CaCO<sub>3</sub> in the loaded product, a temperature of 697 – 750°C is required. But due to the fact that the decomposition of CaCO<sub>3</sub> does not occur at 650°C, in previous research papers, the addition of a separate CaO to the process by grinding it was studied, which gives a sufficient effect for the binding of CaO silicon oxides Fe<sub>2</sub>SiO<sub>4</sub>, and in this process, an additional 1:2 ratio was introduced, which requires the addition of additional lime. The number of these samples can be determined by the number of elements listed in Table 1. The amount of iron, carbon and silicon is large, theoretically Cu – 0,536 %, Fe – 2,98 %, Zn – 0,96 %, Ca – 0,83 %, S – 1,06 %, Al – 4,00 %, Si – 18,22%, Mg – 0,87 %, it is proved that the waste contains Fe - Si substances.

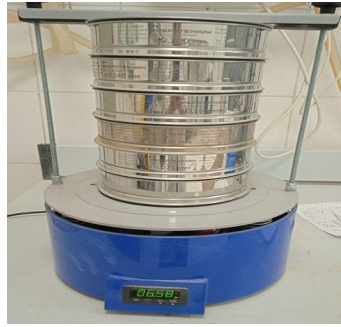
Due to the high content of iron oxide substances, the formed compounds were subjected to a magnetic separation process. The essence of magnetic enrichment is that all objects are divided into diamagnetic, paramagnetic and ferromagnetic minerals depending on their magnetic properties. Diamagnetic minerals have a negative magnetization, in which Cu, Zn and Al are repelled by an inhomogeneous magnetic field, and the tendency of ferromagnetic substances to magnetization is manifested in FeO and FeS. High iron content in the waste of the copper processing plant: a) residual products consisting mainly of hematite - Fe<sub>2</sub>O<sub>3</sub> remain in the fluxed slag; b) compatibility of CaO with SiO<sub>2</sub> (twice as much); c) compatibility of Fe<sub>2</sub>O<sub>3</sub> with CaO. Here, the mass of FeS, Fe<sub>2</sub>O<sub>3</sub> and SiO<sub>2</sub> in the waste is very large [6]. Therefore, the main product here is calcium ferrite. CaO and Fe<sub>2</sub>O<sub>3</sub> are the most common in fluxed waste. This is the fastest reaction in the solid phase. CaO+SiO<sub>2</sub> at the initial temperature; Fe<sub>3</sub>O<sub>4</sub> + SiO<sub>2</sub> reactions continue. At the same time, the reaction of calcium ferrite formation continues without stopping. This scheme has been proven experimentally, i.e., reduced hematite-magnetite does not react with CaO.

For the complex extraction of metals from dump tailings, leaching with sulfuric acid is carried out at the AMMP. The main indicators of the leaching reaction are given in the diagram, the reaction is described by the following schemes:



The higher the concentration of sulfuric acid, the faster it is consumed in dissolution reactions, because not only copper compounds, but also other minerals are completely dissolved, which increases the useless consumption of acid. With an increase in the concentration of sulfuric acid in solution (up to 75 g/l), the solubility of the ore components increases linearly and reaches a maximum. A further increase in the concentration (from 75 g/l) does not increase the rate of dissolution of copper and, on the contrary, after a while causes a slight slowdown in the process. An increase in the concentration of sulfuric acid from 75 g/l has only a slight effect on the dissolution of copper. For leaching ore with sulfuric acid, we recommend that the concentration of sulfuric acid not exceed 75 g/l, this can regulate the degree of dissolution of related minerals. Thus, the following optimal ore leaching conditions were established: sulfuric acid concentration 50-75 g/l. Under these conditions, the degree of extraction of copper oxides into the solution is 98-99% [7].

Granulometric analyses of the tailings of the copper processing plant were studied, for the formation of fine grinding, the tailings were crushed for 20 minutes in ball mills. The resulting waste was sent to a sieve and experimental work was carried out on the "Vibrotechnics" housing (Figure 1) with a granulometric waste size of +0.080 mm.



**Fig. 1.** The “VIBROTECHNIK” screen.

The characteristics of paramagnetic and diamagnetic wastes FeS and FeO, Fe<sub>3</sub>O<sub>4</sub> have been studied in order to determine the magnetism index in the composition of waste. At the same time, 399 grams of magnetic fraction were formed from 1000 grams of tailings of the copper processing plant, and the remaining part was 601 grams of non-magnetic fraction.

Three different samples were taken for the study, lime (CaO) was added to the samples in a 1:2 ratio. At the same time, the firing processes were carried out at temperatures of 500 - 550°C, 600 - 700°C, 800 - 850°C and for 120 minutes in muffle furnaces (SNOL - 2.5x2.5x2.5/3l) at the Department of Metallurgy (Figure 2). The crushed tail must be constantly stirred so that it is completely exposed with oxygen to form the oxide form of minerals.



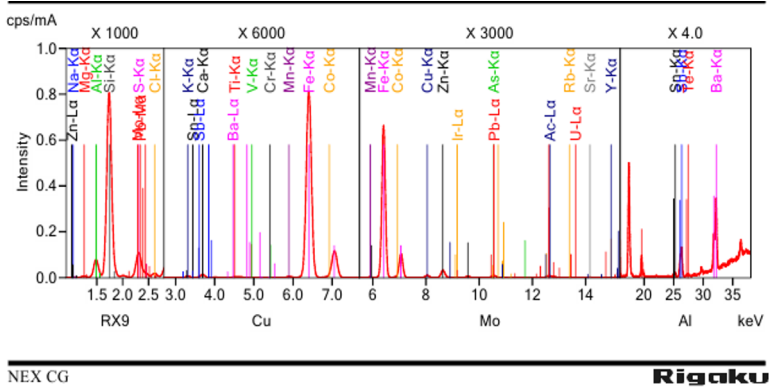
**Fig. 2.** The process of roasting copper processing plant waste.

The process of oxidative roasting – the cinder samples were analyzed on an X-ray fluorescence spectrometer with NEX CG-Rigaku polarization (FP method. Figure 3) at the Department of Inorganic Substances of the Institute of Chemistry and Technology, analyses of the results were entered in Table 2.

**Table 2.** Sample of oxidized candle stub.

№	Components	Results, %	№	Components	Results, %
1	Fe <sub>2</sub> O <sub>3</sub>	2.4	12	CuO	0.4469
2	Cu <sub>2</sub> O <sub>3</sub>	0.0891	13	ZnO	1.32
3	Na <sub>2</sub> O	2.26	14	As <sub>2</sub> O <sub>3</sub>	0.0182
4	MgO	1.64	15	Y <sub>2</sub> O <sub>3</sub>	0.0049
5	Al <sub>2</sub> O <sub>3</sub>	6.64	16	ZrO <sub>2</sub>	0.306
6	SiO <sub>2</sub>	15.63	17	MoO <sub>3</sub>	0.279

7	SO <sub>3</sub>	1.20	18	SnO <sub>2</sub>	0.0080
8	CaO	3.58	19	Sb <sub>2</sub> O <sub>3</sub>	0.0678
9	TiO <sub>2</sub>	0.301	20	BaO	0.191
10	V <sub>2</sub> O <sub>5</sub>	(0.0094)	21	PbO	0.286
11	Cr <sub>2</sub> O <sub>3</sub>	0.0281	22	MnO	0.232

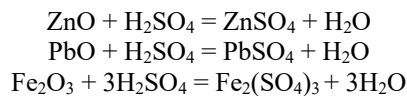


**Fig. 3.** IR spectroscopy of the tailings of a copper processing plant.

Leaching requires a separate specific requirement for the composition and preparation of ores: the ore should be as porous as possible, with microscopic channels that facilitate the penetration of solutions, the rock should crack, crumble under the action of the solution. Chalcosine and covelin after primary processing, during hydrometallurgical processes, go into solution, need to be crushed and fired at high temperatures. After oxidative treatment in hydrometallurgical leaching, it passes into solution. Copper should be in the ore in the form of easily leached compounds (chalcosine or chalcantite - natural copper sulfate or oxides). Taking into account the complex nature of the feedstock, we fired and leached with sulfuric acid, it was important to investigate the behavior of the valuable components accompanying copper in sulfuric acid solutions in order to ensure complete separation of copper into a separate product and selectivity of copper extraction. In this case, the ratio is T : W = 1 : 15; 1 : 10; 1 : 7,5. After hydrometallurgical treatment, it was formed, i.e., copper passed into solution 1.2 times more (Figure 4).



**Fig. 4.** Leaching with sulfuric acid of oxide compounds Cu, Zn, Pb, Fe.



With the number of samples obtained g/l, 1,177 g/l of CuSO<sub>4</sub> was transferred from the stub to the solution. The resulting stub, i.e. the oxide compound of copper oxide, iron oxide, zinc oxide, lead oxide, dissolved with sulfuric acid. The amount of solution was determined by spectrometric analysis and included in Table 3.

**Table 3.** Atomic – emission spectroscopy with inductively coupled plasma (ISP-ASM).

№	Sample	Al	As	Bi	Ca	Cd	Cu	Fe	Li
1	Solid g/t	51300	<1,0	1.96	3700	0.122	567	33800	11.5
2	Solution g/l	920	12.56	0.38	38.4	0.02	642	7200	2.38
№	Sample	Ti	Zn	S	Pb	Ni	Na	Mn	Cr
1	Solid g/t	1190	75.8	27400	29.6	<0.1	4280	53.3	84.7
2	Solution g/l	124.9	50.2	40850	7.3	<0.5	48	4.12	1.62

## 4 Conclusion

According to the conducted research, a technology has been developed for extracting copper and other valuable elements from the waste of the copper processing plant, initially the waste (tailings) of the copper processing plant were fired in pyrometallurgical processes at 7000C, and in subsequent stages the transition from the sulfide state to the oxide state using sulfuric acid, with a pH concentration of 3-4, the most optimal process is the process of selective leaching. The tailings of the copper processing plant in the solid state amounted to 0.536 g, and a sufficient amount of copper was transferred to the solution, so that 2 times more copper is released in the solution.

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