PROCESSING OF TAILINGS AFTER ENRICHMENT OF COPPER PRODUCTION SLAG

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Abstract. *The current state of the mining and metallurgical industry requires a tendency to process man-made waste that has accumulated for many years. Depletion of rich ore deposits and increased requirements for environmental protection indicate the need for special attention to increasing the complexity of the use of raw materials and the use of innovative energy-saving technologies using man-made production waste. Waste after enrichment by flotation of copper production slags is a storage of iron-containing technogenic waste, which will serve as a raw material for the production of pigmented iron oxide compounds. The article states that oxide compounds are associated with silica, and the main task is to free from silicon dioxide and obtain pigmented iron oxide.*

Keywords: *waste after slag enrichment, industrial waste, pigment iron, slag, alkaline firing, leaching, sludge fraction.*

Introduction. Currently, the industrial enterprise JSC Almalyk MMC annually generates more than 30 million tons of waste: 22 km^3 of wastewater and up to 10 billion tons of solid waste, the main part of which is slag and tailings from processing factories, waste from mining and mineral processing and metallurgical waste.

The basis of waste-free technology is the development and implementation of fundamentally new technological processes that exclude any type of waste, various drainless technological schemes and water circulation cycles based on effective treatment methods, as well as the widespread use of waste as secondary raw materials[1].

At Almalyk MMC JSC Copper concentrating factory-2, dump slag was processed by flotation in the amount of 421.9 thousand tons, together with copper ore. The extraction of copper from raw materials was 82.06%, gold 62.5%, silver 63.04%. When comparing the performance of the factory using ore and when processing slags from the Copper smelter together. The factory managed to improve its production of metals: copper by 2346 tons and a certain amount of gold and silver.

Involvement in slag processing made it possible not only to obtain additional metals, but also to cover the shortage of raw materials (ore) at Copper concentrating factory-2. Further laboratory and pilot tests showed that the best results are obtained by separate processing of slag and ore. It has become possible to extract molybdenum from a collective concentrate obtained from ore, as well as to use slag flotation tailings containing 35-37% iron.

Based on the above, the management of the plant decided to process slag and ore separately. Thus, 622.2 thousand tons of slag were processed separately. Slag processing is carried out according to a two-stage grinding scheme - main and control flotation.

In copper smelting slag the amount of iron is very high and reaches 41.40-65.70% in terms of FeO. The silicic acid content in them is in the range of 16.34-35.70%. These two oxides represent the main part of the slag, so the study of these slags was carried out within the framework of the $FeO-SiO_2$ system.

According to a number of researchers (Mac Lellan); Smirnov; Mostovich; Beloglazov et al. The silicate formed in the converter slag of copper smelting production has a more acidic composition than fayalite and corresponds to the formula $4FeO \cdot 3SiO_2$ (38.6% SiO_2 61.4% FeO).

According to Olshansky, who studied the $FeS-FeO-SiO_2$ system or the quaternary system $Fe-S-Fe_3O_4-SiO_2$, the melting point of the ternary eutectic in this system is 920-1000 °C with a composition of Fe - 65%, FeO - 35% and SiO_2 no more than 3%. This shows a noticeable decrease in the melting temperature of the iron-silicate slag melt in the presence of sulfide [3].

Therefore, flotation tailings differ significantly from the original sulfide ores not only in content, but also in the degree of oxidation of minerals in the surface layer, the presence of a significant number of intergrowths and slimy particles. Therefore, tailings material is a more complex enrichment object and its processing using existing technologies is ineffective.

Maximum extraction of valuable components from copper production slags was achieved during flotation enrichment. However, some useful components are lost in the processing tailings. In addition, the tailings from the Copper concentrating factory-2 enrichment plant are rich in iron content.

The output of tailings from Copper concentrating factory-2 JSC "Almalyk MMC" is more than 600 tons/year. Due to the protection of ecology and the external environment, such material is not stored. Currently, these tailings are used as binding compounds in the production of cement and building materials. However, this material can serve as a raw material for the production of valuable components such as iron and noble metals.

Cost-effective processing of technogenic raw materials is possible by conducting preliminary waste mapping and developing technologies for processing individual fractions of raw materials in accordance with the needs of the economy based on the use of new modern methods and equipment, with the production of high-quality commercial products.

Waste-free and low-waste technology is a modern direction for the development of industrial production. The main goal of this direction is to reduce the harmful effects of industrial waste on the environment. Non-waste technologies provide the opportunity for complex processing of raw materials, and the development of such technological processes helps. As a result of the development of these technologies, it is possible to use natural resources more efficiently, recycle industrial waste, reduce the amount of waste and reduce its negative impact on the environment[4].

Results and discussion. The goal of the work is to develop methods for processing waste (tailings) of flotation enrichment of copper production slags with the extraction of valuable components and the production of iron oxide pigment Fe_2O_3.

In waste raw materials, iron is in sulfide and oxide forms with a silicon dioxide compound. Iron sulfide compounds do not react with acids and require additional technology to convert it into an oxide compound.

From the results of the chemical analysis of tailings, we can conclude that traditional methods for processing copper slag tailings do not allow complete extraction, therefore it is possible to use an unconventional method for extracting valuable components, based on the combination method of pyro and hydrometallurgy. Sulfide and complex chemical compounds of iron do not dissolve in acids, so alkaline roasting is carried out with the addition of NaOH to the charge and leaching of the cinder. This is a simple and economical method for extracting Fe_2O_3, which is considered as a raw material for the production of pigment iron.

Laboratory experiments are being carried out to study the optimal parameters of roasting and leaching.

To conduct the experiments, we took iron-containing technogenic waste (tailings) from copper processing plant-2 of Almalyk MMC JSC with the following chemical composition, which is given in Table 1.

Table 1

Chemical composition of tailings after slag flotation CCF-2 JSC "Almalyk MMC"

Product name	**Content, %**								
	FeS	**Fe_2O_3**	**Fe_3O_4**			**CuO**			
CCF-2 tails	10-15,0	49,0	69,0	33,3	6,73	0,617	1,56	0,0014	2,31

From Table 1. It can be seen that the iron content in the waste tailings of the flotation of slags from copper production in some cases exceeds the content of iron-containing ores of a natural phenomenon, due to which the waste (tailings) after flotation of slags can be used as raw material for the production of iron pigment.

The firing of slag tailings with sodium hydroxide goes through the stage of formation of ferrate and silicate compounds of metals with sodium, then they decompose to metal hydroxides according to reactions.

$$Fe_2SiO_4 + 5NaOH \rightarrow Na_2SiO_3 + Na_2FeO_4 + NaFeO_2 + H_2 \quad (1)$$

Slag tail is fired in a muffle furnace at t>300-350 °C, firing duration is 60-120 minutes. The reaction begins to proceed with the formation of sodium complex compounds. When the temperature rises to 400 °C, the content of iron oxide increases significantly. However, the presence of Al_2O_3 in the tailings (Table 1), when the firing temperature increases above 350 °C, sodium aluminate $NaAlO_2$ is formed, which is highly soluble in water and can impair the precipitation of iron hydroxide $Fe(OH)_3$ in the sediment. The dependence of firing on time is shown in Fig.1.

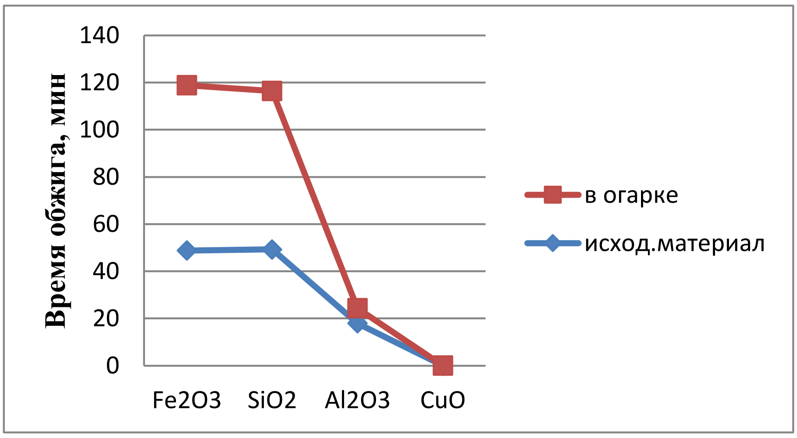

Fig.1. Dependence of firing on time

From Fig.1. It can be seen that during firing the oxide compounds of the charge components increase.

Firing slag tailings with sodium hydroxide in a muffle furnace at t = 350 °C, its main components being sodium ferrate Na_2FeO_4 and sodium silicate Na_2SiO_3. Fayalite (Fe_2SiO_4) may also be present. During further processing, it is necessary to take into account that the resulting product is represented by soluble complex sodium compounds: Na_2FeO_4, $NaZnO_2$, Na_2SiO_3.

When firing slag tailings with sodium hydroxide in a muffle furnace, the degree of opening of silicon dioxide increases with increasing temperature and excess hydroxide.

The dependence of the extraction of iron oxide into cinder on temperature is shown in Fig. 2.

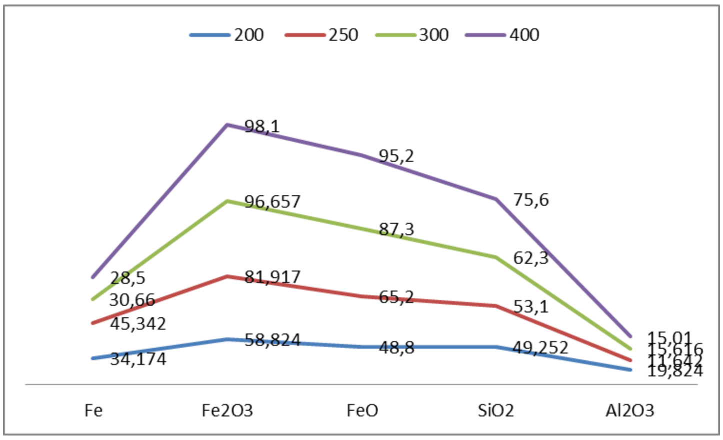

Fig.2. Dependence of caustic roasting of tailings on temperature

From Fig.1. it can be seen that with increasing temperature the content of iron oxides increases by 98%, however, with an increase in temperature above 350 - 400 °C, sodium aluminate appears in the cinder, which closely binds to iron oxides and leads to sintering of the material. Therefore, it is advisable to carry out alkaline firing at a temperature of 320-350 °C.

According to reaction (1), reactions occur with the formation of three chemical compounds, which, during aqueous leaching, silicon dioxide is transferred into solution (2), and iron hydrates remain in the sediment according to reactions (3)-(4).

$$Na_2SiO_3 + H_2O \rightarrow 2Na^{+} + SiO_3^{-2} + H_2O \quad (2)$$

$$Na_2FeO_4 + H_2O \rightarrow NaOH + Fe\ (OH)_3 + O_2 \quad (3)$$

$$NaFeO_2 + 2H_2O \rightarrow NaOH + Fe\ (OH)_3 \quad (4)$$

The cake containing after water leaching is subjected to acid leaching with sulfuric acid with a concentration of 30 g/l, the duration of leaching is 1-2 hours. The purpose of leaching is to transfer iron and its oxides into solution.

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It should be noted that it is possible to abandon acid leaching if impurities such as $Cu\ (OH)_2$, $Na_2[Zn(OH)_4]$, $NaZnO_2$, etc. are neutralized during water leaching.

The cake content after water leaching and extraction into solution is shown in Fig-3.

After water leaching, the cake is filtered and subjected to acid leaching with sulfuric acid with a concentration of 30 g/l at a temperature of 50 °C. The solution after acid leaching is neutralized with ammonia or calcium carbonate at pH 6. Upon neutralization, red-orange small shavings of Fe_2O_3 precipitate.

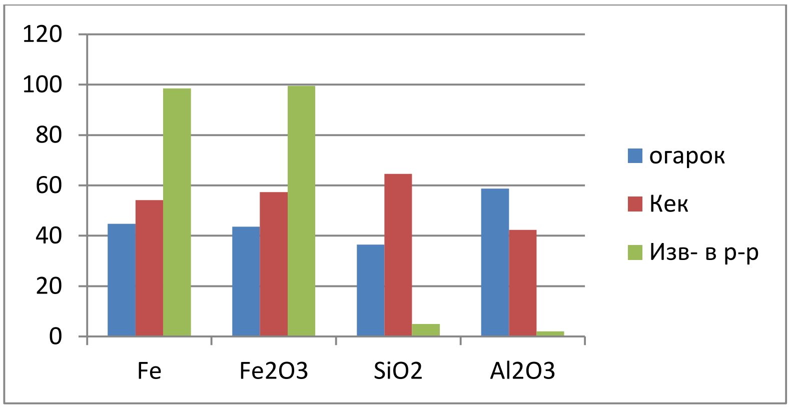

Fig.3. Extraction of iron oxide into solution after acid leaching.

Conclusion. According to the results of chemical and mineralogical analyzes of the material under study, the following are obtained:

1. The accumulation of unprocessed waste causes potential economic and environmental problems: waste of resources and pollution of the environment: water, forests, land, atmosphere, etc.

2. From literary analysis it has been established that the total volume of waste (tailings, slag, sludge, dust, etc.) already accounts for more than half (about 60%) of the volume of the original iron ore, and 11-12% of subsequent processing, metallurgical, metalworking, etc.

3. It has been established that iron-containing waste (tailings) of CCF-2 contains iron and its compounds more than 50% or more.

4. It has been established that iron-containing waste CCF-2 contains iron oxide compounds in the form of hematite 49%, silicon dioxide 33-34%, CuO - 0.6%, ZnO - 1.56%, S - 0.8%.

5. It has been established that tailings after enrichment of copper production slag CCF-2 is an iron-containing raw material for the production of iron pigment Fe_2O_3.

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