

ORCID iD : 0009-0004-1810-9482

CURRENT STATE OF PROCESSING COPPER CONCENTRATES

Abdirazakov Akmal Ibrahimovich

Associate Professor, Department of

“Oil and Gas Work and Processing Technology”,

Karshi State Technical University, Uzbekistan. Karshi.

E-mail : abdirazakov34@gmail.com.

Turdiyev Farid Razzoq o'g'li

Senior lecturer of the department

“Oil and Gas Work and Processing Technology”,

Karshi State Technical University, Uzbekistan. Karshi. city.

ANNOTATSIYA

So'nggi 200 yil ichida, ayniqsa 20-asrning ikkinchi yarmida global iqtisodiy rivojlanish tajribasi shuni ko'rsatdiki, aksariyat xom ashyo turlari uchun zahiralarning kamayishi emas, balki ularning sifat jihatidan o'zgarishi muhim ahamiyatga ega. Ko'pgina xom ashyo turlari (mis, qo'rg'oshin, rux va temir rudasi) uchun foydali komponent miqdori va ruda massasining umumiy hajmi o'rtasida o'zaro bog'liqlik mavjud. Rudaning mineral tarkibining arifmetik pasayishi ruda hajmining eksponensial o'sishiga olib keladi. Shuning uchun, insoniyat yangi konlarni qidirish va rivojlantirishda davom etadi, global xarajatlar yiliga 5,1 milliard dollardan oshadi, agar bu iqtisodiy jihatdan samarali bo'lib qolsa va foydali komponentning past konsentratsiyasiga ega mineral rudalarning tobora ko'proq massalarini iqtisodiy aylanishga olib kirsas.

АННОТАЦИЯ

Опыт развития мировой экономики за последние 200 лет, особенно за вторую половину XX века, показал, большинства видов сырья речь идет не об истощении запасов, а об их качественном изменении. Для многих видов сырья (медная, свинцовая, цинковая, железная руда) существует зависимость между содержанием полезного компонента и общим объемом рудной массы. Понижение содержания минерала в руде в арифметической прогрессии приводит к возрастанию объемов руды в геометрической прогрессии. Так что поиск, расходы на который в мире уже превысили 5,1 млрд. долларов в год, и разработку новых месторождений человечество будет вести до тех пор, пока это будет экономически рентабельно, вовлекая в хозяйственный оборот все более значительные массы минеральных руд с низкими концентрациями полезного компонента [16].

ANNOTATION

Experience with global economic development over the past 200 years, particularly in the second half of the 20th century, has shown that for most types of raw materials, it's not a question of depletion of reserves, but rather of their qualitative transformation. For many types of raw materials (copper, lead, zinc, and iron ore), there's a correlation between the content of the useful component and the total volume of the ore mass. An arithmetic decrease in the mineral content of the ore leads to an exponential increase in the volume of ore. Therefore, humanity will continue to explore for and develop new deposits, with global expenditures already exceeding \$5.1 billion annually, as long as it remains economically viable, bringing ever-larger masses of mineral ores with low concentrations of the useful component into economic circulation.

Kalit so'zlar: mineral, mis, metall, rux, ruda, shteyn, shuxta, shlak, nikel, tozalash, konsentrat, qora mis, pech, mis-rux.



Ключевые слова: минерал, мед, металл, цикл, руда, штейн, шихта, шлак, никель, рафинирования, концентрат, черновую медь, печь, медно-цинковых.

Key words: mineral, copper, metal, cycle, ore, matte, charge, slag, nickel, refining, concentrate, blister copper, furnace, copper-zinc

Introduction

In the depths of Uzbekistan there are deposits of almost all elements of the periodic table, and the predicted copper indicators will ensure production for a century [1 7. 2. 3].

Global industrial development steadily follows scientific and technological progress and technological advances. More and more countries are adopting modern consumerism: a new refrigerator every seven years, a new car every five. And all of this requires copper. Speaking about the current state of blister copper production—the pyrometallurgical method—it's necessary to discuss the prospects for copper production and the volume of its natural reserves, which are estimated at between 654 and 1,600 million tons. The distribution of copper production by country is shown in Figure 1.10 [4].

The world's leading copper producer is the Republic of Chile (Fig. 1.10), which holds the largest reserves of this metal. The country holds over 350 million tons of copper. Uzbekistan holds over 13.48 million tons of copper, which provides copper production for 100-120 years. Currently, the main consumers of copper products are China, the United States, and Japan, which account for 50% of all copper consumed, although refined copper is used in 70 countries worldwide. It is the economic growth of these countries and the demand for the metal in the coming years that will have a significant impact on copper production volumes [5].

The energy crisis of the 1970s created conditions for moving the final stages of copper production to developing countries with cheap labor.

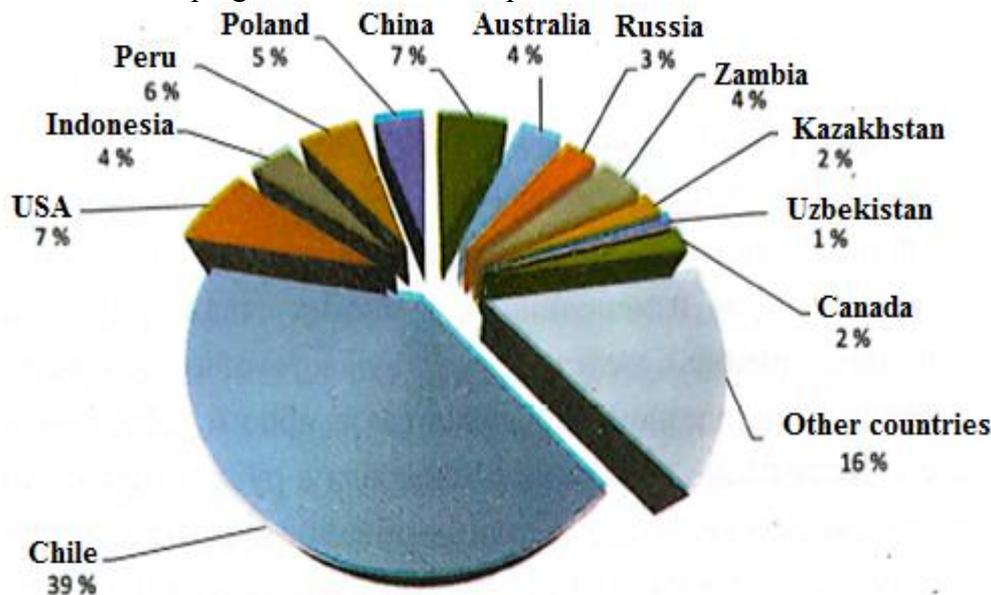


Fig. 1.10. Structure of world copper reserves

Analysis of literature on this topic

Copper mining countries have begun gradually completing the missing technological steps in copper production to a full cycle. Naturally, due to energy shortages and remoteness from consumers, refined copper production is slow. Mexico refines 75% of its blister copper production. Chile, the world's largest copper ore producer, refines only 60% of its copper output.

Uzbekistan, unlike other countries, produces copper at the Almalyk Mining and Metallurgical Combine (MMC) JSC, which is one of the largest enterprises in the metallurgical industry in the country. It is in a better position in terms of territorial location: ore mining and



enrichment, concentrate production, blister copper production, and copper refining are located within short distances. The plant's production capacity is based on ore reserves in the city of Almalyk, Tashkent Region. The Kalmakyr deposit is located 8 km from the processing plant and factory, and the copper smelting production is located on the plant's territory. Ore transportation costs are insignificant, which makes the enterprise more attractive to investors [6].

Research methodology

The development of the copper industry in recent years has been characterized by the modernization and expansion of existing enterprises using new technology. There is a trend toward the restructuring of large associations and plants, encompassing the full production cycle from ore mining to finished metal production and its subsequent processing (copper rod, rolled products, etc.). Copper smelters in the CIS countries and Uzbekistan primarily use low-grade (14-18%) complex concentrates. Up to 50% of copper is smelted from mattes obtained in reverberatory and electric furnaces, and the remaining 50% is smelted in autogenous furnaces. Shaft furnaces are used only in older plants for processing high-grade ores (semi-pyrite) and sulfur ores (improved pyrite), as well as for substandard secondary raw materials. In terms of matte conversion and copper refining, the performance of plants in the CIS and Uzbekistan is on par with leading international companies. The production and continuous casting of oxygen-free copper, the production of copper rod, etc., has been mastered.

The smelting of copper concentrates into matte in reverberatory furnaces began in the late 19th century, as increasingly poorer ores were being processed in metallurgy and their pre-beneficiation methods developed. The essence of reverberatory smelting is that the charged charge is melted using the heat from the combustion of carbon fuel in the furnace's horizontal working chamber. Torch,

formed during fuel combustion is located on the surface of the melt. When melting raw and dried concentrates, the charged charge forms slopes along the side walls of the furnace; when melting cinders, it spreads over the surface of the molten slag mirror. The charge and the surface of the molten fuel, above which, in reverberatory furnaces, are heated by direct radiation from the hot flue gas torch and thermal rays reflected from the inner surface of the dome [7].

The composition of the charge for reflective smelting includes sulfides and oxides of metals, rock-forming compounds, silicates, carbonates, liquid converter slag compositions and other compounds. Pouring of liquid converter slag is provided for by the process regulations, since it is a recycled product. The task of reflective and electric smelting is to sulfidize copper and convert it into matte with simultaneous slagging of iron. The mineralogical composition of the concentrates is as follows, %: Cu_2S - 14-20; CuFeS 2-10-45; CuSFeS 4 - 1-26; FeS_2 -3-50; PbS - 1-2; ZnS - 1-10; Fe_2O_3 - 1-3; SiO_2 - 1-25; CaCO_3 - 0.2-4.0.

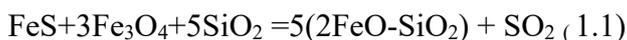
Analysis and results

The atmosphere in the reverberatory furnace's gas space is considered neutral or slightly oxidizing, having no real effect on desulfurization and not participating in chemical interactions with the charge and melt. The chemical processes occurring in the reverberatory furnace can be divided into several stages:

1. When the charge is heated in a neutral atmosphere, moisture evaporates and thermal dissociation of unstable chemical compounds—higher sulfides and carbonates—occurs. High furnace temperatures promote the rapid and complete decomposition of pyrite, covellite, chalcopyrite, and other higher sulfides. All carbonates also completely decompose during smelting.

2. Chemical transformations during reverberatory melting include reactions between ferrites and sulfides, which are also accompanied by sulfur removal. Of particular importance is the reaction between magnetite and iron sulfide in the presence of silica:





The decomposition reactions of other ferrites proceed similarly. The low degree of desulfurization, coupled with the large volume of flue gases, also results in low SO₂ content in the exhaust gases (less than 1.5%), which in turn complicates and greatly increases the cost of gas treatment and sulfur recovery for commercial products. When smelting raw concentrates, approximately 50% of the original sulfur is irretrievably lost.

Increasing the magnetite content in slag and matte has a detrimental effect on their physical and chemical properties. The source of magnetite in the reverberatory smelting of raw concentrates is the recycled converter slag, which is poured in liquid form into the reverberatory furnace.

3 - Chemical reactions occurring in a reverberatory furnace, reactions involving the interaction of non-ferrous metal oxides with sulfides. The interaction between oxides and iron sulfide is described by the equation of a reversible reaction:



The direction and completeness of their course are determined by the difference in the affinity of metals to sulfur and oxygen, and the activity (concentration) of the reaction products in the contacting phases.

Metals with a high affinity for oxygen (Si, Ca, Mg, Al, etc.) are almost completely converted into slag during smelting in the form of their corresponding oxides. In turn, metals such as copper and nickel, which have a high affinity for sulfur, are concentrated primarily in the matte.

4 - processes of distribution of valuable components among the smelting products. Precious metals accompanying copper in the ore raw material are almost entirely concentrated in the matte during reverberatory smelting. Almost all the iron previously bound with sulfur remains in the sulfide form and is completely converted into the matte. As a result, the matte content is high, while the copper content is low – 16-20%. To increase the copper content, the batch must be pre-roasted with oxidizing agents.

Converting is a process that involves blowing oxygen-containing gases (air, oxygen-air mixture) through sulfide melts to remove iron and sulfur. Matte processing is carried out in converters using the heat content of the original matte and, mainly, due to the exothermic reactions that develop during the process. The process occurs in two periods: in the first period, sulfur is oxidized and removed, and iron is converted to ferrous oxide and magnetite. The resulting oxides, together with quartz loaded into the converter, form a recycled converter slag, which is drained from the converter and poured into a reverberatory furnace. After the first period, pure copper semisulfide Cu₂S, the so-called white matte, remains inside the converter. In the second period, white The matte is processed into converter blister copper. The liquid matte consists mainly of copper and iron sulfides with a small amount of magnetite [8].

Slags from the copper and nickel industries, like slags from other metallurgical processes, are complex alloys of oxides. They are formed from the gangue oxides of the feedstock and specially introduced fluxes and serve as a medium for concentrating gangue components and separating them from valuable metals. Slags play a significant role in pyrometallurgical processes. Critical physicochemical transformations occur in molten slag. Due to the typically low content of valuable components in the feedstock and the high gangue content, copper and nickel pyrometallurgy is characterized by high slag yields. Although the content of copper, nickel, and other associated metals in the slags is relatively low (0.1-1.5%), the high slag yield results in significant absolute losses of valuable components. The most important oxides that form the basis of copper and nickel smelting slags are SiO₂, FeO+Fe₃O₄, CaO, MgO and Al₂O₃. The physicochemical properties of slag melts and their behavior in pyrometallurgical processes



have a decisive influence on the processes of formation and separation of smelting products. In turn, the physicochemical properties of slag melts are a function of their chemical composition and temperature. The most important physicochemical properties of slags, which have great practical significance, primarily include the melting temperature (fusibility) of slags, surface tension, density and viscosity [8].

Since copper production currently relies predominantly on sulfide raw materials, autogenous processes are gaining ground [17]. The requirement for autogenous raw materials is the presence of components whose combined reactions with blast oxygen generate heat for the smelting process. The main components of sulfide raw materials are iron, copper, and nickel sulfides, among others. Of the main types of smelting, heated blast (Finnish flash smelting) is the most technologically and instrumentally developed autogenous process. A distinctive feature of flash smelting with oxygen blast is the use of furnaces with a horizontal torch. The KIVCET process (oxygen-suspended cyclic electrothermal smelting) is an improved version of flash smelting for processing sulfide copper, copper-zinc, and other bulk concentrates.

Oxygen-fueled (oxygen-torch) smelting (OFS) was used only at two plants in the world - in Canada at the Copper Cliff plant and at the Almalyk Mining and Metallurgical Combine copper plant [8-10].

Vanyukov furnace smelting is a highly efficient development of the autogenous technology for sulfide raw materials smelting in a liquid bath (PLB), used in non-ferrous metallurgy plants. The advantage of this furnace is that the furnace's working area can be divided into (one, two, or three) zones, maintaining the required atmosphere (oxidizing and reducing), neutral, or change the temperature in these zones. Process gases are sent to the sulfuric acid shop for the production of sulfuric acid [11, 12]. The disadvantage of the Vanyukov furnace is that it cannot process the recycled melt (converter slag), which contains 2-7% copper.

Conclusions and suggestions

The Ausmelt and Isasmelt autogenous furnaces, developed in the 1990s, are currently being further developed. However, in 2006, after reviewing several advanced smelting unit options, the management of Russian Copper Company selected an Australian smelting unit from Ausmelt as the new furnace. According to information provided by Karabashmed, a subsidiary of Russian Copper Company, the Ausmelt furnace has not become obsolete in 10 years: the smelting unit was originally designed to handle a variety of raw materials—wet (up to 10%), coarser fractions, and varying copper content. Furthermore, the Ausmelt is highly automated and requires virtually no manual labor, which is crucial in such a complex production environment.

Ausmelt technology is becoming increasingly widespread worldwide. According to available data, 19 global metallurgy companies employ it, including one in Russia. Blister copper production using this technology is approaching 1 million tons. Therefore, Ausmelt furnaces continue to be built worldwide.

The development of "Ausmelt" and "Isasmelt" technologies occurred primarily in the copper industry, but their successful application in the production of lead, zinc, and tin is already known. Both processes utilize a vertical cylinder with compressed oxygen pumped into it to create a turbulent environment [13-14].

Copper concentrate will be delivered by rail Railcars to a batch blending plant. Prior to processing in the ISASMELTT™ copper furnace, these raw materials will be stored in a copper concentrate yard. The materials will be unloaded in controlled tonnages using weigh feeders and mixed in a drum pelletizer. The mixed material will be loaded from the top of the ISASMELTT™ copper furnace using a series of belt conveyors. The furnace roof and the exhaust gas duct above the furnace will include a boiler stack and will be connected to a waste heat boiler system. Before entering the electrostatic precipitator, the gases will pass through the waste heat boiler. In



this production cycle, almost all sulfur-containing gases will be produced in the ISASMELTT™ copper furnace and Peirce - Smith converters . The gas from these furnaces will have a high SO₂ content and is suitable for processing in a sulfuric acid plant. Matte and slag are produced by melting materials with oxygen-enriched process air. Mixed matte and slag are periodically tapped through a single water-cooled launder at the base of the furnace. The slag and matte are fed into an electric furnace for matte precipitation, located adjacent to the ISASMELTT™ furnace for cooling. The matte will contain approximately 60% Cu . In the electric furnace, the matte and slag are separated due to their different densities. Copper and magnetite are partially recovered by the addition of coke. The slag tapped from the electric furnace is granulated and transported in full volume for backfilling mine voids and for the reclamation of quarries left after mining operations. The matte is transferred from the electric furnace to ladles and fed to a Peirce - Smith converter for subsequent conversion. The conversion product is blister copper, which is then fire-refined in anode furnaces. Anode copper contains a significant amount of impurities, requiring further purification. The copper is cast into anode molds using an automatic machine. The copper anodes then undergo electrolytic cleaning during the electrolysis stage. The final product of copper production is a commercial product: cathode copper [15].

References

1. Хасанов А.С. Шлаки медного производства. Издательство “Muharrir nashiyoti” Ташкент, 2004. 445 с
2. Хурсанов А.Х., Хасанов А.С. и др. Технология платиноидов, Ташкент-2022. 420 с.
3. Хасанов А.С. Совершенствование медной промышленности в Узбекистане и за рубежом // Тез. докл. междунар. конф. Ташкент, 2004. 48-52 с.
4. Хасанов А.С. Физические свойства жидких шлаков и штейнов // Горный вестник Узбекистана, 2004. № 3/18. Навои, 84-85 с.
5. Хасанов А.С. Возможности применения ПВ на ОАО “Алмалыкский ГМК”//Респ. научно-техн. конф. (с междунар. участием) Истиклол: Тез. докл. Навои, 2004, 117-118 с.
6. Хурсанов А.Х., Абдукадыров А.А., Хасанов А.С. Перспективы развития производства редких металлов “Алмалыкский ГМК”//Горный Вестник Узбекистана, №4 (79), 2019
7. Хасанов У.А. Мис эритиш печларида тошкол таркибидаги мис микдорини камайтиришнинг асосий омилларини ишлаб чиқиш. Диссертация. 2021. 110 с.
8. Марченко Н.В. Металлургия тяжелых цветных металлов. Учебное пособие. Красноярск: 2009.
9. Юсупходжаев А.А. и др. Малоотходные технологии в медном производстве. Ташкент, 2020.
10. Кэцзянь Вэй и др. Способ и печь для конвертирования медных штейнов посредством донной продувки. Патент РФ, RU2647418C2.
11. И. А. Кирпиченков. «Анализ процесса плавки в печи Ванюкова с целью увеличения извлечения суммы цветных металлов» Записки Горного института, vol. 155, no. 2, 2003.
12. Данилова Н.В. Автоматизированная система управления процессом автогенной плавки медно-никелевого сульфидного сырья на основе нечеткой логики. Дисс.кан. наук., 2010.
13. Писарев Александр Иванович и Костин Евгений Владимирович. "Метод оптимального управления процессом плавки медного никельсодержащего сырья



- В печах Ванюкова" Информатика, телекоммуникации и управление, по. 3 (150), 2012.
14. Ярмаков Р.Р., Агарков П.В. «Техническое перевооружение цеха серной кислоты ООО «ММСК» с изменением схемы переработки металлургического газа С одинарного контактирования на схему ДК/ДА» Вестник науки, vol. 1, по. 12 (69), 2023.
 15. Технологический регламент. Проект «Новая металлургия».
 16. Атаманов Е.А. Экономические аспекты пространственного недропользования // Экономика региона, №4, 2008.
 17. <https://gazprombank.investmets/>

