International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 5 Issue 4, April - 2021, Pages: 182-188

The Main Trends in the Integrated Processing of Waste from Mining and Metallurgical Industries

Shokhrukh Khojiev[1], Dilnoza Fayzieva[2], Sukhrob Mirsaotov[3], E'tibor Narkulova[4]

[1]Senior Lecturer of the Department of Metallurgy, Tashkent State Technical University,
[2]Assistant of the Department of Metallurgy, Tashkent State Technical University,
[3]Student of the Department of Metallurgy, Tashkent State Technical University,
[4]Magistr of the Department of Metallurgy, Tashkent State Technical University,
E-mail: hojiyevshohruh@yandex.ru

Abstract: *XXI century is the century of high technologies. Further scientific and technological progress, reaching the world level in quality and ensuring high rates of industrial production force the intensive exploitation of natural resources, among which the share of mineral raw materials accounts for more than 70%. Over the past 25 years, approximately the same amount of mineral raw materials has been extracted from the bowels of the earth as in the entire previous 100 years. In connection with a general decrease in the content of useful components in mineral raw materials, maintaining the achieved level of industrial production requires an increasing volume of raw materials. Under the current situation, the physical volume of extraction of mineral raw materials doubles every 30 years, and of fossil fuels every 15 years. The main trends in the complex processing of industrial waste from mining and metallurgical production are considered. The main sources of man-made waste formation and methods of their processing are analyzed. New technologies of waste processing developed by domestic and foreign researchers are presented. Special attention is paid to the solution of issues of ecology and environmental protection.*

Keywords— *metallurgy, slag, copper, recycling, ecology, environmental protection, technogenic waste, production.*

1. INTRODUCTION

World reserves of mineral raw materials are geographically distributed extremely unevenly, and there is no industrialized country in the world that could fully provide itself with its own mineral resources [1].

Unlike other countries, the economy of Uzbekistan develops almost entirely on its own raw material base and does not depend on the import of mineral raw materials from other countries. However, in our country, mineral resources are gradually being depleted [2].

Proceeding from this, along with the task of constantly increasing reserves of mineral raw materials through the development of geological exploration, one of the main ways to solve the problem of providing industry with fuel, chemical raw materials, ferrous, non-ferrous and light metals is the comprehensive and fullest possible use of mineral deposits and extracted mineral raw materials.

The leadership of Uzbekistan has raised the problem of the complex use of mineral resources to the level of state technical policy. At the same time, special attention is paid to this problem in ferrous and non-ferrous metallurgy, which is explained by the extremely important value of the products of this industry for the country's economy and technical progress in the national economy [3-7].

A reliable legal basis for the strategy for the development of environmentally friendly technologies in the development of mineral deposits, the integrated development of natural resources and the processing of industrial waste is provided by a number of laws of the Republic of Uzbekistan, in particular the Law "On Nature Protection", the Law "On Subsoil", the Law "On Waste", etc. These legislative documents state that a more complete and comprehensive use of ore raw materials is the most important factor in expanding resources for the production of ferrous and non-ferrous metals and reducing costs per unit of production, as well as contributing to the prevention of environmental pollution by industrial emissions [8].

Despite the richness of natural mineral resources, effective forecasting of the country's economic development is impossible without taking into account the involvement of mining and metallurgical industry waste in processing, in which the content of valuable components is often significantly higher than in the extracted primary raw materials [9].

OJSC "Almalyk Mining and Metallurgical Plant" (AMMC), is one of the largest enterprises in Uzbekistan, includes copper and zinc production complexes. Despite the advanced technologies used, mining and metallurgical production is not waste-free [10].

Currently, more than 1 billion tons of flotation tailings and 13 million tons of flotation tailings have been accumulated in the dumps of AMMC. tons of waste slag from a copper smelter. Annually, about 400 thousand tons of waste slag with an iron content of 35-40%, copper up to 0.7%, gold up to 0.2-0.4 g / t are stored here. Dozens of hectares of land are occupied by dumps. Significant funds are spent annually on the maintenance of dump farms. A very large volume of slags with valuable components, formed during the processing of copper ores, determines the urgency of the problem of their rational use [11-15].

For many years, scientists not only from our republic, but also from many other countries, have been studying the complex processing of waste, including slags from copper production. However, to date, no integrated processing technology has been implemented. AMMC uses the technology of slag flotation processing. However, this technology is hardly promising, since the extraction of copper into concentrate is small. In this case, the tailings of the slag are entirely directed to the production of building materials. This leads to the fact that a significant amount of copper is irretrievably lost and will never be disposed of. Considering that all over the world natural reserves of copper are decreasing and prices for them are increasing, such losses are unlikely to be justified [16-19].

At the Department of Metallurgy, Tashkent State Technical University, several promising technologies for the integrated processing of slags have been developed, which are awaiting their industrial implementation. Their introduction will significantly increase the coefficient of integrated use of raw materials, improve the environment and switch to low-waste technology [20].

The amount of copper and precious metals contained in man-made waste could ensure the operation of the AMMC without being involved in ore processing for many years to come. Of undoubted value are the oxides of iron, silicon, and aluminum contained in them, which may well be used for obtaining additional products [21].

The same tasks, aimed at processing tailings and man-made dumps of operating mining enterprises with the introduction of modern technologies, are being solved at the largest state-owned enterprise - Navoiy Mining and Metallurgical Combine (NMMC). In particular, the mineralized mass storage facilities of the Muruntau mines and the tailings of the Marzhanbulak gold processing plant can serve as the objects of ore processing in future periods [22].

Since the beginning of the development of the Muruntau gold deposit, about 2 billion tons of mineralized mass with a gold content of about 0.3 g / t have been accumulated in the dumps of the mine's storage facilities. Today, these mineral wastes from mining have become man-made ores, as gold prices in the world have risen sharply and continue to rise [23].

Usage over 100 mln. tons of tailings from hydrometallurgical production with a gold grade of about 0.8 g / t of the Marzhanbulak gold processing plant will extend the life of the plant by 8-10 years [24].

The creation of a waste-free technology for any enterprise, as a rule, consists of two stages. At the first stage, the processing of waste generated in the production process is organized, the accumulation of which in this case stops. At the second stage, the processing of already accumulated waste is organized, which will allow, over time, to eliminate these dumps. From this point of view, the task of the determined optimal production capacity for waste processing is equivalent to the task for processing ores of a deposit with limited reserves [25].

2. THE MAIN DIRECTIONS OF DEVELOPMENT OF TECHNOLOGIES FOR THE PROCESSING OF INDUSTRIAL WASTE

In the first low-waste, non-waste technologies as the main way of engineering and environmental development, society was proposed in the mid-60s of the last century, mainly by scientists from the CIS countries. On the basis of their application, it was assumed not only to maximally use the consumed raw materials, but also to try to completely recycle the resulting waste [26].

In the general case, according to the theory of the spread of pollution, for which the name "miasmotology" has been proposed, the following phenomena are observed during the development of any industrial production:

- in a continuous technological process, environmental pollution occurs as a result of incomplete disposal of waste due to imperfection of the process itself or the presence of significant impurities in the original product;
- any pollutant after the release and any part of the biosphere to the limit dissolves in it, and also simultaneously penetrates into other parts of the biosphere and interacts with them [27-28].

Thus, according to these laws, the main technological task is to process waste on site and at the time of its occurrence, the further the waste is removed from the place of its generation, the more difficult this task becomes and at some stage it becomes unsolvable. Therefore, when developing technological schemes for cleaning and disinfecting harmful emissions into the environment, one should proceed from the principles of local primary cleaning from a specific type of waste. It is permissible to combine waste related components that require the same treatment [29]. Even the most harmless waste, accumulating in large quantities, will actively affect the existing balance and, therefore, negatively affect the ecological parameters of the environment. Expansion of ways of cooperation in the field of small and zero-waste technologies contributed to the adoption by the United Nations at a meeting in Geneva in 1979 of the international "Declaration on low-waste and zero-waste technology and waste management."

The main activities in this direction include:

- scientific and technical aspects;
- rational use of natural resources and energy through the development and implementation of new technologies and the improvement of existing ones;
- the use of new energy resources, the creation of closed water circulation systems and the utilization of material and energy losses;
- socio-ecological parameters;
- carrying out analyzes and scientific forecasting of short-term and long-term consequences of the development of material production for humans, flora and fauna and preservation of normal conditions for the development of natural ecosystems [30-32].

In 1979, in Geneva, a program was adopted for introducing waste-free technologies into world practice, and the concept itself sounded like this: "Waste-free technology is the practical application of knowledge, methods and means to ensure, within the framework of human needs, the most rational use of natural resources, energy and environmental protection" [33].

A waste-free technological system should be understood as such production, as a result of which there are no emissions into the environment. Waste-free production is a set of organizational and technical measures, technological processes, equipment, materials that ensure maximum and comprehensive use of raw materials and allow minimizing the negative impact of waste on the environment [34].

Waste-free production can be characterized by all possible utilization of waste generated in direct technological processes. The ideal production model in most cases cannot be fully realized, but with the development of technological progress it is getting closer to it [35].

Low-waste technology is an intermediate stage to non-waste technology and differs from it in that it provides a finished product with not fully utilized waste.

Waste is a by-product released in the production process of the main types of products and is characterized by certain physical and chemical properties. Waste from production and consumption, suitable for processing into marketable products, refer to secondary material resources [36].

Waste-free technology can be developed in the following directions:

- creation of drainless technological schemes based on existing, introduced and promising methods of purification. In this case, a sharp decrease in water consumption is achieved, but, as a rule, secondary pollution formed in the form of solid precipitation or saturated solutions;
- development and implementation of systems for processing production and consumption waste, which should be considered as secondary material resources. During the operation of modern water and gas purification systems, solid waste is formed, which is a concentrated mixture of pollutants;
- organization of fundamentally new processes for obtaining products, allowing to exclude or reduce processing stages (or technological stages), which generate the bulk of waste;
- development and creation of territorial-industrial complexes (TIC) and a closed structure of material flows and raw materials and waste within the TIC, with a minimum of emissions. In the conditions of Uzbekistan, such a TIC could be created on the basis of the AMMC and APO "Uzmetkombinat" [37].

Previously, the process was based on an increase in labor productivity, but now - an increase in resource productivity.

Rational consumption of resources and protection of the environment can be carried out by implementing the following solutions:

- closure in the cycle of effluents, emissions, energy resources;
- disposal of solid waste;
- change in the technology of the main production of the main path when creating waste-free technologies. It can be implemented at levels such as;
- raising the professional level and culture of production operation;
- reconstruction and technical re-equipment of production;
- creation of fundamentally new resource-saving, waste-free production facilities, distinguished by a high level of engineering, economic and environmental excellence;
- saving resources;
- release of products of a fundamentally new quality [38].

3. THE MAIN TRENDS IN THE RATIONAL USE OF MINERAL RAW MATERIALS

The main reason for the relatively low level of efficiency in the use of the deposit's raw materials is that, in the presence of, as a rule, several useful components in the extracted rock mass, mining and metallurgical enterprises are programmed to obtain in the vast majority of only one type of commercial product. Therefore, significant reserves of mineral raw materials are accumulated in the dumps [39].

The idea of the complex use of raw materials was formulated in the 1930s by Acad. A.E. Fersman and is a consequence of his scientist about technogas, which is understood as a set of geomorphological processes caused by human production activities, comparable in their influence with natural geological and geochemical processes. This idea was developed through successive transformation, first into the concept of integrated development of deposits, and then into the concept of integrated development of subsoil based on low-waste and non-waste technologies for using natural deposits of minerals and man-made deposits that have arisen as a result of storing waste from mining, processing and use of raw materials [40].

According to experts, the practical implementation of the already developed technical solutions for the development of technogenic deposits will reduce the volume of extraction of mineral raw materials by 20-30%.

The idea of low-waste and non-waste technologies includes (along with considerations in the field of resource conservation) the requirement for the normal functioning of the environment, which determines a certain organization of mining and processing production and presupposes the creation of conditions for the involvement of all mineral resources of natural and technogenic origin in economic turnover with the burial of inevitable remains. The creation of such conditions with a quantitative assessment of their characteristics is a difficult task, since numerous factors influence the resources interacting in the process of field development [41].

4. Basic laws of ecology and problems of nature management

The principles of ecology and nature management are based on the four laws of B. Commoner.

The first law of ecology of B. Commoner - everything is connected with everything - draws attention to the universal connection of processes and phenomena in nature. It is close in meaning to the law of internal dynamic equilibrium.

The second law of ecology of B. Commoner's - everything must go somewhere - is also close to the law of internal dynamic equilibrium, and is also close to the law of development of a natural system due to the environment around it, especially its first consequence: absolutely waste-free production is impossible, so we can count only its low-waste options [42].

The third law of ecology B. Commoner - nature "knows" better - is that until we have absolutely reliable information about the mechanisms and functions of nature, we easily harm natural systems, trying to improve them. He urges us to be extremely careful in our actions. Every intervention in nature has unexpected consequences. And only with the passage of time it became clear that any decision entailed side effects, which, in fact, no one wanted.

His fourth law of ecology - nothing is given for free - B. Commoner explains as follows: “... The global ecosystem is a single whole, within which nothing can be won or lost and which cannot be the object of general improvement; everything that has been extracted from it by human labor must be replaced. " The same problems are generalized by the law of the development of a natural system at the expense of its environment: Human impact on nature requires measures to neutralize these impacts, since they can turn out to be destructive for the rest of nature according to the rule of compliance with environmental conditions of the genetic predetermination of the organism, and threaten the person himself. In this regard, nature protection is one of the mandatory components of the socio - economic development of human society [43].

The basic laws of ecology were developed in functional laws and rules, supplemented by empirical consequences, from the point of view of which the practice of field development is considered [44].

The law of the development of a natural system at the expense of the environment around it: any natural system of coins develops only through the use of the material, energy and information capabilities of its environment. So, for example, the extraction of minerals is based on information obtained during prospecting and exploration work, which requires a constant increase in the subsoil disturbed by mining operations. Moreover, the volumes of these violations are many times greater than the volumes of recoverable minerals. Therefore, the main resource costs are not for the mineral, but for the enclosing rocks and the expansion of the worked-out area [45].

The law of decreasing the energy efficiency of nature management: With the course of historical time, more and more energy is expended to obtain a unit of useful product from natural systems. Contributes to the correct understanding of this law. The "principle of remoteness of an event" is a phenomenon, distance in time and space, seems to be less significant. In the use of natural resources, the principle quite often becomes the basis for incorrect practical actions. It is assumed that in the future, on the basis of scientific and technological advances, the problem will be solved more easily than now. In fact, the descendants will have to pay more, which is convincingly evidenced by the growth of costs for the extraction of mineral raw materials associated with the deterioration of the mining and geological conditions involved in the development of deposits [46].

5. Conclusion

Le Chatelier-Brown's principle: under external influence, which brings the natural system out of the state of stable equilibrium, the balance of displacement in the direction in which the effect of external influence is weakened. This principle is supplemented by the "Rule of the inevitability of valuable reactions": Any change in the environment inevitably leads to the development of natural valuable solutions that go towards neutralizing the change made or the formation of new natural systems.

The law of optimality: with the greatest efficiency, any system operates within certain spatial time limits. The “rule of measure for transforming natural systems”, concretizing the law, says: during the operation of natural systems, it is impossible to cross some limits that allow these systems to retain the properties of self-maintenance.

The principle of naturalness: technical means of nature management over time require more and more investment of funds, up to the irrationality of their maintenance, therefore natural ("soft") forms of management are ultimately always more effective than technical ("hard") ones. This is explained by the fact that “soft” (directing) control of natural processes can cause desirable valuable natural reactions (the rule of “soft” control of nature), while “weighty” control includes such reactions, a significant part of which turns out to be ecologically, socially and economically unacceptable in a long period of time (the rule of chain reactions of "cruel" control of nature).

Uncertainty principle: information during the conduct of actions for the transformation of nature is always insufficient for an a priori judgment about all possible results of the action being taken. This is due to the exceptional complexity of natural systems, their uniqueness and the inevitability of natural chain reactions, the direction of which is often difficult to predict. The principle serves as an important limitation in the use of the analogy method in field development, since the analogy is always incomplete due to the individuality of natural systems.

The principle of deceptive well-being: the first successes or failures in environmental management may be short-term, but taken as the final result, the receipt of which is explained by the fact that in the beginning there was an uncompensated effect that actually contradicted the laws of nature.

Decisions on the involvement of mineral deposits in the industrial turnover should take into account natural resource, material, energy, financial, human, environmental aspects, as well as current reactions to ongoing activities, which makes it possible to predict the consequences of their implementation. Decisions should be aimed at the efforts of the desired feedbacks, ensure the operation of the system, the rationality of the area of changing technical, technological and economic parameters and be implemented in a timely manner.

6. References

[1] Yusupxodjayev A.A., Hojiyev Sh.T., Ochildiyev Q.T. Gidrometallurgiya jarayonlari nazariyasi: amaliy mashg‘ulotlar uchun uslubiy ko‘rsatmalar. –Toshkent: ToshDTU, 2020. -132 b.

[2] Yusupxodjayev A.A., Hojiyev Sh.T., Ochildiyev Q.T. Gidrometallurgiya jarayonlari nazariyasi: laboratoriya ishlari uchun uslubiy ko‘rsatmalar. –Toshkent: ToshDTU, 2020. -36 b.

[3] Abjalova Kh.T., Khojiev Sh.T. Intensification of the process of depletion the converter slag // Texnika yulduzlari, № 4, Toshkent: “ToshDTU”, Dekabr, 2019. 59 – 63 b.

[4] Абжалова Х.Т., Хожиев Ш.Т. Обеднение шлаков кислородно-факельной печи Алмалыкского медного завода // Texnika yulduzlari, № 4, Toshkent: “ToshDTU”, Dekabr, 2019. 53 – 58 b.

[5] Юсупходжаев А.А., Хожиев Ш.Т., Сайназаров А.М., Курбанов Б.Т. Современное состояние и перспективы развития автогенных процессов переработки сульфидных медных концентратов // Инновационное развитие науки и образования: сборник статей X Международной научно-практической конференции, Состоявшейся 10 марта 2020 г. в г. Пенза. – Пенза: МЦНС “Наука и Просвещение”. – 2020. С. 20 – 24.

[6] S.T. Matkarimov, A.A. Yusupkhodjaev, Sh.T. Khojiev, B.T. Berdiyarov, Z.T. Matkarimov. Technology for the Complex Recycling Slags of Copper Production // Journal of Critical Reviews, Volume 7, Issue 5, April 2020. P. 214 – 220.

[7] Юсупходжаев А.А., Хожиев Ш.Т., Мирзажонова С.Б. Анализ состояния системы в металлургии. Монография. – Beau Bassin (Mauritius): LAP LAMBERT Academic Publishing, 2020. P. 189. ISBN 978-620-2-52763-7

[8] Modern Scientific Researches in Metallurgy: from Theory to Practice: monograph / Shokhrukh Khojiev (Ed.). - Beau Bassin (Mauritius): LAP LAMBERT Academic Publishing, 2020. P. 154. ISBN 978-613-9-47121-8

[9] Hojiyev Sh.T., Mirsaotov S.U. Oltin ishlab chiqarishda eritmani zararli unsurlardan tozalash usullari // “Ilm-fan taraqqiyotida zamonaviy metodlarning qo‘llanilishi” mavzusidagi ilmiy onlayn konferensiya to‘plami, Toshkent, 27-iyun, 2020. 442 – 446 b.

[10] Khojiev Sh.T., Kadirov N.A., Obidov B.M. Development of Alternative Fuel Production Technology by Recycling Polyethylene Bags up to 40 Microns Thick // Proceedings of an international scientific and technical online conference on “Challenges and Prospects Innovative Technics and Technologies in the Security Sphere Environment”, Tashkent, September 17-19, 2020. P. 274 – 276.

[11] Khojiev Sh.T. Improving Environmental Protection as a Result of Non-ferrous Metallurgy Industry Waste Recycling // Proceedings of an international scientific and technical online conference on “Challenges and Prospects Innovative Technics and Technologies in the Security Sphere Environment”, Tashkent, September 17-19, 2020. P. 278 – 280.

[12] Хожиев Ш.Т. Разработка эффективной технологии извлечения меди из конверторных шлаков// Journal of Advances in Engineering Technology, Vol.1(1), Sept, 2020. P. 50 – 56.

[13] Sh.T. Khojiev, A.A. Yusupkhodjaev, M. Rakhmonaliev, O.O’. Imomnazarov. Research for Reduction of Magnetite after Converting // Kompozitsion materiallar, Toshkent, 2019, №4. P. 54 – 55.

[14] Hojiyev Sh.T., Mirsaotov S.U. Tarkibida yaroqli uglerod saqlagan maishiy chiqindilarni metallurgiya sanoatiga maqsadli yo‘naltirish// “Ishlab chiqarishga innovatsion texnologiyalarni joriy etish va qayta tiklanadigan energiya manbalaridan foydalanish muammolari” mavzusidagi Respublika miqyosidagi ilmiy-texnik anjumanining materiallari to‘plami, Jizzax, 18-oktabr, 2020. 21 – 27 b.

[15] Hojiyev Sh.T., Mirsaotov S.U. Innovatsion texnologiya orqali metallurgiya sanoati chiqindisini qayta ishlash// “Ishlab chiqarishga innovatsion texnologiyalarni joriy etish va qayta tiklanadigan energiya manbalaridan foydalanish muammolari” mavzusidagi Respublika miqyosidagi ilmiy-texnik anjumanining materiallari to‘plami, Jizzax, 18-oktabr, 2020. 329 – 336 b.

[16] Хожиев Ш.Т. Экономическая эффективность использования местных и альтернативных энергетических ресурсов для снижения расхода природного газа на металлургических предприятиях // Материалы республиканской научно-технической конференции «Инновационные разработки в сфере науки, образования и производства – основа инвестиционной привликательности нефтегазовой отрасли» в г. Ташкент, 3 ноября 2020 г. С. 413 – 416.

[17] Khojiev Sh.T., Matkarimov S.T., Narkulova E.T., Matkarimov Z.T., Yuldasheva N.S. The Technology for the Reduction of Metal Oxides Using Waste Polyethylene Materials // Conference proceedings of "Metal 2020 29th International Conference on Metallurgy and Materials", May 20 – 22, 2020, Brno, Czech Republic, EU. P. 971-978.

[18] Hojiyev Sh.T., Berdiyarov B.T., Mirsaotov S.U. Mis ishlab chiqarishning chiqindisiz texnologiyasini ishlab chiqish muammolari // "Zamonaviy kimyoning dolzarb muammolari" mavzusidagi Respublika miqyosidagi xorijiy olimlar ishtirokidagi onlayn ilmiy-amaliy anjumani to'plami, Buxoro, 4-5 dekabr, 2020. 26 – 28 b.

[19] Berdiyarov B.T., Hojiyev Sh.T., Mirsaotov S.U. Rangli metallurgiya chiqindilarini qayta ishlashning dolzarbligi // "Zamonaviy kimyoning dolzarb muammolari" mavzusidagi Respublika miqyosidagi xorijiy olimlar ishtirokidagi onlayn ilmiy-amaliy anjumani to'plami, Buxoro, 4-5 dekabr, 2020. 61 – 62 b.

[20] Obidov B.M., Hojiyev Sh.T., Mirsaotov S.U. Polietilen paketlari chiqindisi ikkilamchi uglevodorod manbai sifatida // "Zamonaviy kimyoning dolzarb muammolari" mavzusidagi Respublika miqyosidagi xorijiy olimlar ishtirokidagi onlayn ilmiy-amaliy anjumani to'plami, Buxoro, 4-5 dekabr, 2020. 63 – 64 b.

[21] Каримжонов Б.Р., Бердияров Б.Т., Маткаримов С.Т., Хожиев Ш.Т. Анализ современного состояния переработки цинксодержащих сталеплавильных пылей // "Zamonaviy kimyoning dolzarb muammolari" mavzusidagi Respublika miqyosidagi xorijiy olimlar ishtirokidagi onlayn ilmiy-amaliy anjumani to'plami, Buxoro, 4-5 dekabr, 2020. 65 – 66 b.

[22] Khojiev Shokhrukh, Berdiyarov Bakhriddin, Mirsaotov Suxrob. Reduction of Copper and Iron Oxide Mixture with Local Reducing Gases. Acta of Turin Polytechnic University in Tashkent, 2020, Vol.10, Iss.4. P. 7-17.

[23] Мирзараимов З.А., Хожиев Ш.Т., Муносибов Ш.М., Муносибов Ш.М., Ирсалииева Д.Б. Восстановление зубьев вала шестерни мельницы МШР 2700×3600 в условиях АО «АГМК» цеха ЦРМЗ // Образование и наука в XXI веке, 10 (4), 2021. С. 347 – 363.

[24] Alamova G.Kh., Khojiev Sh.T., Okhunova R.Kh. Current State Of Copper Smelting Slags And Their Processing: A Review. Central Asian Journal of Literature, Philosophy and Culture, 2021, 02(02). P. 49-55.

[25] Alamova G.Kh., Khojiev Sh.T., Okhunova R.Kh. Comparative Estimation of the Efficiency of Various Materials in the Reduction of Magnetite in Slag Melt. International Journal for Innovative Engineering and Management Research, 2021, 10(03). P. 191-196.

[26] Хожиев Ш.Т., Эргашева М.С. Изучение гарнисажа образовавшегося на внутренней кладке кислородно-факельной печи при плавке сульфидных медных концентратов. ОБРАЗОВАНИЕ И НАУКА В XXI ВЕКЕ, 2021, 11(2). С. 67-73.

[27] Аламова Г.Х., Хожиев Ш.Т., Охунова Р.Х. Термодинамический анализ процесса восстановления феррита меди в присутствии паров аммиака. ОБРАЗОВАНИЕ И НАУКА В XXI ВЕКЕ, 2021, 11(2). С. 317-322.

[28] Аламова Г.Х., Хожиев Ш.Т., Охунова Р.Х. Некоторые термодинамические аспекты восстановления оксидов меди и железа парами аммиака. ОБРАЗОВАНИЕ И НАУКА В XXI ВЕКЕ, 2021, 11(2). С. 323-327.

[29] Аламова Г.Х., Хожиев Ш.Т., Охунова Р.Х. Изучение первопричины потери меди со шлаками. ОБРАЗОВАНИЕ И НАУКА В XXI ВЕКЕ, 2021, 11(2). С. 328-332.

[30] Аламова Г.Х., Хожиев Ш.Т., Охунова Р.Х. Исследование формы нахождения цветных металлов в промышленных шлаках. ОБРАЗОВАНИЕ И НАУКА В XXI ВЕКЕ, 2021, 11(2). С. 333-340.

[31] Аламова Г.Х., Хожиев Ш.Т., Охунова Р.Х. Изучение диаграммы состояния многокомпонентной шлаковой системы. ОБРАЗОВАНИЕ И НАУКА В XXI ВЕКЕ, 2021, 11(2). С. 341-350.

[32] Alamova G.Kh., Jo'raev Sh.Sh., Rakhimov N.S., Khojiev Sh.T. Kinetics of Carbon-Thermal Reduction of Magnetite. Студенческий вестник: электрон. научн. журн., Часть 3, 2021, 8(153). С. 60-62.

[33] Alamova G.Kh., Rakhimov N.S., Jo'raev Sh.Sh., Khojiev Sh.T. Use of Waste Automobile Tires as a Reducing Agent in Metallurgy. Студенческий вестник: электрон. научн. журн., Часть 3, 2021, 8(153). С. 63-65.

[34] Alamova G.Kh., Rakhimov N.S., Jo'raev Sh.Sh., Khojiev Sh.T. Reduction of Volatile Metal Oxides. Студенческий вестник: электрон. научн. журн., Часть 3, 2021, 8(153). С. 69-71.

[35] Alamova G.Kh., Nazarova Z.S., Khojiev Sh.T., Okhunova R.Kh. Advantages of the Sulfide Concentrate Smelting Process in a Liquid Bath. Студенческий вестник: электрон. научн. журн., Часть 3, 2021, 8(153). С. 66-68.

[36] Rakhmataliev Sh.A., Kadirov N.A., Khojiev Sh.T. Lead Smelting Slag Processing. "Ilm-fan va ta'limda innovatsion yondashuvlar, muammolar, taklif va yechimlar" mavzusidagi 9-sonli respublika ilmiy-onlayn konferensiyasi materiallari to'plami. Farg'ona, 28-fevral, 2021-yil, 2-qism. 23-26 b.

[37] Hojiyev Sh.T., Mirsaotov S.U., Ergasheva M.S. Metall oksidlarini amminotermik tiklashning ba'zi termodinamik jihatlari // UzACADEMIA: scientific-methodical journal, Vol. 2, Issue 1(12), 2021. P. 6-16.

[38] Khojiev S.T., Nuraliev O.U., Berdiyarov B.T., Matkarimov S.T., Akramov O‘.A. Some thermodynamic aspects of the reduction of magnetite in the presence of carbon // Universum: технические науки: электрон. научн. журн., Часть 3, 2021. 3(84). P. 60-64. DOI - 10.32743/UniTech.2021.84.3-4

[39] Khojiev Sh.T., Berdiyarov B.T., Alamova G.X., Abjalova H.T. Application of Energy-Saving Technology in The Smelting of Copper Sulfide Concentrates in Autogenous Processes // International Journal of Academic and Applied Research, 5(3), 2021. P. 30-33.

[40] Shokhrukh Khojiev, Bakhriddin Berdiyarov, Dilfuza Yavkochiva, Jahongir Abduraimov. Study of the Factors Influencing the Decoppering Process of Non-Ferrous Metallurgy Slags: A Review // International Journal of Academic and Applied Research, 5(3), 2021.P. 84-93.

[41] Ergasheva M.S., Mirsaotov S.U., Khojiev Sh.T. Use of Zinc Plant Clinker as a Reducing Agent in The Processing of Copper Slags // European Scholar Journal, Vol. 2, Issue 3, 2021. P. 218-222.

[42] Yusupkhodjaev A.A., Khojiev Sh.T., Valiev X.R., Saidova M.S., Omonkhonov O.X. Application of Physical and Chemical Methods for Processing Slags of Copper Production // International Journal of Advanced Research in Science, Engineering and Technology. Vol. 6, Issue 1, January 2019. pp. 7957 – 7963.

[43] Khojiev Sh.T. Pyrometallurgical Processing of Copper Slags into the Metallurgical Ladle // International Journal of Advanced Research in Science, Engineering and Technology. Vol. 6, Issue 2, February 2019. pp. 8094 – 8099.

[44] M.M. Yakubov, A.A. Yusupxodjayev, Sh.T. Hojiyev. Eritish jarayonida misning shlak bilan isrofini kamaytirish yo’llari // Kompozitsion materiallar. Toshkent, 2017, №1. 18 – 19 b.

[45] A.A. Yusupkhodjayev, Sh.T. Khojiyev. Methods of decreasing of Copper loss with Slag in Smelting Processes// International Academy Journal Web of Scholar. Kiev, March 2017, № 2(11), Vol. 1, PP. 5 – 8.

[46] A.A. Yusupkhodjaev, Sh.T. Khojiev, B.T. Berdiyarov, D.O. Yavkochiva, J.B. Ismailov. Technology of Processing Slags of Copper Production using Local Secondary Technogenic Formations// International Journal of Innovative Technology and Exploring Engineering, Volume-9, Issue-1, November 2019. P. 5461 – 5472.