International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 6 Issue 4, April - 2022, Pages:74-79

Study of Metallurgical Analysis of the Process of Recovery of Chalcopyrite with Minerals and Metals

Toshpulatov D.D.[1], Khojiev Sh.T.[1], Rakhmatalev Sh.A.[1], Berdiyarov B.T.[1]

[1]Tashkent State Technical University, Tashkent, Uzbekistan
E-mail: hojiyevshohruh@yandex.ru

Abstract— *It is not known how the name of the mineral came to be. It is believed to be related to the name of a place called Magnesia (in Macedonia) or to the name of the shepherd Magnes. Synonym: magnetic ironstone. Singoniya kubik. The color is black as iron. The line is black. Its luster is like metal. Hardness - 5.5-6 Specific gravity 4.9 - 5.2 Strength - brittle Connection plane - no. Origin, association, deposits, practical significance. In igneous rocks it is in the form of sparse grains. Magnetite is found in small amounts in many pegmatite veins. Contact is more common in metasomatic and hydrothermal conditions. The formation of magnetite under exogenous conditions can occur only under specific conditions. The main component of the black sands that can be washed from the golden sands is magnetite. Aluminothermy, alyumo-thermal (aluminum and Greek therme - heat) - a method of obtaining metals and alloys by returning metal oxides with aluminum; When a powder mixture of a metal oxide and a metallic aluminum is heated to a high temperature, a heat of up to 3000 °C is released, and the iron is easily recovered from its oxide due to the excess heat released. If a wire is stretched by mixing aluminum and iron oxides (FeO + Fe_2O_3), the course of a very intense exothermic reaction has been studied several times in practice. This process is widely used in the welding of train rails:* $8Al + 3Fe_3O_4 = 4Al_2O_3 + 9Fe + 3300$ kJ. As a result of the reaction, the mixture is heated to 3500 ° C. Therefore, recovery processes with aluminum are autogenous processes.

Keywords— metallurgy, man-made waste, aluminum, acid, processing, magnetite, ironstone, thermodynamic changes.

1. INTRODUCTION

Magnetite Fe, Fe_3O_4

It is not known how the name of the mineral came to be. It is believed to be related to the name of a place called Magnesia (in Macedonia) or to the name of the shepherd Magnes. Synonym: magnetic ironstone.

Singoniya kubik.

The color is black as iron. The line is black. Its luster is like metal.

Hardness - 5.5-6

Specific gravity 4.9 - 5.2

Strength - brittle Connection plane - no.

Origin, association, deposits, practical significance. In igneous rocks it is in the form of sparse grains. Magnetite is found in small amounts in many pegmatite veins. Contact is more common in metasomatic and hydrothermal conditions. The formation of magnetite under exogenous conditions can occur only under specific conditions. The main component of the black sands that can be washed from the golden sands is magnetite. Martinization of magnetite only in certain places is also found in metamorphic deposits, which are not associated with exogenous processes. Magnetite occurs in association with sulfides (pyrrhotite, pyrite, chalcopyrite), biotite, sphene, apatite and other minerals. Deposits Temirkon (Uzbekistan), Magnitnaya gora Kusinsk (Russia). Doshkesan (Azerbaijan), Krivoy Rog (Ukraine), Kirunavaara and Lyuossovaara (Sweden). Magnetite ores, often containing about 60% Fe, are important raw materials for cast iron and steel.

Aluminothermy, alyumo-thermal (aluminum and Greek therme - heat) - a method of obtaining metals and alloys by returning metal oxides with aluminum; When a powder mixture of a metal oxide and a metallic aluminum is heated to a high temperature, a heat of up to 3000 °C is released, and the iron is easily recovered from its oxide due to the excess heat released. This method was discovered in 1859 by the Russian chemistry N. N. Beketov (1827–1911). Manganese, chromium, vanadium, tungsten and various alloys are obtained by aluminothermy method. A mixture of 8 moles of aluminum and 3 moles of magnetite (Fe_3O_4) is called termite, which is sometimes used to weld metals. If a wire is stretched by mixing aluminum and iron oxides (FeO + Fe_2O_3), the course of a very intense exothermic reaction has been studied several times in practice. This process is widely used in the welding of train rails [1-10]:

$$8Al + 3Fe_3O_4 = 4Al_2O_3 + 9Fe + 3300 \text{ kJ}$$

As a result of the reaction, the mixture is heated to 3500°C. Therefore, recovery processes with aluminum are autogenous processes.

Metallic aluminum can also be used in the separation of non-ferrous metals. However, due to the high cost of aluminum, many metal oxides may not be economically viable. This situation requires metallurgists to look for cheap and secondary sources of aluminum. The results of chemical and mineralogical analysis of man-made wastes of aluminum showed that the slags formed in the secondary aluminum metallurgy contain powdered metallic aluminum.

2. STUDY THE POSSIBILITIES OF THE PROCESS OF OXYGENATION OF CHALCOPYRITE WITH MAGNETITE

In the process of studying the chemical properties of magnetite, its ability to oxidize and regenerate chalcopyrite made it possible to obtain pure metal. Several studies have been conducted to study the possibility of the recovery of chalcopyrite with magnetite. The chemical reaction equation for the process taking place in the system:

$$CuFeS_2 + Fe_3O_4 = Cu + 4FeO + 2S$$

The thermodynamic values of the starting materials are given in Table 1.

Table 1

Appropriate thermodynamic quantities of substances (298 K)

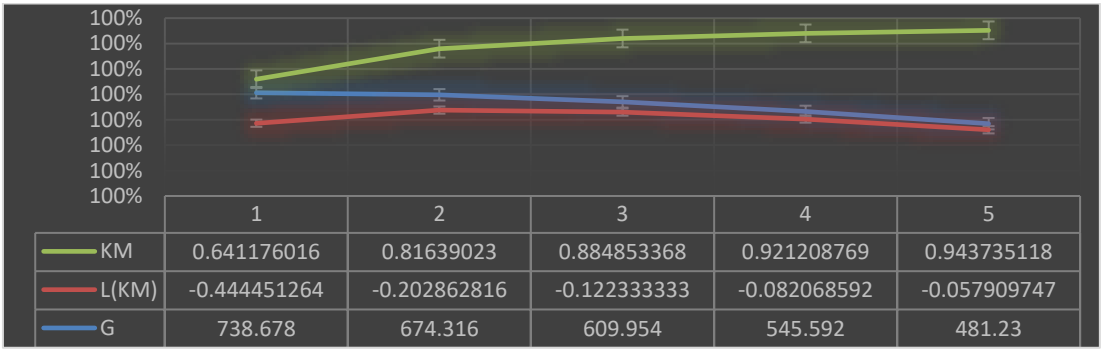
Substance	$CuFeS_2$	Fe_3O_4	Cu	FeO	S
ΔH (kJ/mol)	-188.3	-1117.13	0	-265	278.81
ΔG(kJ/mol)	-194.1	-1014.17	0	-244	238.31
ΔS(J/(mol*K))	143.8	146.19	33.1	60.8	167.75

$\Delta H^{298}_{Reaction}$=803.05 kJ $\Delta G^{298}_{Reaction}$=708.89 kJ $\Delta S^{298}_{Reaction}$=0.32181 kJ

From the results under standard conditions, it can be seen that the enthalpy value of the reaction is positive (endothermic), ie heat is absorbed as a result of the reaction. The value of the free energy of the reaction is also positive, which requires that the substances give the appropriate activation energy for the chemical reaction to take place. The values of the equilibrium constant from the Gibbs energy values are shown in Table 2 and in the diagram, along with how the increase in temperature affects the reaction rate after the substances have started to interact in the system [11-20]:

Table 2

H	S	T	R	G	L(KM)	KM
803,04	0,32181	200	8,31	738,678	-0,44445	0,641176
803,04	0,32181	400	8,31	674,316	-0,20286	0,81639
803,04	0,32181	600	8,31	609,954	-0,12233	0,884853
803,04	0,32181	800	8,31	545,592	-0,08207	0,921209
803,04	0,32181	1000	8,31	481,23	-0,05791	0,943735



When the thermodynamic possibilities of the oxidation of chalcopyrite with magnetite were studied, it was found that at 707°C (1000 K) the equilibrium in the chemical reaction shifted to the right, that is, to the product formation side.

In this case, the thermal processing of the raw material with magnetite prevents the contamination of the product with harmful (unnecessary) elements, as well as restores the copper metal in its pure form without additives.

3. STUDY OF THE THERMODYNAMICS OF THE PROCESS OF PURE PETROLEATION OF PURE PETROLEUM WITH ALUMINOTERMY

In the secondary metallurgical plants of aluminum production, the following compounds are found in the composition of salt slag from liquefaction furnaces: KCl - 22%; NaCl - 13%; Al_2O_3 - 34%; SiO_2 - 3.5%; CaO - 1.9%; MgO - 4.8%, Zn - 0.6%, CuO - 0.4%; metallic aluminum - 11%; Fe_2O_3 - around 2.6%. From these slags, metallic aluminum is extracted by dry grinding or by dissolving its salts in water, which is then used as a reducing agent. For example, chalcopyrite is recovered by aluminumotherm to obtain pure metallic copper and iron[21-25]:

$3CuFeS_2 + 4Al = 3Cu + 3Fe + 2Al_2S_3$

The thermodynamic possibilities of this chemical process have been studied .The thermodynamic quantities of the corresponding substances in the system are shown in Table 1.

Table-3

Some thermodynamic values of the reactants

Substance, (298 K)	$CuFeS_2$	Al	Cu	Fe	Al_2S_3
ΔH (kJ/mol)	-188.3	0	0	-	-724
ΔG(kJ/mol)	-194.1	0	0	-	0
ΔS (J/(mol*K))	143.8	28.34	33.1	27.15	0

According to Hess's law, the enthalpy and entropy values of a chemical reaction are calculated for standard conditions. The value of the free energy of the reaction is also positive, which requires that the substances give the appropriate activation energy for the chemical reaction to take place. The Gibbs energy values were calculated, and the values of change at this temperature at several temperatures are given in Table 2 and shown in the diagram[26-34]:

Table-4

H	S	T	R	G	L(KM)	KM
-883,1	-0,364	400	8,31	-737,5	0,221871	1,248411
-883,1	-0,364	600	8,31	-664,7	0,133313	1,142608
-883,1	-0,364	800	8,31	-591,9	0,089034	1,093118
-883,1	-0,364	1000	8,31	-519,1	0,062467	1,064459

From the values in Table 2, it can be seen that energy is released (i.e., exothermically) in a chemical reaction, and that the Gibbs energy value increases with increasing temperature. But the value of the equilibrium constant leads to a decrease. Because the reaction is exothermic, a decrease in temperature leads to an increase in the rate of the chemical reaction according to Le Chatelier's principle.

The process of magnetic separation is used to separate the components of the process. In this case, pure copper and iron metals are obtained. No harmful (unnecessary) elements are released during the process in the system and do not harm the environment [35-50].

4. REFERENCES

1. Обидов Б.М., Ҳожиев Ш.Т. Способ переработки цинксодержащих отходов металлургического производства // Заявка на изобретение № IAP 2019 0014, Официальный бюллетень Агентства по интеллектуальной собственности Республики Узбекистан. № 2(214). Ташкент, 2019. С. 27-28.
2. Юсупходжаев А.А., Ҳожиев Ш.Т., Акрамов У.А. Способ получения металлизированных окатышей // Заявка на изобретение № IAP 2019 0523, Официальный бюллетень Агентства по интеллектуальной собственности Республики Узбекистан. № 2(226). Ташкент, 2020. С. 29-30.
3. Abjalova H.T., Hojiyev Sh.T. Tarkibida uglerod saqlagan texnogen chiqindilarni metallurgiya sanoatiga maqsadli yo‘naltirish // “Fan va Texnika taraqqiyotida intellektual yoshlarning o‘rni” nomli Respublika online ilmiy-amaliy anjumanining ma’ruzalar to‘plami, Toshkent, 23-aprel, 2021, ToshDTU. 318 – 319 b.
4. Alamova G.X., Hojiyev Sh.T. Mis boyitmalarining issiqlik berish xususiyatini oshirish // “Fan va Texnika taraqqiyotida intellektual yoshlarning o‘rni” nomli Respublika online ilmiy-amaliy anjumanining ma’ruzalar to‘plami, Toshkent, 23-aprel, 2021, ToshDTU. 312 – 313 b.
5. Mirsaotov S.U., Hojiyev Sh.T. Mis ishlab chiqarishning kam chiqindili texnologiyasini ishlab chiqish // “Fan va Texnika taraqqiyotida intellektual yoshlarning o‘rni” nomli Respublika online ilmiy-amaliy anjumanining ma’ruzalar to‘plami, Toshkent, 23-aprel, 2021, ToshDTU. 314 – 315 b.
6. Yusupkhodjaev A.A., Khojiev Sh.T., Khayrullayev P.A. Technology for the complex processing of wastes of non-ferrous metallurgy // Proceedings of International Conference on Integrated Innovative Development of Zarafshan Region: Achievements, Challenges and Prospects, Navoi, November 28, 2019. P. 129 – 135.
7. Юсупходжаев А.А., Хожиев Ш.Т., Акрамов У.А. Использование нетрадиционных восстановителей для расширения ресурсной базы ОАО «Узметкомбинат» // Черные металлы, апрель 2021, № 4 (1072). С. 4 – 8. DOI: 10.17580/chm.2021.04.01
8. Alamova G.Kh., Khojiev Sh.T. Economic efficiency of using secondary energy resources in the industry // Texnika yulduzlari, 2021, №1-2. P. 294 – 298.
9. Alamova G.Kh., Khojiev Sh.T. Improving properties of molten copper slags // Texnika yulduzlari, 2021, №1-2. P. 301 – 305.
10. Alamova G.X., Hojiyev Sh.T. Mis boyitmalarining issiqlik berish xususiyatini oshirish // Texnika yulduzlari, 2021, №1-2. 305 – 310 b.
11. Alamova G.X., Hojiyev Sh.T. Metallurgik jarayonlarni matematik modellashtirish muammolari // Texnika yulduzlari, 2021, №1-2. 314 – 317 b.
12. Khojiev Sh.T., Ergasheva M.S., Khamroqulov Sh.F., Khamroev J.O’. The Current State of Copper Metallurgy and Its Raw Material Base // IJEAIS, 5(5), 2021. P. 7-14.
13. Karimova T.P., Khojiev Sh.T., Saidova M.S., Bakhodirova N.Q. To Prevent the Loss of Copper with Slag during the Casting of the Converter Slag // IJEAIS, 5(5), 2021. P. 15-22.
14. Berdiyarov B., Khojiev Sh., Rakhmataliev Sh., Suyunova M., Rasulova N. Modern Technologies of Aluminum Production // IJEAIS, 5(5), 2021. P. 100-105.
15. Mukhametdjanova Sh., Khojiev Sh., Rakhmataliev Sh., Avibakirov I., Mamatov M. Modern Technologies of Copper Production // IJEAIS, 5(5), 2021. P. 106-120.
16. Rakhmataliev Sh., Sultonov Kh., Khojiev Sh., Abdukholiqov A. Modern Technologies of Gold Production // IJEAIS, 5(5), 2021. P. 121-131.
17. Khojiev Sh.T., Berdiyarov B.T., Kadirov N.A., Obidov B.M. and Turan M.D. (2021) Utilization of household waste-based solid fuel // Technical science and innovation: Vol. 2021: Iss.1. P. 168-176.
18. Makhsudova L.T., Khojiev Sh.T., Shamaribkhodjaeva G.J., Annakulova N.K. The Practical Importance of the Use of Innovative Educational Technologies in the Teaching of Technical Sciences // IJAPR, 5(6), 2021. P. 55-63.
19. Khojiev Sh.T., Alamova G.X., Yavkochiva D.O. Application of energy-saving technologies in the autogenous processing of copper sulfide concentrates // International scientific and practical online-conference proceedings of “Innovative solutions to current problems in the field of highmolecular metallorganic compounds”, Part II, Tashkent, May 28, 2021. P. 183 – 185.
20. Khojiev Sh.T., Alamova G.X., Yavkochiva D.O. Application of energy-saving technologies in the autogenous processing of copper sulfide concentrates // Материалы международной научно-практической онлайн конференции «Проблемы, перспективы и инновационный подход эффективной переработки минерального сырья и техногенных отходов» в г. Алмалык, 27 мая 2021 г. С. 122 – 123.
21. Khojiev Sh.T., Berdiyarov B.T., Mirsaotov S.U. Development of low waste technology of copper production // Материалы международной научно-практической онлайн конференции «Проблемы, перспективы и инновационный подход эффективной переработки минерального сырья и техногенных отходов» в г. Алмалык, 27 мая 2021 г. С. 126 – 127.
22. Khojiev Sh.T., Matkarimov S.T., Akramov O‘.A. Complex processing of zinc-containing waste from non-ferrous and ferrous metallurgy // Материалы международной научно-практической онлайн конференции «Проблемы, перспективы и

инновационный подход эффективной переработки минерального сырья и техногенных отходов» в г. Алмалык, 27 мая 2021 г. С. 130 – 131.

23. Rakhmataliev Sh.A., Khojiev Sh.T., Berdiyarov B.T. Extraction pure silver from household waste // Материалы международной научно-практической онлайн конференции «Проблемы, перспективы и инновационный подход эффективной переработки минерального сырья и техногенных отходов» в г. Алмалык, 27 мая 2021 г. С. 154 – 155.
24. Khojiev Sh.T., Khamroev J.O'., Khamroqulov Sh.F. Complex use of raw materials in the production of non-ferrous metals // Материалы международной научно-практической онлайн конференции «Проблемы, перспективы и инновационный подход эффективной переработки минерального сырья и техногенных отходов» в г. Алмалык, 27 мая 2021 г. С. 100 – 101.
25. Khojiev Sh.T., Khamroqulov Sh.F., Khamroev J.O'. Increasing efficiency by partial changing the ore grinding process // Материалы международной научно-практической онлайн конференции «Проблемы, перспективы и инновационный подход эффективной переработки минерального сырья и техногенных отходов» в г. Алмалык, 27 мая 2021 г. С. 115.
26. Toshpulatov D.D., Khojiev Sh.T., Berdiyarov B.T. Analysis of Non-Ferrous Metallurgy Waste Processing Capacity // IJEAIS, 5(11), 2021. P. 41-50.
27. Rakhmataliyev Sh.A., Khojiev Sh.T., Kodirov N.A., Berdiyarov B.T., Rakhmonaliev M.M. Analysis of texnologies for processing lead-containing minerals // Proceedings of international scientific and scientific-technical conference on "Practical and Innovative Scientific Research: Current Problems, Achievements and Innovations (Dedicated to the memory of professor A.A. Yusupkhodjaev)", Tashkent, December 6, 2021. P. 185 – 186.
28. Toshpulatov D.D., Khojiev Sh.T., Berdiyarov B.T. Thermodynamic analysis of molybdenum dioxide acidical oxidation // Proceedings of international scientific and scientific-technical conference on "Practical and Innovative Scientific Research: Current Problems, Achievements and Innovations (Dedicated to the memory of professor A.A. Yusupkhodjaev)", Tashkent, December 6, 2021. P. 190 – 192.
29. Khojiev Sh.T., Toshpulatov D.D., Berdiyarov B.T., Ismailov J.B. Thermodynamic analysis of aluminothertic reduction of metal oxides // Proceedings of international scientific and scientific-technical conference on "Practical and Innovative Scientific Research: Current Problems, Achievements and Innovations (Dedicated to the memory of professor A.A. Yusupkhodjaev)", Tashkent, December 6, 2021. P. 207 – 208.
30. Хайруллаев П.Х., Маткаримов С.Т., Мухаметджанова Ш.А., Хожиев Ш.Т. Исследование возможности обогащения титаномагнетитовых руд Тебинбулакского месторождения // Proceedings of international scientific and scientific-technical conference on "Practical and Innovative Scientific Research: Current Problems, Achievements and Innovations (Dedicated to the memory of professor A.A. Yusupkhodjaev)", Tashkent, December 6, 2021. P. 276 – 278.
31. Khojiev Sh.T., Berdiyarov B.T., Karimova M.Sh. Processing of copper production dust // Proceedings of international scientific and scientific-technical conference on "Practical and Innovative Scientific Research: Current Problems, Achievements and Innovations (Dedicated to the memory of professor A.A. Yusupkhodjaev)", Tashkent, December 6, 2021. P. 377 – 379.
32. Rakhmataliyev Sh.A., Khojiev Sh.T., Kodirov N.A., Berdiyarov B.T., Gulomov I.I. Investigation of the kinetic possibilities of processing high-zinc-containing slags from lead production // Proceedings of international scientific and scientific-technical conference on "Practical and Innovative Scientific Research: Current Problems, Achievements and Innovations (Dedicated to the memory of professor A.A. Yusupkhodjaev)", Tashkent, December 6, 2021. P. 383 – 384.
33. Toshpulatov D.D., Khojiev Sh.T., Berdiyarov B.T. Study of the possibilities of the metallothermic reduction process of zinc ferrite // Proceedings of international scientific and scientific-technical conference on "Practical and Innovative Scientific Research: Current Problems, Achievements and Innovations (Dedicated to the memory of professor A.A. Yusupkhodjaev)", Tashkent, December 6, 2021. P. 386 – 388.
34. Rakhmataliyev Sh.A., Khojiev Sh.T., Kodirov N.A., Berdiyarov B.T., Shoazizov F.N. Recycling of lead production dust // Proceedings of international scientific and scientific-technical conference on "Practical and Innovative Scientific Research: Current Problems, Achievements and Innovations (Dedicated to the memory of professor A.A. Yusupkhodjaev)", Tashkent, December 6, 2021. P. 400 – 401.
35. Gulomov I.I., Khojiev Sh.T., Berdiyarov B.T., Rakhmataliyev Sh.A. Mis metallurgiyasida toshqol va chiqindilarni qayta ishlashning ahamiyati // Proceedings of international scientific and scientific-technical conference on "Practical and Innovative Scientific Research: Current Problems, Achievements and Innovations (Dedicated to the memory of professor A.A. Yusupkhodjaev)", Tashkent, December 6, 2021. P. 419 – 420.
36. Hojiyev Sh.T., Berdiyarov B.T., Abjalova H.T. Shlaklar bilan misning isrofini kamaytirish texnologiyasini tadqiq etish // Proceedings of international scientific and scientific-technical conference on "Practical and Innovative Scientific Research: Current Problems, Achievements and Innovations (Dedicated to the memory of professor A.A. Yusupkhodjaev)", Tashkent, December 6, 2021. P. 420 – 422.
37. Hojiyev Sh.T., Berdiyarov B.T., Muxametdjanova Sh.A. Sulfidli mis boyitmalarini oksidlovchi ishtirokida tanlab eritish tadqiqoti // "Mineral xomashyolar va texnogen chiqindilarni qayta ishlashda fundamental tadqiqotlar va amaliy ishlanmalar" nomli, professor M.M. Yakubovning 70 yillik yubileyiga bag'ishlangan respublika ilmiy-texnik anjumani ma'ruzalar to'plami, Olmaliq, 10-dekabr, 2021. 154 b.

38. Hojiyev Sh.T., Berdiyarov B.T., Muxametdjanova Sh.A., Toshpulatov D.D. Rux ferritini metallik rux bilan tiklanish jarayonining tadqiqoti // “Mineral xomashyolar va texnogen chiqindilarni qayta ishlashda fundamental tadqiqotlar va amaliy ishlanmalar” nomli, professor M.M. Yakubovning 70 yillik yubileyiga bag‘ishlangan respublika ilmiy-texnik anjumani ma’ruzalar to‘plami, Olmaliq, 10-dekabr, 2021. 155 b.
39. Hojiyev Sh.T., Berdiyarov B.T., Muxametdjanova Sh.A., Mamatov M.A. Sulfidli mis boyitmalarini oksidlash yo‘li bilan ulardagi misning konsentratsiyasini oshirish // “Mineral xomashyolar va texnogen chiqindilarni qayta ishlashda fundamental tadqiqotlar va amaliy ishlanmalar” nomli, professor M.M. Yakubovning 70 yillik yubileyiga bag‘ishlangan respublika ilmiy-texnik anjumani ma’ruzalar to‘plami, Olmaliq, 10-dekabr, 2021. 156 b.
40. Hojiyev Sh.T., Berdiyarov B.T., Muxametdjanova Sh.A., Hamroqulov Sh.F. Nanometallurgiyani rivojlantirishning muammolari // “Mineral xomashyolar va texnogen chiqindilarni qayta ishlashda fundamental tadqiqotlar va amaliy ishlanmalar” nomli, professor M.M. Yakubovning 70 yillik yubileyiga bag‘ishlangan respublika ilmiy-texnik anjumani ma’ruzalar to‘plami, Olmaliq, 10-dekabr, 2021. 157 b.
41. Рахматалиев Ш.А., Хожиев Ш.Т., Кадыров Н.А., Суюнова М.Н. Переработка свинец-содержащих отходов // “Mineral xomashyolar va texnogen chiqindilarni qayta ishlashda fundamental tadqiqotlar va amaliy ishlanmalar” nomli, professor M.M. Yakubovning 70 yillik yubileyiga bag‘ishlangan respublika ilmiy-texnik anjumani ma’ruzalar to‘plami, Olmaliq, 10-dekabr, 2021. 77-78 b.
42. Хожиев Ш.Т., Бердияров Б.Т., Рахматалиев Ш.А., Рахмоналиев М.М., Якубов А.О. Переработка цинксодержащих отходов // “Mineral xomashyolar va texnogen chiqindilarni qayta ishlashda fundamental tadqiqotlar va amaliy ishlanmalar” nomli, professor M.M. Yakubovning 70 yillik yubileyiga bag‘ishlangan respublika ilmiy-texnik anjumani ma’ruzalar to‘plami, Olmaliq, 10-dekabr, 2021. 79-80 b.
43. Berdiyarov B.T., Khojiev Sh.T. Thermodynamic analysis of reduction of oxidized copper compounds in a slag phase // Kompozitsion materiallar, 2021, №4. P. 39 – 43.
44. Toshpo‘latov D.D., Hojiyev Sh.T. Oksidlangan mis birikmalarini etil spirti bilan tiklab mis olishning termodinamik tahlili // Texnika yulduzlari, 2021, №4. P. 13 – 18.
45. Berdiyarov B.T., Xasanov A.S., Hojiyev Sh.T., Mutalibxonov S.S., Karimova Sh.K. Mis ishlab chiqarishning silikatli shlaklarini mahalliy tiklovchi moddalar bilan qayta ishlash jarayonining termodinamik imkoniyatlarini o‘rganish // Материалы II-Республиканской научно-практической конференции с участием зарубежных ученых «Инновационные разработки и перспективы развития химической технологии силикатных материалов», Ташкент, 19 января 2022 г. С. 432-434.
46. Бердияров Б.Т., Хасанов А.С., Исмоилов Ж.Б., Ҳожиев Ш.Т. Рух ишлаб чиқариш куйиндиларини қайта ишлаш технологиясини такомиллаштириш // Материалы II-Республиканской научно-практической конференции с участием зарубежных ученых «Инновационные разработки и перспективы развития химической технологии силикатных материалов», Ташкент, 19 января 2022 г. С. 434-437.
47. Hojiyev Sh.T., Berdiyarov B.T., Xasanov A.S., Ochildiyev Q.T. Xalkopirit mineralini oltingugurt bilan termik parchalash orqali hosil bo‘luvchi silikatli shlaklar miqdorini kamaytirish // Материалы II-Республиканской научно-практической конференции с участием зарубежных ученых «Инновационные разработки и перспективы развития химической технологии силикатных материалов», Ташкент, 19 января 2022 г. С. 556-558.
48. Ochildiyev Q.T., Xasanov A.S., Berdiyarov B.T., Hojiyev Sh.T. Metallarning shlak bilan mexanik isrof bo‘lish sabablarini o‘rganish // Материалы II-Республиканской научно-практической конференции с участием зарубежных ученых «Инновационные разработки и перспективы развития химической технологии силикатных материалов», Ташкент, 19 января 2022 г. С. 564-566.
49. Xasanov A.S., Ochildiyev Q.T., Berdiyarov B.T., Hojiyev Sh.T. Silikatli shlak tarkibidan rangli metallarni ajratib olish // Материалы II-Республиканской научно-практической конференции с участием зарубежных ученых «Инновационные разработки и перспективы развития химической технологии силикатных материалов», Ташкент, 19 января 2022 г. С. 568-571.
50. Хожиев Ш.Т., Бердияров Б.Т., Мухаметджанова Ш.А., Нематиллаев А.И. Некоторые термодинамические аспекты карботермических реакций в системе Fe-Cu-O-C // O‘zbekiston kimyo jurnali. – Toshkent, 2021, – №6. – С. 3 – 13.