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2015 IOP Conf. Ser.: Mater. Sci. Eng. 81 012051

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Effect of electric pulse processing on physical and chemical properties of inorganic materials

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Abstract.

This article analyzes various aspects of the practical application of electric pulse technology of industrial raw materials processing as a result of a spark electric discharge in a liquid solution of the raw material under processing. The object of the study are samples of technogenic materials from a deposit in Central Kazakhstan, which are crushed and ground to particles with a preset degree of fragmentation. The electric pulse processing is performed by using different numbers of discharges. The effect of electric pulse processing with different electrical parameters is carried out on the basis of comparison of the properties and structure of metal-containing and industrial raw materials after machining and electric pulse processing. The X-ray spectral microanalysis was performed using a scanning microscope. The researchers obtained data on changes in the microstructure and elemental composition of inorganic material samples as a result of electric pulse processing. It was established that the technology of electric pulse crushing and grinding of inorganic materials makes it possible to obtain not only a final product with desired size of dispersed particles, but also to change their physical and chemical properties.

1. Introduction

Kazakhstan has large deposits of ferrous and non-ferrous metals and is a major producer of iron and steel products. Increasing demand for metal-containing raw materials, on the one hand, and the requirements strengthening for environmental protection, on the other hand, required both improvement of ores and concentrates parameters and higher degree of utilization of secondary energy resources. Achieving high comprehensive utilization of raw materials is not possible without the development and implementation of methods and equipment to ensure the optimization of technological processes with high reliability [1-4].

The role of the enrichment processes increases in connection with processing of low-grade metal ores and accumulation of final tailings of mining and metallurgical production. The degree of metal content in the processed raw materials determines the index numbers of a metallurgical enterprise: productivity; labour costs; consumption of fuel, power, and auxiliary materials; loss of recoverable

metals and cost of final products, etc. The higher the metal content in the processed raw material, the more economical is its metallurgical processing net result. As a rule, ore enrichment is carried out by machining when only the ratio of the quantitative values between valuable minerals and waste rock changes in the feedstock and the final product.

In recent years, more and more studies are carried out on the development of technologies for inorganic materials enrichment aimed at increasing the degree of extraction of valuable components. For example, the development of technology for the extraction of gold and non-ferrous metals from technogenic structures composed of mature final tailings using gravitational, flotation, hydrometallurgical methods of enrichment [5, 6].

The works of the Institute of Geological Sciences named after K.I. Satpaev are well known as well. One of them is deals with the development of the device with mechanical and hydrodynamic high-frequency pulsating rotary aerator generating fluctuations within a narrow range of 2,4-3,4 kHz that makes possible almost 1.5-fold increase in the extraction of lead in lead concentrate.

In hydrometallurgy leaching procedure, electrolysis, chemical precipitation, adsorption, ion exchange, evaporation and flotation are used to extract metals from aqueous solutions and for the selective extraction of non-ferrous, rare and precious metals from ores, sludges, settlings or solutions. These methods are widely used in the process of waste recovery and wastewater treatment as well [4]. These data confirm the importance of the development and implementation of technologies for processing of inorganic materials not only to increase the output of precious and non-ferrous metals without the cost of developing new fields, but also to restore favorable environment in the areas of accumulation of process plants waste. This article discusses various aspects of use of a high-voltage spark discharge in a liquid medium.

2. Statement of the problem

Modern technologies of generating materials with desired properties a high-voltage electric discharge in a liquid medium is used as a powerful source of mechanical energy. The essence and distinctive feature of the electric pulse technology is that processing of ore and technogenic raw materials using strong energy pressure makes it possible to grind quickly and clear raw material from impurities and get enriched product with desired degree of fineness. That product can then be used directly in the production processes of metalworking. The electric pulse processing technology based on the unique effect of instantaneous energy release at the moment of electric discharge has huge unknown potentialities and unexpected effects [7]. Release of enormous energy in nearly pinpoint space of incompressible liquid medium is accompanied by a sharp rise of temperature and pressure and causes various physical and chemical processes, phase transformations and thermal kinetic phenomena. As a result, the structure and properties of the processed inorganic materials change.

The electrical discharge parameters and properties of liquids are the factors that determine the speed and amount of kinetic and thermal energy released in the area of electrical discharge. In this case, due to the intensive evaporation of the liquid in the area of electrical discharge and the steam expansion in the electric arc gap, a liquid compressional wave arises. The liquid compressional wave can be caused both by a single powerful electric discharge impulse and a series of successive impulses. The electric pulse fragmentation is an efficient method for grinding of various materials in order to obtain a product with a desired degree of fineness of a specific granulometric composition and has a high selectivity for fragmentation [8]. Possibility to control the energy level in the discharge channel and the duration of the energy release, i.e. changing the electrical pulse repetition rate in combination with electrode systems of various design make it possible to change the processing mode depending on the properties of the raw material. It is possible to change the granulometric composition of the product by varying the parameters of a single pulse or series of them during electric pulse disintegration of the material. [9] shows the possibility to affect the size of the resulting particulate product for mineral raw materials. The authors chose for the latter the copper-sandstone ore from Central Kazakhstan.

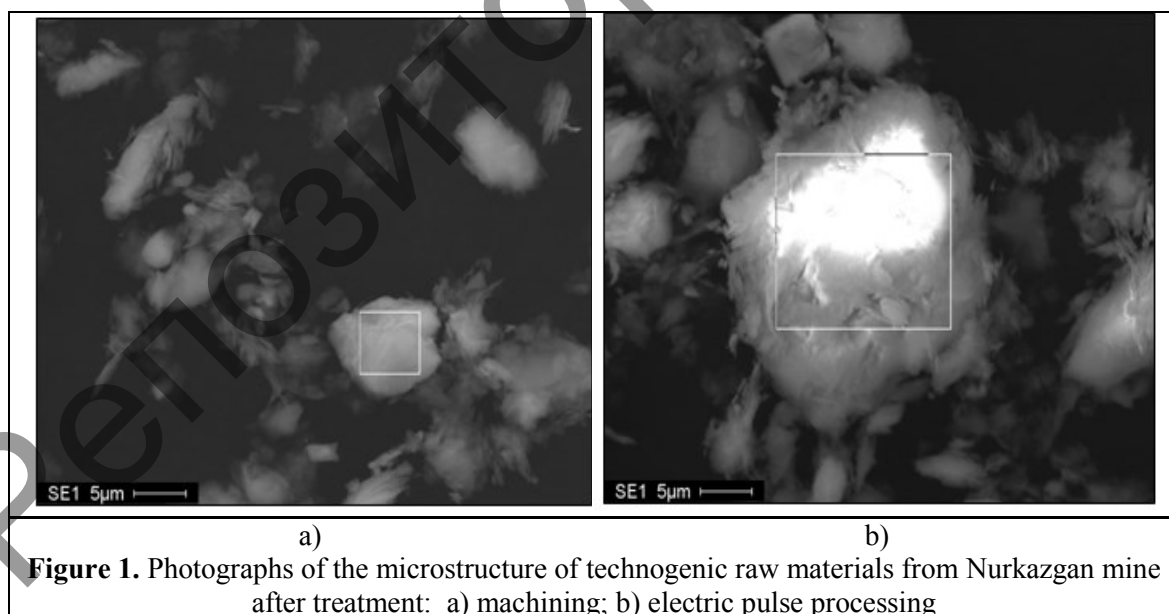
3. Experimental results and discussion

To ensure identical conditions, samples of the same raw material were ground by machining and electric pulse processing to a diameter of fragmented particles $(0.1-0.3) \cdot 10^{-3} m$. Within the framework of this project a vibrating cone crushing mill VCCM-6 (St. Petersburg) was used for mechanical crushing and grinding of samples of raw materials.

The operational blocks, functional principle and electro technical parameters of the electric pulse plant are described in detail in [8-10]. The electric pulse processing was carried out by changing the inter electrode distance within the range $l_d = 3 \div 14 \cdot 10^{-3} m$ while adjusting the values of supplied pulse voltage $U = 8 \cdot 10^3 V \div 40 \cdot 10^3 V$. The capacitance value of the capacitor bank varied within $C = (0,25; 0,5; 0,75) \cdot 10^{-6} F$. In order to ensure, the processing of each sample was carried out under the same conditions at least 5-7 times. In the course of the experiments the optimal capacitance value equal to $C = 0,5 \cdot 10^{-6} F$ was determined that provided maximum yield of the final product, crushed to desired sizes. For samples of raw material from the Nurkazgan mine the yield of the final particulate product was 37%.

Analysis of changes in the microstructure and properties of the start material composition after the electric pulse processing compared to machining was carried out using a scanning electron microscope Philips SEM 515 on the basis of the Scientific Center of Tomsk State University. The studies were performed in accordance with the standard procedure STR TSU N041-2009 "Procedure of research on the structure of a solid surface by scanning electron microscopy." Data on the elemental composition were obtained on the basis of the measurements of energy spectra, the mass concentration W,% and the atomic concentration A,%.

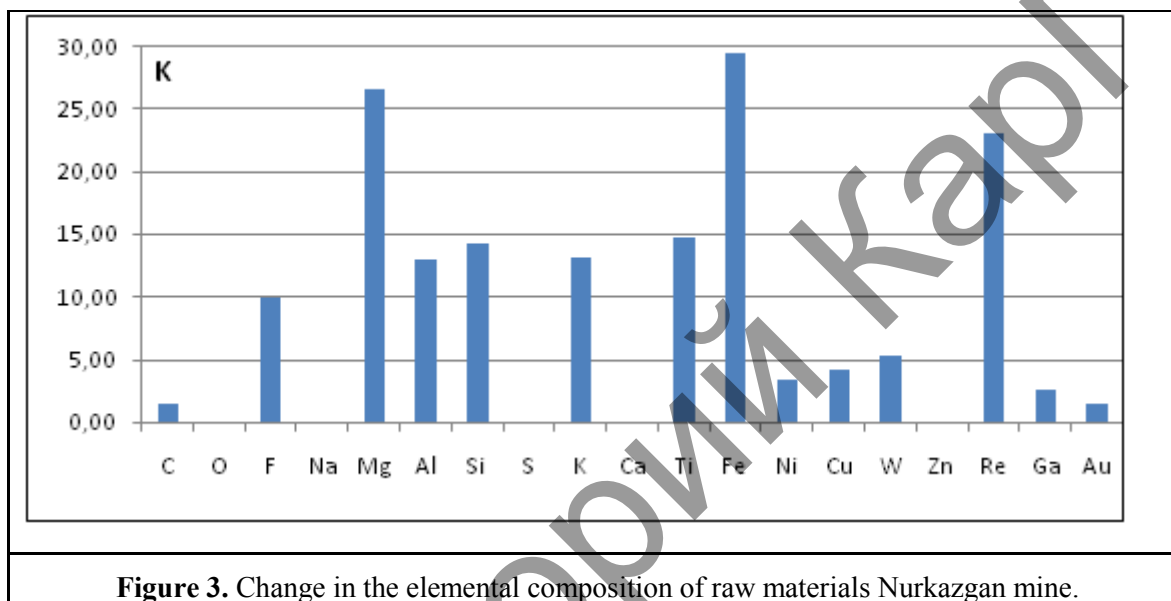
Figures 1 and 2 show photographs of the microstructure at a magnification by 101 times and energy spectra of the samples of industrial raw materials from Nurkazgan mine after treatment in a different ways.



The results of X-ray spectral microanalysis were obtained by using a rather known sufficiently accurate ZAF method, which includes three types of corrections in the data retrieval [11]. These corrections are represented in the title and indicate: Zi - correction for difference in an average atomic number between the sample and reference standard, it is due to reflection and deceleration of electrons; Ai - correction for the absorption of X-rays in the sample, it is determined by the energy of

The coefficient K is defined as the ratio of the mass concentration value of the element after the electric pulse processing $W_{ep}\%$ to the mass concentration values of the element after machining $W_m\%$. For these samples of the industrial raw materials from Nurkazgan mine it was found that as a result of electric pulse processing the percentage of magnesium increased by 26.50 times, the same of aluminum grew by 12.92 times, of iron – by 29.39 times, of copper – by 4.2 times.

More clearly the results are shown in the diagram of changes in the elemental composition of samples of raw material from Nurkazgan mine, Figure 3, which confirms the enrichment of the original product and possibility to extract some valuable components more efficiently.



The analysis confirms various changes both in the structure and elemental composition of the processed samples after the mechanical grinding and after electric pulse processing. Similar results were obtained for samples of industrial raw materials and "poor" ore from Annensk and Kushmurun deposits in Kazakhstan [9, 10].

These data confirm that the developed electric pulse technology for disintegration and grinding of metal-containing raw materials makes it possible to obtain a final product with desired properties such as parameters of granulometric composition and the degree of fineness, and to increase the percentage of particular elements.

4. Conclusion

This paper discusses the results of the use of electric pulse technology for enrichment of inorganic materials using the example of technogenic raw materials from Nurkazgan mine in Central Kazakhstan. The authors studied the effect of the electric pulse processing on the properties of inorganic materials on the ground of research on their structure and elemental composition after treatment.

The experimenters obtained data on the concentration rise of particular elements by several times. The experimental results provide an opportunity to draw a conclusion that the electric pulse processing makes it possible not only to crush and grind metal-containing and technogenic raw materials effectively, but also to enrich it, thus increasing the possibility to extract valuable components, including rare metals.

The results of these experiments provide an opportunity to elaborate the foundations for a new, knowledge-based electric pulse technology for processing of inorganic materials and mineral structures to implement them further at the processing industry enterprises.

The work was performed as part of the project №508-Ph 14 within the program No 055 of the Kazakhstan Republic Ministry of Education and Sciences

References:

- [1] Batrakova L H, Egeubaev B S, Edenbaev SS 2003 *Complex processing of mineral raw materials of Kazakhstan (state, problems, solutions)* Almaty 390
- [2] Usov AF 2001 Prospects technologies of destruction of rocks and ores. *Proceedings of the Academy of Sciences, Energy* vol. **1** pp. 54 – 62
- [3] Mamaev YA 1996 Scientific and methodological and technological basis for the rational development of gold-mining: Author. dis. Doctor. techn. Science MGG A Moscow 40
- [4] Kramarenko SA 2005 Processing of mature tailings of CMF "Ilyich MMP " *IMS NAS of Ukraine*, Kiev pp. 130-132
- [5] Kazakova Y, Novikov O N 2006 Patent 2006104513/02 (004898) RU. The method of extraction of metals.
- [6] Ivasishin OM, Oshkaderov SP, Spivakovskiy VB, Makovskaya GV et al. 2003 Patent of Ukraine 59062. Pulsation reactor.
- [7] Yutkin LA, Goltsova LI 1983 Method of crushing hard materials **Bi. 8**
- [8] Nussupbekov BR, Kussaiynov KA, Sakipova SE, Khassenov AK 2014 On the issue of improving the technology of complex extraction of rare and trace metals by electro-method. *Metal Physics and Advanced Technologies*. vol. **2 (36)** pp. 275-286
- [9] Kussaynov K, Sakipova SE, Nussupbekov BR, Aitpaeva ZK 2013 *Eurasian Physical Technical Journal* vol. **1(19)** pp.52-55
- [10] Kussaiynov K., Sakipova SE, Nussupbekov BR, Khassenov AK, Akhmerova KE 2014 Electro-pulse processing metal containing raw materials for extraction of valuable components. Int. Scientific Colloquium "Modeling for Electromagnetic Processing"- MEP 2014, Hannover pp.289-295.
- [11] Physical bases of X-ray spectral microanalysis. <http://lab.bmstu.ru/rem/index>