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CHANGES IN PROPERTIES OF METAL-CONTAINING RAW MATERIALS AS A RESULT OF ELECTRIC PROCESSING

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The article discusses the results of use of electric pulse technology for processing metal-containing raw materials. It shows the results of the analysis of the elemental composition of ore samples from Nurkazgan and Annensk deposits in Kazakhstan before and after electric pulse processing. The authors obtained data on changes in properties of the samples and on increase in weight concentration of some elements, including rare metals after the electric pulse processing. Application of electric pulse processing of metal-containing and technogenic raw materials makes it possible to obtain dispersion materials with preset parameters and it facilitates efficient extraction of valuable components. It was established that the electric pulse processing technology may be used in practice in enrichment process of metal-containing raw materials.

Keywords: metal-containing and technogenic raw materials, electric pulse processing, materials with preset parameters, enrichment process

INTRODUCTION

Improvement of the technique and technology of enrichment of raw materials has made it possible to significantly expand the raw material supplies base for industry and to implicate into processing the stocks of new deposits of precious, rare and non-ferrous metals. The relevance of the theme of this study is the fact that most of mined metal ores have relatively poor polymetallic content. The grade of valuable components in the ore is low. The total extraction of precious metals from the ore cannot be realized without the use of modern methods of enrichment, which is the main base in the production of non-ferrous metals and determines the effectiveness of processing of metal-containing raw material [1, 2]. It is necessary not only to increase metal extraction, but also to ensure the comprehensive utilization of technogenic materials. Therefore, improvement of the technological level and the development of new innovative processes in this important sector of non-ferrous metallurgy is of strategic importance for our country.

The analytical review showed that in the scientific publications there are studies on the use of electric hydro-pulse effect to improve the physical and chemical properties of highly viscous oil, those of uranium ore to extract uranium, as well as many rare and scattered elements from rocks. However, there are no published data on application of electric pulse effect during the enrichment process of mineral ores, metal-containing and technogenic raw materials. This article presents the results of a study of the effect of the electric pulse processing on the element composition and properties of technogenic raw materials from two deposits in Central Kazakhstan, called Nurkazgan and Annensk ones. These studies are a continuation of research on the changes in the properties of processed technogenic raw materials as a result of electric pulse effects presented in [3, 4] .

EXPERIMENTAL CONDITIONS

The essence and distinctive feature of the proposed technology is that processing of the ore and technogenic raw materials is performed by means of electro-hydraulic effect using pressure energy released when an electric discharge takes place in water. This makes it possible to get from technogenic raw milled and free of impurities material with a preset degree of dispersion, which can be used directly for further processing. The electric discharge parameters and properties of the liquids are the factors that affect the rate and amount of released kinetic and thermal energy in the electric discharge zone. At the same time, due to the intensive evaporation of the fluid in the electric discharge zone and steam expansion, a fluid compression wave arises in the electric arc gap. The fluid compression wave can be caused both by a single powerful electric discharge pulse, and by a series of successive pulses. The power of the electric discharge is increased by electric energy storage devices.

The processing medium in electro-hydraulic crushers can be any fluid, mainly it is service water. The physical processes accompanying the electrical discharge in aqueous solutions of disperse media, are described in [5, 6].

When passing through a liquid medium that is a moistened ore material, a powerful impulse causes an electrical breakdown, followed by hydraulic shock of great destructive power. The technical result is achieved due to the formation of a powerful shock wave between working electrodes dipped into the liquid in the chamber. The technical result is achieved due to the formation of a powerful shock wave as a result of an electric discharge between working electrodes dipped into the liquid in the chamber. At a powerful pulsed electric discharge there takes place an electric pulse effect, i.e. the rapid release of energy in the discharge channel increases the pressure in it and its further expansion causes a shock wave and fluid flows. The shock wave propagates along the grain boundaries and natural fissures of the rock at high speed, facilitating the efficient disclosure of grains of the mineral useful component [7-8]. It realized an intense force impact on the processed raw materials. The fluid flows that propagate at a velocity of $(10^2 \div 10^3) m/\sec$, transfer the kinetic energy to the processed object, like the shock wave causing mechanical changes in it.

After the intense fragmenting all fines in the form of high-dispersion rock particles are swept away in the drain, and heavy particles of rare metals remain in a set-in case. In the process of destruction and targeted disposal of gangue through the drain there is an increase in mass of valuable component in the circulating product. After the selective grinding, the shutter opens and the circulating product is let out in the concentrate through a branch pipe.

Figure 1 shows the dependence of the fineness degree of the metal-containing raw materials samples from two deposits on the electric discharge energy level. These results confirm that the electric pulse processing makes it possible to obtain effectively and quickly raw materials with the preset parameters of dispersed particles, as well as to change significantly the structure and properties of metal-containing and technogenic materials.

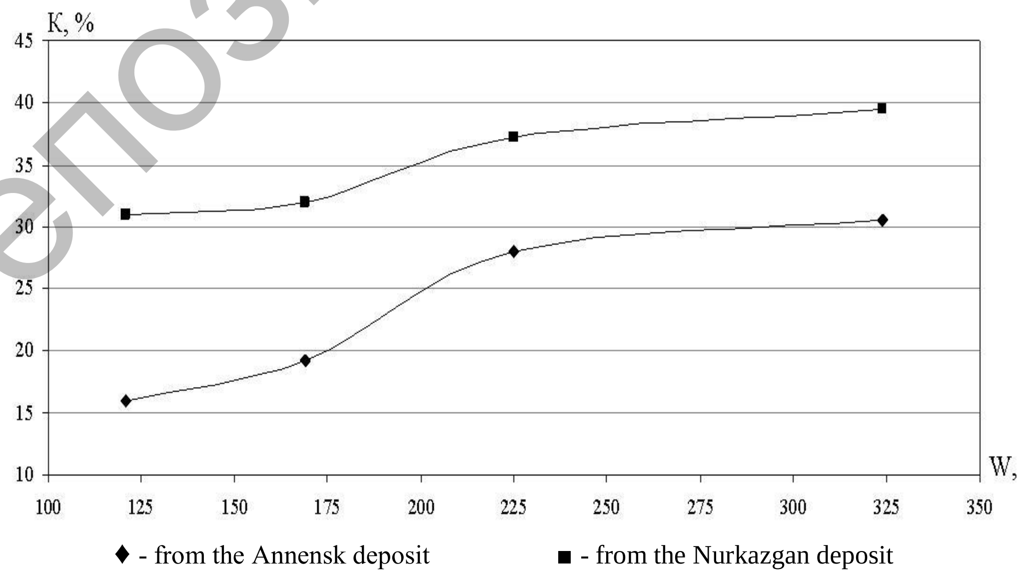


Fig.1. The dependence of the degree of ore fractions fineness on the discharge energy level

In the course of the experimental studies the experimentalists determined the optimal parameters of the equipment, providing a preset fineness degree of the initial technogenic raw from Annensk and Nurkazgan deposits.

The electric pulse processing was performed with the samples of dispersed particles with a diameter (d_{fr}) $7 \cdot 10^{-3}\, m$, $14 \cdot 10^{-3}\, m$ and $21 \cdot 10^{-3}\, m$. The processing time (τ_{proc}) was $360\sec$. The capacity of the capacitor banks ranged within $C = (0{,}25; 0{,}5; 0{,}75) \cdot 10^{-6}\, F$. In the experiments at fixed values of inter-electrode distance $l_d = 3 \div 14 \cdot 10^{-3}\, m$ the value of the supplied pulse voltage ranged within ($U = 8 \cdot 10^3 V \div 40 \cdot 10^3 V$). Tests at the laboratory setup were performed repeatedly (10-15 times) so as to ensure the reliability of the results. When the voltage at the spark discharger rises up to 30kV, the fineness degree of fine fractions to the size of the diameter within the range ($0{,}1 \cdot 10^{-4} \div 0{,}9 \cdot 10^{-3}\, m$) grows to 48 % of the total amount of the ore.

At a fixed value of the inter-electrode distance of the spark discharger $l_d = 10^{-3}\, m$, the fineness degree of the metal-containing ore uniformly changes, and the required weight fraction of the product increases to 70%. Therefore, this value of the inter-electrode distance of the spark discharger at the used setup is the most effective.

Subsequent electric pulse processing tests of samples of metal-containing and technogenic raw materials from the Annensk and Nurkazgan deposits were performed at the discharge energy level $(W = 65 \div 200\, J)$ and the value of capacitance of the capacitor bank $C = (0{,}25; 0{,}5; 0{,}75) \cdot 10^{-6}\, F$. It was established that with the increase in the capacitance of the capacitor bank, the fineness degree grows. In these experiments, the optimal capacitance value was C = $0{,}5 \cdot 10^{-6} F$, since the output of the final product, ground to the fraction size of 0.2 mm from the Annensk deposit was 26.7 % and from the Nurkazgan deposit it was 37 %.

SPECTRAL ANALYSIS RESULTS REVIEW

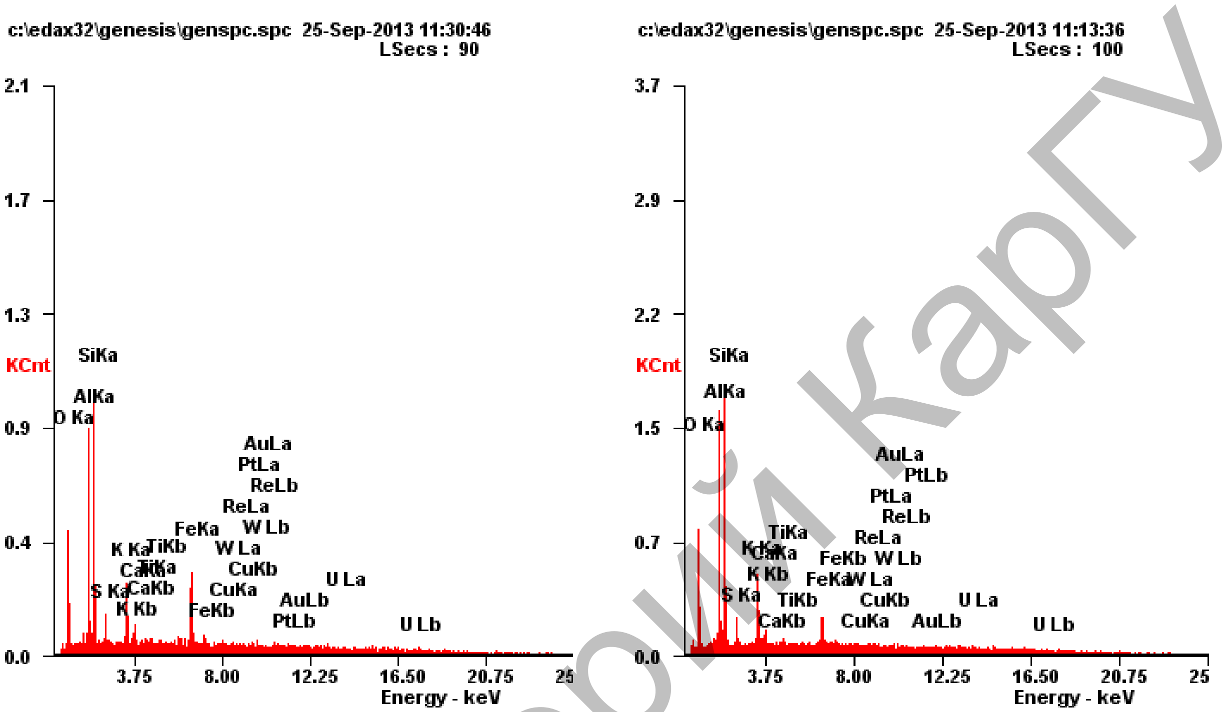
In the course of conducting this project the experimentalists investigated the microstructure of ore samples from Nurkazgan and Annensk mines before and after processing using the electric pulse method. They got results of spectral and elemental analyses of metal-containing and technogenic raw materials using a scanning electron microscope Philips SEM 515, performed on the basis of the Federal State Budget Institution of Higher Professional Education "National Research Tomsk State University". The studies were performed according to standard procedures STO TSU № 041-2009 "Methodology for studies of the solid surface structure by scanning electron microscopy." On the basis of performed measurements of weight concentration W,% and the atomic concentration A,% they obtained data on the elemental composition.

Figures 2 and 3 show the results of spectral and elemental analyses of metal-containing raw material samples from the Nurkazgan and Annensk mines before and after processing using the electric pulse method.

The comparative analysis of weight concentration in the initial and final ore samples from the Nurkazgan deposit shows an increase in the content of some elements, including rare metals after electric pulse processing. For example, in the ore samples from the Nurkazgan deposit percentage by weight W,% of aluminum increased from 13.33 % to 15.0%, of potassium from 3.79% to 4.35%, of copper from 0.40% to 0.54%, of tungsten from 0.63% to 0.89%, of rhenium from 0.99% to 1.44%, of gold from 1.13% to 1.41%. On the contrary, the percentage by weight of some metals decreased, for example, that of lithium, titanium, iron, platinum, etc.

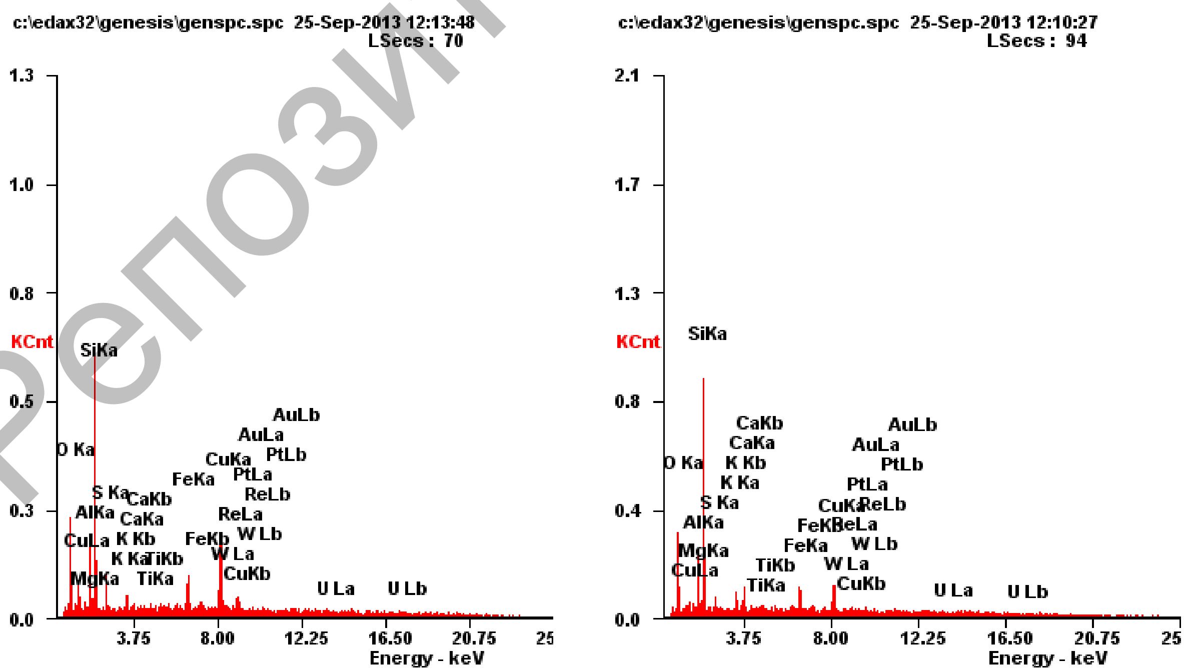
In the samples of raw materials from the Annensk mine magnesium (Mg) was detected, which was not found in the samples of the Nurkazgan deposit. The comparative analysis of obtained values of weight concentration in the initial and final samples of raw materials from the Annensk deposit shows a significant increase in copper from 8.59% to 16.25%, i.e. it almost doubled after the electric pulse processing.

In the latter samples it was also found an increase in percentage by weight of the following valuable elements: rhenium from 1.38% to 1.9%, platinum from 0.56% to 1.6%, gold from 0.91% to 1.05%, tungsten from 1.36% to 1.41%, sulfur from 1.69% to 2.85%, titanium from 0.4% to 0.58%.



a) b)

Fig.2. Energy spectra of samples of metal-containing raw materials from the Nurkazgan mine a) before and b) after the electric pulse processing



a) b)

Fig.3. Energy spectra of samples of metal-containing raw material from the Annensk mine a) before and b) after the electric pulse processing

One can note that in the samples of raw materials from Annensk deposit the content of aluminium and silicon has decreased, while in the samples from the Nurkazgan mine there has been observed an increase in their concentration after the electric pulse processing. At first glance, the experimentalists obtained a slight increase in the percentage of elements mentioned above. However, in terms of the equivalent amount of tons of processed metal-containing and technogenic materials in practice, it will significantly increase extraction of required elements.

CONCLUSION

Analyzed in the paper electric pulse method of ore and technogenic raw materials processing is based on use of energy of pulse shock wave initiated by an electric spark discharge in a liquid. It is experimentally shown that this method of electric pulse ragging is efficient, economical, environmentally friendly and can be automated. The electric pulse effect of underwater spark electric discharge results in destruction and grinding of minerals and contribute to more efficient extraction of valuable components, including rare metals. As a result of studies the authors prepared recommendations for determining optimal technical parameters of the equipment, the values of the inter-electrode distance and discharge energy at the switching device and other technical parameters of the equipment taking into account peculiarities of the processed technogenic raw materials. All this makes it possible to create a new, knowledge-based, competitive technology and to apply it in the processing industry in future.

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