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EFFECT OF ELECTRIC PULSE MACHINING ON THE QUALITY OF TECHNOGENIC RAW MATERIALS FROM AKSHATAU DEPOSIT

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The paper substantiates the advantages of electric pulse machining of ore and technogenic raw materials. It describes the major features of electric pulse technology, which uses the energy of shock wave pressure. We experimentally determined the optimal parameters of electric pulse device for efficient crushing of ore from Akshatau deposit. The paper presents the results of spectral analysis of technogenic raw materials before and after the electric pulse machining. It demonstrates that electric pulse machining can significantly increase the amount of copper and silver in the original raw materials.

Keywords: spark discharge, shock wave, electric pulse machining, technogenic raw materials, "bare" ore, enrichment.

Introduction

Kazakhstan known as a major industrial center in the field of heavy and non-ferrous metals production, is among the top ten copper producing countries in the world. The quantity of industrial waste and output of mined ore define requirements for processing methods. These methods should be simple in terms of technology and hardware and contribute to the degree of valuable components extraction complexity. The need to improve the parameters of non-ferrous metal ores and concentrates, stricter requirements to ecological environmental protection, higher degree of utilization of secondary energy resources require the development of new high technology, providing optimal technological processes and high reliability [1]. The article discusses the prospects of electrical pulse technology of industrial raw materials processing as an effective and environmentally safe method of enrichment. The proposed method of improving the ore grinding and its quality is based on the energy of an impulse shock wave resulting from an electrical spark discharge in liquid.

Statement of the problem

Practice shows that the majority of copper ore mined in mines in Kazakhstan, is a "bare" polymetallic rock, of which only a small part is suitable for direct processing of the steel metallurgical [2]. Therefore, a pre-processing of industrial raw materials through enrichment since basic indicators of a company such as productivity, labor costs, consumption of fuel, power and auxiliary materials, loss of recoverable metals, and cost of finished products depend on the content of metals in raw materials. The greater is metal content of the processed raw material, the more economical will be production of final products.

Mineral raw materials at the processing plant during the initial processing are subjected to a series of successive operations: preparatory, basic enrichment, auxiliary, such as dehydration, thickening and drying. To detect valuable components of the raw material and to obtain its required size (fineness), the ore is first subjected to crushing and grinding, and for mechanical separation of the resulting mixture by size classes it is subjected to screening operations [3-5]. When enriching the ores by mechanical methods of processing, the chemical composition remains unchanged, changing only the quantitative relation between the valuable minerals and waste rock in the original raw materials and product of enrichment.

After crushing, the ore is sent to a dry or wet grinding, which is the final operation in the cycle of preparation of ore for enrichment. The grinding process is performed using a drum mill, and then, the industrial raw material contains dispersed fractions of (0.2-5.0) mm particle size value mm. According to technical requirements, the size of the ground ore should be less than 1mm, since it is with these parameters the processed raw materials can be considered the concentrate and subjected to further processing

As a rule, ore dressing is performed by means of machining process, in which the chemical composition remains unchanged; by changing only the ratio between the quantitative values of valuable minerals and waste ore in the source raw materials and concentration product. Moreover, the known mechanical methods of processing ores and concentrates of rare, precious and non-ferrous metals and existing industrial plants require a lot of power, they do not provide a complete production of the pure product and are not efficient in terms of labour intensity.

Chemical methods of enrichment are various types of leaching (cyanoless leaching, heap leaching, underground leaching, etc.); they imply harmful chemical effects on the ecological condition of water and soil in the deposit area.

In the laboratory of Physics of pulse phenomena in heterogeneous media we developed electric pulse processing technology that made it to a certain extent possible to solve the problems of crushing and grinding of mineral raw materials to fractions of specified sizes. The developed technology is based on the known electro-hydraulic pulse effect (the effect of Yutkin) that allows you not only to grind various solid materials to a given degree of grinding, but also having a considerable impact on the elemental composition and properties of industrial materials.

Description of the experimental research technique

The schematic diagram of the electric pulse plant contains a control panel to monitor and manage the operation. Using it you can set various operation modes and control the process of operation. The electric schematic diagram of the control panel contains four single-mesh inductance-capacitance filters designed to filter high-frequency currents and amplitudes. The control panel of the plant provides settings to enable or disable the mode, adjusting the frequency of repetition of the discharge pulse at the air-gap arrester, signaling of the operating mode switching, the availability of voltage supply and the basic parameters control [6].

Electric pulse effect is obtained by electrical discharges in water; they are accompanied by almost instantaneous release of large amounts of energy in the area between the electrodes. The ability to use electrical power for the processing of natural and industrial raw materials making hydrodynamic disturbances, contributes to extend the applications of this technology. For example, at cold metal working, rock breaking, demulsification of liquids, intensification of chemical reactions, etc. [4-7] This unique effect of abnormal energy release at an electrical discharge in a liquid has a huge hidden potential and a broad scope of new useful unexpected beneficial applications due to high-speed gradient processes at high pressure. The distinctive feature of this process is that the conversion of electrical power into mechanical energy is performed without intermediaries; it increases the efficiency of the plant and provides reliable, durable performance. Of all the complex set of phenomena that occur at an electric discharge in a liquid, the direct transformation of electric energy into pressure energy of shock waves is used.

The essence of this method is that in a liquid medium, which is wetted ore, an electric breakdown accompanied by hydraulic shock of great destructive power is generated. Explosive phenomena pas and as a result of vibrations, they s through the body of a particle containing recoverable metals, and the resulting vibrations are separated from the mineral foundation. Emerging cavitation processes contribute to further increase in the pressure. Due to intensive evaporation of the liquid in the area of electrical discharge and steam expansion in the electric arc gap, a wave of liquid compression emerges.

The wave of liquid compression can be caused by the single driving force behind electric discharge and a series of successive pulses. The power of the electrical discharge is increased by electric power storage devices. The electrical discharge parameters and properties of liquids are the factors that affect the speed and the quantity of kinetic and thermal energy emitted in the area of electrical discharge. While conducting experiments we changed the value of the voltage at the switching device, the capacity of the condenser, the space between electrodes. During the experiments we determined the optimal conditions of the process: the processing time of 4 minutes, the 7-10 mm space between electrodes, the optimal fraction diameter d = 5 mm, installation with San resistance = 0.25 μF [8].

The distinctive feature of this process is that the conversion of electrical power into mechanical energy is performed without intermediaries; it increases the efficiency of the plant and provides reliable, durable performance. Of all the complex set of phenomena that occur at an electric discharge in a liquid, the direct transformation of electric energy into pressure energy of shock waves is used. The practical advantage of electric pulse technology is that it is possible to reduce energy consumption by 3-5 times while increasing the extraction of rare and precious metals in productive solutions and concentrates.

The advantage of electric pulse crushing devices is that they have no moving parts and in fact do not wear out in the process of operation. During the operation no dust is produced, they occupy a relatively small working space and admit the combination of processes of crushing, mixing and flotation of materials. The working media in the electro-hydraulic crushers can serve industrial water. The technological process of electric pulse crushing easily amenable to automation. The electric pulse technology can effectively crush and grind any solid material.

Discussion of the experimental results

The object of this study was the copper ore and industrial raw materials from deposits of Akshatau. Copper is one of the most precious and common non-ferrous metals. The most important and widely used properties of copper are its high thermal conductivity and low electrical resistance. Electrical industry is the largest consumer of copper. Copper is used for production of power cables, telephone and telegraph wires, and in generators, electric engines and switches [1-2]. In addition, copper is widely used in the manufacturing of various alloys such as brass, bronze and copper-nickel alloys, but also finds use in the automobile and construction industries. Copper reserves of Kazakhstan are 5.5% of world reserves (more than 37 million tonnes). Aqshatau is one of the largest copper ore deposit fields in Karaganda region. Therefore, the development and introduction of new innovative technologies for copper ore processing and industrial raw materials from deposits of nonferrous metallurgy is of strategic importance for our country.

To study the effect of electric pulse processing on qualitative and elemental composition of industrial raw materials an atomic emission (spectral) analysis of samples was held using a scanning electron microscope, the microprobe REMMA 2000. Table 1 shows the chemical composition of copper ore deposits in Akshatau before and after the electric pulse processing.

According to the results of the elemental analysis the content of Cu in copper ore after electric pulse processing is 8.8%, while the original content of copper in the ore was 7.27%. Quite a significant increase in content of copper of 21% can be attributed to oxidation-reduction reactions taking place during the crushing process:

$$CuFeS_2 + 4{,}25O_2 + 0{,}5(n+2)H_2O \rightarrow CuSO_4 + 0{,}5Fe_2O_3 \cdot nH_2O + H_2SO_4$$

The table shows that during the electric pulse processing of ore from the deposit field of Akshatau there also is a significant increase in the concentration of silver from 170.3 g/t to 223.1 g/t, representing an increase of 31%. Similarly, content of Ba increased by 32%, the content of Sr increased by 17% and the content of Fe increased by14%. On the contrary, the concentration of some elements after the electric pulse processing decreased: they are manganese, cobalt, zinc, cadmium, bismuth, etc.

Table 1. Data of the elemental analysis of copper ore deposits from Akshatau before and after the electric pulse processing

Chemical element	The content of elements in the ore,%	
	before processing	after processing
K	0,53	-
Mn	0,097	0,048
Co	0,094	0,046
Zn	10,98	7,13
Se	0,001	0,002
Sr	0,069	0,081 (+17%)
Mo	0,094	0,10
Ag	170,3 g/t	223,1 g/t (+31%)
Sn	0,002	0,002
Ba	4,18	5,50 (+32%)
Pb	3,36	3,02
Cr	0,052	0,036
Fe	24,77	28,34 (+14%)
Cu	7,27	8,80 (+21%)
As	0,35	0,44
Rb	0,004	0,003
Y	0,006	0,005
Pd	0,001	-
Cd	406,1 g/t	272,2 g/t
Sb	0,023	0,031
W	0,15	0,070
Bi	0,041	0,035

Conclusion

The electric pulse processing technology makes it possible to change not only the size distribution, but also the physical and chemical properties of industrial raw materials and wastes of mining industry. The analysis of the elemental composition of the industrial raw materials from Akshatau deposit field shows that the copper content after the electric pulse treatment increased by 21% compared to the content of copper in the initial ore and silver by 31%. Taking into account the scale of production, the increase in the content of valuable components can significantly improve the quality of the finished product.

It is experimentally proved that the electric pulse processing technology makes it possible to quickly and effectively crush and grind the original industrial raw materials up to fractions with the given parameters, greatly improving the quality of the products. There is no doubt that the implementation of the results of studies on enterprises will contribute to the technological progress in domestic industries and the establishment of resource-saving way to extract valuable components using electric pulse processing technology of industrial raw materials.

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