Igor Piotr KURYTNIK[1], **Bekbolat Rakishevich NUSSUPBEKOV**[2], **Ayanbergen Kairbekovich KHASSENOV**[2], **Dana Zhilkibaevna KARABEKOVA**[2], **Nazgul Kdyraliyevna TANASHEVA**[2]

Heat of Department of Process and Qualiity Engineering The W. Pilecki State University of Malopolska in Oswiecim, Poland (1), E.A. Buketov Karaganda state university, faculty of physics and technology (2)

doi:10.15199/48.2020.10.27

About an electric pulse method of grinding gold ore

Abstract. *The article deals with an electric pulse method for grinding gold-containing ore based on the use of pulsed shock wave energy resulting from an underwater spark discharge. The proposed method is the most appropriate in production conditions, since it allows you to effectively crush and grind the necessary materials to the desired size and control the granulometric composition of the finished product with high selectivity. The proposed technology reduces dust pollution during working hours.*

Streszczenie. *W artykule omówiono metodę rozdrabniania złotonośnej rudy w oparciu o wykorzystanie energii pulsacyjnej fali uderzeniowej powstałej w wyniku podwodnego wyładowania iskrowego.Proponowana metoda zapewnia skuteczne kruszenie do pożądanego rozmiaru oraz kontrolowanie rozkładu wielkości cząstek gotowego produktu z wysoką selektywnością. Opracowano układ elektryczny i określono optymalne parametry impulsów. Proponowana technologia zmniejsza pyłowe zanieczyszczenie środowiska pod czas pracy.* ***Metoda rozdrabniania rudy złota impulsami elektrycznymi***

Keywords: ore crushing, electrical pulses.
Słowa kluczowe: rozdrabnianie rudy, impulsy elektryczne.

Introduction

In the Republic of Kazakhstan, metallurgy of ferrous and non-ferrous metals is well developed. Each sub-industry of nonferrous metallurgy has significant reserve deposits. The non-ferrous metallurgy of the republic comprises a number of sources and enterprises: 40 operating underground and 30 open-pit mines, 21 concentration plants and 11 metallurgical plants [1, 2].

Mainly rocks and ores crushing and grinding processes in greater volume are produced by the mining and metallurgical industries, manufacturers of construction and road-building materials, etc. In this case, crushing and grinding plants are used to produce crushed-stone materials, cement articles, metal and non-metal natural minerals for further enrichment as well as grinding of the chemical industry products. In the processing of rocks, ores and solid materials, various crushers and standard mills are commonly used [3-7].

Improvement of the technology of enrichment of the raw material base of the industry makes it possible to expand and use for processing the reserves of new deposits of non-ferrous, noble and rare metals. As a rule, the content of noble components in the ores is very low, as well as in the concentrates extracted from the final tailings. In this regard, the complete extraction of valuable metals from ore is impossible without the use of modern technologies and methods of enrichment. To increase the degree of extraction of metals and ensure the integrated use of technogenic raw materials, the improvement of selective flotation is used, which is the main reserve in the production of non-ferrous metals and, to some extent, determines the success of metallurgical processing of concentrates [8-10].

The objective of this work is to develop a integrated electric pulse technology for the destruction of materials to extract valuable components from natural and technogenic materials.

The proposed method of grinding ore is based on the use of the energy of a pulsed shock wave resulting from a spark discharge in a liquid. The operating medium in electric impulse crushers is technical water. The main physical processes accompanying the electric discharge in liquid dispersion media were studied and described in [11, 12]. The electrical discharge in a liquid is accompanied by fast-flowing, high-gradient processes at high pressure. A distinctive feature of this process is that the conversion of electrical energy into mechanical energy takes place without intermediate links, which increases the efficiency of the plant and ensures reliable, durable operation [13].

The electric pulse plant and grinding features

As the results of experimental work show, the crushing and grinding method used is efficient, economical, environmentally friendly, and the crushing unit is easily integrated into the production line [14].

A distinctive feature of the proposed technology is that the processing of ore and technogenic raw materials using the energy of the shock wave released by electropulse effect makes for obtaining a product of the required size that is quickly crushed and purified from impurities, which can then be used directly for subsequent enrichment.

To obtain the optimal characteristics of crushing and grinding of gold-bearing ore and technogenic raw materials, a three-phase electric pulse plant (TEPP) using the Yutkin effect and a working node were developed and constructed in the "Electrohydrodynamics" laboratory of the physical-technical faculty of E.A. Buketov Karaganda State University [15].

The block scheme of a three-phase electric pulse plant (TEPP) is shown in Figure 1. Structurally, the plant consists of a high-voltage power supply HPS-25-8 (A1), a pulse capacitor with built-in protection unit (C1) and an operating commutation switch (FV1).

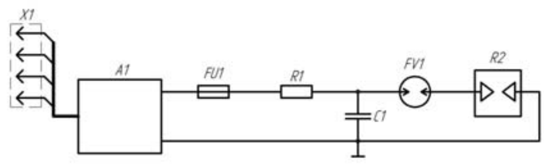

Fig.1. Block scheme of the electric pulse plant: A1 – a high-voltage power supply HPS-25-8, FU1 – a safety unit, C1 – a capacitor battery, FV1 – a commutation switch, R1 – a charging resistor (PEV-50-120), R2 – load or working channel, X1 – connector, a three-phase plug.

The high-voltage power supply (A1) is designed to charge a capacitive storage in various devices. In accordance with standard technical requirements, the charge-discharge circuit of a high-voltage power supply consists of a step-up power supply, a capacitor battery, a safety unit, an operational discharger, a charging resistor, and a load. The supply is a voltage regulator, made on the basis of an autonomous inverter. The constancy of the voltage on the storage capacitor is maintained by the control circuit using a feedback system. The high voltage supply uses a control circuit that provides for regulation, stabilization, voltage measurement of the power supply and limiting the maximum load current. Feedback to the regulator is provided from the voltage sensor.

The high-voltage part of the supply is arranged in a plastic box with dimensions of 190x130x70 mm. This box contains voltage multipliers, a resistive voltage divider, a current-limiting resistor. The purpose of the current-limiting resistor is to protect the high-voltage power supply from the effects of a reverse voltage wave with an amplitude of 25 kV, formed in the cable that connects the supply to the load. On the operating desktop of the control panel of the HPS-25-8 power supply, there are switches and a screen for regulating the control, elements of protection, switching and indication. The output power of this source is 8 kW, the maximum stored energy is 40 kJ.

Material and experimental technique

To carry out experimental work, we used natural ore from the deposits of Kazakhstan – Akbastau mine and technogenic raw materials of Akshatau ore [16].

In the most recent studies, the initial diameter of the ore was 20 mm, and that of technogenic raw materials it was from 1 to 3 mm. The initial parameters of ore and technogenic raw materials are selected for purposes of energy saving for preliminary grinding of large pieces of material. In the course of the experiment, the preset value of the crushed ore and technogenic raw materials was chosen to be 0.2 mm.

Previously, all the experimental work on the crushing and grinding of various ores (for example, the ores of the Annensky, Nurkazgansky deposits) in the "Electrodynamics" laboratory was carried out using a single-phase electrohydraulic pulse setting (Iskra-M). Optimum regimes for the setting were obtained. However, this setting does not make for complete grinding of the ore with an initial diameter of 20 mm or more [16].

In this regard, the subsequent experiments were carried out using a three-phase electric pulse plant (TEPP) and the results obtained were compared with data obtained using Iskra-M.

To select the optimal operating parameters of TEPP electric pulse plant,, crushing and grinding of materials were carried out at different parameters of capacitance (C) of capacitor batteries (0.25-1.05 μF) and interelectrode distance (lp) at the switching device (8-14 mm). The effectiveness of the crushing and grinding regime was determined by the mass content of the obtained fractions.

Results and discussion

The results of experimental tests carried out using the electric pulse plant with a high-voltage power supply (HPS-25-8), it was found that the grinding degree of Akbastau ore with an initial diameter of 20 mm, with a capacitor battery capacity of 0.25 μF was 2,7%, 0.4 μF – 7.1%, 0.65 μF – 12.3%, 0.8 μF – 13.2%, and 1.05 μF – 15.2%.

Further experiments were carried out at different values of the interelectrode distance at the switching device. Figure 3 shows that the smaller the initial diameter of the fraction, the higher the product yield. With an increase in the interelectrode distance at the switching device, l_p=8□14 mm ground to 0.2 mm in constant values of the capacitor battery capacitance C=0.8 μF and the number of pulse discharges N=1000 increased in the following range: the Akbastau ore with an initial diameter of 15 mm – K:=9□16.3% [16], 20 mm – K:=7□13.7% (Iskra-M), 20 mm – K:=11□16.5% (TEPP).

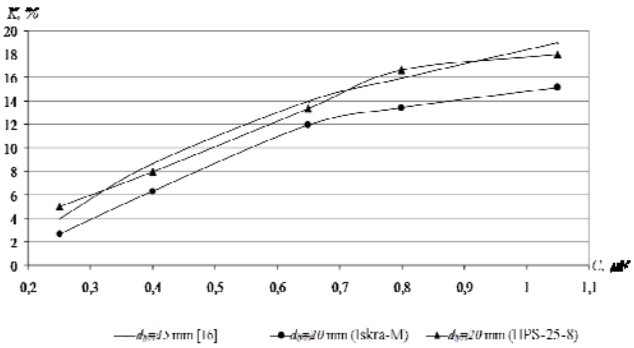

Fig. 2. Dependence of the grinding degree of Akbastau ore (up to 0.2 mm) on the capacity of capacitor batteries

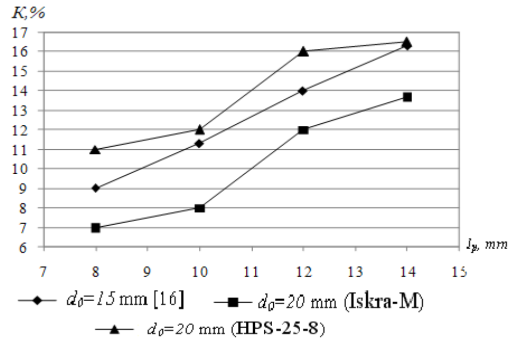

Fig. 3. Dependence of the grinding degree of Akbastau ore (up to 0.2 mm) on the discharge energy and on the interelectrode distance at the switching device of the TEPP

With fixed parameters of the electric pulse plant (the number of pulse discharges *N=1000*, capacitor battery capacitance *0.65 μF*, the interelectrode distance at the switching device l_p*=12 mm*), technogenic raw materials of Akshatau ore are ground and materials obtained in the following particle size distribution: 0.063 mm; 0.2 mm; 0.7 mm (Table 1).

Table 1. The dependence of the grinding degree of Akshatau technogenic raw materials (ground 0.063□0.7 mm) from the initial diameter of the material

Initial diameter of fraction (d0, mm)	The diameter of the fraction of the obtained product by the electric pulse method (d, mm)		
	0,063 мм	0,2 мм	0,7 мм
	Degree of grinding of Akshatau technogenic raw materials (K, %)		
1	35,6	38	24
3	28	33	36,4

In this case, the initial technogenic raw material was ground completely and the percentage of the ground product was 92%.

Conclusion

Based on the above data, we can draw the following conclusions:

– optimal energy and geometrical characteristics of the electric pulse plant for processing natural and technogenic raw materials were obtained;

– the dependences of the grinding of natural ores on the interelectrode distance at the switching device, capacitor battery capacitance and energy discharge were found.

As practice shows, at lower energy values from the established parameters, the grinding degree decreases by 20-25%, and at higher values, the energy consumption for crushing ores increases by 10-15%.

Authors: Professor Igor Piotr Kurytnik, The W. Pilecki State *University of Malopolska in Oswiecim, 8 m. Kolbego str., 32-600 Oświęcim, Poland, E-mail address: ikurytnik@outlook.com; Professor Bekbolat Rakishevich Nussupbekov E.A. Buketov Karaganda state university, faculty of physics and technology, University street, 28.100028 Karaganda, Kazakhstan, E-mail address: bek_nr1963@mail.ru; PhD Ayanbergen Kairbekovich Khassenov, E.A. Buketov Karaganda state university, faculty of physics and technology, University street, 28.100028 Karaganda, Kazakhstan, E-mail address: ayanbergen@mail.ru; PhD Dana Zhilkibaevna Karabekova, E.A. Buketov Karaganda state university, faculty of physics and technology, University street, 28.100028 Karaganda, Kazakhstan, E-mail address: karabekova71@mail.ru; PhD Nazgul Kdyraliyevna Tanasheva, E.A. Buketov Karaganda state university, faculty of physics and technology, University street, 28.100028 Karaganda, Kazakhstan, E-mail address: nazgulya_tans@mail.ru*

REFERENCES

[1] Bukaeva A.D., Production of the non-ferrous metals in the Republic of Kazakhstan,Theory and practice of social development (2012), №12, 561-564.
[2] Alshanov R.A., Kazakhstan in the world mineral market: problems and their solutions (analysis and forecast), Almaty: Print-S (2005).
[3] Andreev E.E., Tikhonov, O.N., Crushing, grinding and preparation of raw materials for enrichment, St. Petersburg: St. Petersburg mining Institute (2007).
[4] Abdel-Zaher M.A., Douglas W.F., Grinding of mineral mixtures in high-pressure grinding rolls, International Journal of Mineral Processing (2009), 93, 1, 59-65.
[5] Liu L., Tan Q., Liu L., Li WJ., Lv L., Comparison of grinding characteristics in high-pressure grinding roller (HPGR) and cone crusher (CC), Physicochemical problems of mineral processing (2017), 53, 2, 1009-1022.
[6] Van Der Meer, Frank P., Pellet feed grinding by HPGR, Minerals engineering (2015), 73, 21-30.
[7] Jankovic A., Suthers S., Wills T., Valery W., Evaluation of dry grinding using HPGR in closed circuit with an air classifier. Minerals engineering (2015), 71, 133-138.
[8] Avdokhin V.M., Fundamentals of mineral processing. Enrichment processes, Moscow: Publishing house of the Moscow state mining University (2018).
[9] Chanturia V.A., Kozlov A.P., Modern problems of complex processing of hard-to-rich ores and technogenic raw materials, Materials of the International scientific conference Modern problems of complex processing of hard-to-rich ores and technogenic raw materials, 12-15 September 2017 (pp. 3-6), Krasnoyarsk: Siberian Federal University (2017).
[10] Koeninger B., Hensler T., Romeis, S., Peukert W., Wirth K.E., Dynamics of fine grinding in a fluidized bed opposed jet mill, POWDER TECHNOLOGY (2018), 327, 346-357.
[11] Kurets V.I., Solovev, M.A., Zhuchkov, A.I., Barsky, A.V., Electric discharge technology of processing and destruction of materials, Tomsk: Publishing house of Tomsk Polytechnic University (2012).
[12] Krivitsky E.V. Dynamics of electric explosion in liquid, Kyiv: Hayкf Dumka (1986).
[13] Kurets V.I., Usov A.F., Zuckerman, V.A., Electrical pulse disintegration of materials. Apatity: Publishing house of Kola scientific center of RAS (2002).
[14] Kurytnik I.P., Nussupbekov B.R., Khassennov A.K., Karabekova D.Zh., Disintegration of copper ores by electric pulses, Archives of metallurgy and materials, (2015), 60 (4), 2549-2551. DOI: https://doi.org/10.1515/amm-2015-0412
[15] Nusupbekov B.R., Kusaiynov K., Sakipova S.E., Khasenov A.K., Beysenbek A.Zh., On Improvement of Technology of Complex Extraction of Rare and Trace Metals by Electropulse Method, Metallofizika i Noveishie Tekhnologii (2014), 36(2), 275-286.
[16] Kurytnik I.P., Nussupbekov B.R., Karabekova D.Zh., Khassenov A.K., Kazhikenova A.Sh., Investigation of a Crushing and Grinding Unit of an Electropulse Installation. Archives of Foundry Engineering (2018), 18, 1. 61-64.