A R C H I V E S O F M E T A L L U R G Y A N D M A T E R I A L S
Volume 60 2015 Issue 4
DOI: 10.1515/amm-2015-0412

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DISINTEGRATION OF COPPER ORES BY ELECTRIC PULSES

ROZDROBIENIE RUDY MIEDZI IMPULSAMI ELEKTRYCZNYMI

The article is concerned with methods of ragging and grinding of copper ore. The proposed electric pulse technology is one of the energetically favorable methods of ragging and grinding of natural minerals and anthropogenic raw materials. This paper presents optimal parameters in processing of the product. The results obtained by grinding of copper ore using the offered technology may be used under industrial conditions in the future.

Keywords: electric pulse technology, copper ore, reduction range

Opracowana oryginalna technologia rozdrabniania różnych materiałów, w tym rud miedzi, za pomocą impulsu elektrycznego. Badania ustaliły, że optymalna energia impulsu wynosi 333 J. Przy rozdrabnianiu rudy miedzi o granulacji 10mm do 1mm drobna frakcja stanowiła 36,9%, a z rudy o o granulacji 15mm odpowiednio 31%. Przytoczone dane o zależności drobnej frakcji od odległości elektroda – ruda

1. Introduction

In recent decades, there has been some reduction of metal content in ores of most fields. To increase the production of non-ferrous, rare and precious metals it is necessary to exploit ore deposits that are more complicated geologically for mining; to process complex poor value ores; to use dumps of long stored intermediates and metallurgical wastes; to develop and implement new technological processes; to carry out many technical measures to reduce ore loss in the ground and ore dilution during extraction; to increase recovery of metals in ore dressing and metallurgical processing of concentrates. Crushing and grinding are the most expensive operations of ore processing at concentration plants. They require large capital expenditures and operating costs. However, these operations have a significant impact on qualitative enrichment values, as designed for the opening of minerals, providing the necessary conditions for a successful flotation. [1]

At processing ores or rocks in order to extract useful components there should be directed selective disintegration of raw materials when the material is not broken uniformly but along the boundaries of minerals intergrowth, uncovering and separating the useful component from enclosing rocks.

One of the ways to solve these problems is the electric pulse method of disintegration of rocks based on the effect of disintegration of solids by an electric pulse breakdown. Disintegration in this case is due to tensile and shear forces generated by high-speed broadening of a discharge channel formed inside the solid. This method of loading of solids is similar to the explosion of chemicals, but it does not require to make special holes in the material, where the explosive substance is laid – it is replaced by the discharge channel, which is formed at the electrical breakdown of material [2, 3] .

The distinction of electric pulse crushing is the possibility to regulate the energy characteristics of the discharge channel due to change of the energy level of the pulse (changing pulse amplitude and discharge capacity of the generator), the time of its release by regulating the inductance of the discharge circuit of the generator, the energy density per unit length of the discharge channel by changing the size of the working clearance, etc. If a perforated plane or a hemisphere is used as a ground electrode, it is possible to regulate the general size of the destructed raw material. Thus, the electric pulse method of disintegration of heterogeneous solids is a highly adaptive method, which is used for disintegrating materials with different physical-mechanical and electric-physical properties [4, 5].

2. Experimental work

For crushing and grinding copper ore the authors developed and assembled an electric pulse device that enabled to some extent to solve problems related to disintegration of ores. [8] The principle of operation of the plant is based on the use of the effect of the shock wave generated by a high-voltage

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discharge in a liquid and called an electro-hydraulic effect.

The electric pulse plant is made in the form of functional units (Fig. 1) that consist of a control panel, a generator with a discharger, a protection unit with a capacitor.

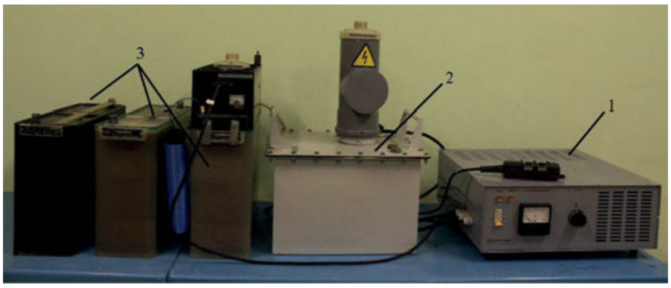

Fig. 1. An electric pulse plant. 1 – a control panel, 2 – a generator with a discharger, 3 – a protection unit with a capacitor

The generator with the discharger is one of the main plant units. It has been designed to transform the alternating input voltage into direct voltage at the output. The high voltage from the output of the generator is simultaneously supplied to the capacitor that accumulates energy. When reaching the specified voltage value at the capacitor, the discharger supplies a high voltage pulse to the interelectrode spacing, transmitting the stored energy to form a shock wave in the operating environment.

The control panel provides switching on and off the plant, regulation of the pulse repetition rate of discharge, the plant switch-on alarm and the availability of the supply voltage.

The protection system of the plant disables the plant in cases when voltage at the capacitor exceeds the specified safe working discharge voltage.

The protection unit operates as follows. On exceeding the specified safe operating voltage, a surge arrester is activated closing onward the circuit, consisting of resistance and the primary winding of the pulse transformer. The alternating voltage from the secondary winding is rectified and supplied to relay that actuates disconnecting the plant.

The plant is designed to operate under the following conditions: air temperature from 278 to 313°K (from +5 to +40°C); relative humidity of ambient air not more than 80% at a temperature of 293°K (+30° C); no conductive dust and vapours of chemically active substances, destroying the insulation of conductor wires of devices in the surrounding atmosphere.

Unlike mechanical breaking machines for crushing, electric pulse devices have no moving parts, are made of ordinary structural steel, and their body almost does not wear out when operating. During the operation process these devices do not form dust, occupy relatively small production areas and they make it possible to combine the processes of crushing, mixing and flotation of materials. The technological process of electric pulse crushing is easily automated; the maintenance of electro-hydraulic crushers does not require a large number of highly skilled workers.

During the process of electric pulse effect on a solid as a pressure-transmitting medium, service water was mainly used, as it is the most available, economical and quality medium [5-8].

The electric pulse method specifies substantial general regularities in the energy indicators change when varying the parameters of the pulse source, the characteristics of working chambers, physical-mechanical and electrical properties of the material to be disintegrated.

3. Results and discussion

The following parameters the pulse source, sufficiently critical to basic energy indicators of disintegration can be distinguished: pulse energy (Table 1), which can be varied by changing the value of capacitance of the capacitor or the value of discharge voltage; an interelectrode spacing, determining the voltage growth rate of an object and time of energy release in the discharge channel (Table 2).

TABLE 1

Crushed up to 1 mm product (C,%), depending on the pulse energy (W, J) at different values of capacitance of the capacitor and at a constant amount of discharge pulses (N=1000)

Original fraction diameter, mm	**Pulse energy (J) at the capacitance of the capacitor of 0,4 μF**			
	96.8 J	**135.2 J**	**205 J**	**259 J**
10 mm	13 %	24.2 %	33 %	33,4 %
15 mm	10 %	20.5 %	29.6 %	28,8
Original fraction diameter, mm	**Pulse energy (J) at the capacitance of the capacitor of 0,65 μF**			
	157 J	**220 J**	**333 J**	**421 J**
10 mm	21 %	28 %	36.3 %	37 %
15 mm	16 %	22 %	31 %	32 %
Original fraction diameter, mm	**Pulse energy (J) at the capacitance of the capacitor of 0,9 μF**			
	218 J	**304 J**	**461 J**	**583 J**
10 mm	24 %	30 %	38.4 %	39 %
15 mm	20 %	24.5 %	33 %	31.7 %

One of the most important characteristics defining the indicators of the process of disintegration is pulse energy. Under other equal conditions, an increase in pulse energy leads to more intense disintegration.

Increase in the interelectrode spacing leads both to growth of the crusher zone, and to the rise of proportion of energy released in the discharge channel for the first half-period of oscillations of the discharge current, that leads to the rise of specific productivity of the process with a high degree of probability of broadening of the discharge channel. This mechanism explains the ascending branch of dependence of the product fineness factor on the working clearance at a constant value of discharge energy to the point where the amplitude level of the pulse voltage becomes insufficient to break down the solid.

TABLE 2

Crushed up to 1 mm product (C,%), depending on the interelectrode spacing (L, mm) at constant values of pulse energy (W=333J) and at a constant number of discharge pulses (N=1000)

Original fraction diameter, mm	Interelectrode spacing L, mm			
	1 mm	**3 mm**	**5 mm**	**7 mm**
10 mm	25 %	33 %	40 %	39.5 %
15 mm	18 %	24 %	34 %	35 %

4. Conclusion

The technology of electric pulse crushing is a new method of grinding various materials that makes it possible to obtain specified fineness factor with a certain granulometric composition of the product and highly selective crushing.

The investigations determined the optimal parameters of the plant:

- the pulse energy W=333 J, since the output of the final product crushed up to 1 mm from the original ore with the fraction diameter of 10 mm was 36.3%, and from ore with initial fraction diameter of 15 mm it was 31%;
- interelectrode spacing L=5 mm, since the output of the final product crushed up to 1 mm from original ore with the fraction diameter of 10 mm was 40%, and from ore with the initial fraction diameter of 15 mm it was 34%.

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Received: 10 January 2015.