ON THE DETERMINATION OF THE OPTIMUM TIME OF MICROWAVE EXPOSURE TO PYRITE-CONTAINING ORE

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ABSTRACT. The method of constructing an experimental dependence on temperature of the pyrite-containing ore samples during microwave exposure time is given. According to the results of the experiments, the stabilization temperature and the optimum microwave exposure time are determined. The character of the dependence of the stabilization temperature on the pyrite content in the samples is defined.

Keywords: pyrite-containing ore, microwave exposure, optimum microwave exposure time, stabilization temperature

ОПРЕДЕЛЯНЕ ОПТИМАЛНОТО ВРЕМЕ НА ЕЛЕКТРОМАГНИТНО ВЪЗДЕЙСТВИЕ ВЪРХУ ПИРИТСЪДЪРЖАЩИТЕ РУДИ

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РЕЗЮМЕ. Описана е методика за построяване на експериментална зависимост на температурата на образец от пиритсъдържаща руда от времето на СВЧ въздействие. На основание на резултатите от експериментите е определена температурата на стабилизация и оптималното време на СВЧ въздействие. Установен е характерът на зависимостта на температурата на стабилизация от съдържанието на пирита в образците.

Ключови думи: пиритсъдържаща руда, СВЧ въздействие, оптимално време за облъчване, температура на стабилизация

Defining the task

It is well known that during the technological processes for mineral processing – crushing and grinding – a large quantity of hard to be ground ores and rocks is involved in order to extract the useful components. Since the ores of ferrous metals are, as a rule, of high strength, the use of traditional processing and grinding methods leads to a significant increase in energy costs, intensive wear on the metal parts of the mills, and considerable losses of extracted useful components due to the incomplete uncovering of the twins. Therefore, it is necessary to determine the methods for purposeful modification of the technological properties of the hard to be ground minerals, which increase the efficiency of their processing. Finding new approaches that take into account the heterogeneity of the rock types that make up the ore body and the reasons for the structural transformations of the ore minerals will make it possible to significantly reduce the energy intensity of the grinding process. Such studies have been carried out by well-known scholars – I.A.Birger, N.P.Vloh, Julij I. Zetser, M.G. Zilbershmidt, V.A.Kondrashov, J.M.Misnik, A.N. Moskalev, G.Y. Novik, A. D. Sashurin, R. M. Sultanalieva, K. Tazhibaev, M. Friedman and others.

One of the possible impacts on rock types with high hardness (strength), which increases the efficiency of their destruction, are the electrophysical fields. Their action is based on the absorption of the energy supplied to the rock and after its transformation, the rock is broken or there is a significant reduction of its hardness (strength). The electrophysical fields used can be classified into several groups: based on the use of direct current or industrial frequency current, high voltage electrical pulses, high and ultra-high frequency (UHF) electromagnetic field energy, infrared or optical effects.

From the point of view of impact on the physico-mechanical properties of the rocks and ores, the effect of the microwave exposure is quite perspective. The decrease in rock mass strength under such an impact is predetermined by the volumetric nature of the conversion of the radiated UHF energy into heat energy within the depth of waves' penetration as well as by the high heating temperature and the influence of the resulting thermal stresses which ensure the rate of the strength reduction, commensurate with the mechanical loading velocities [1,2].

Duration of the microwave exposure is one of the key points for determining the parameters of microwave exposure on minerals in hard rocks. Most of the scientists studying the effects of microwave exposure on rocks determined the temperature of the samples by using a calculation method based on their thermoformance and the experimental results for the relative (specific) volumetric intensity of the grinding depending on the optimum exposure time. Data show that this time ranges from 3 to 5 minutes [3]

This paper presents the results of the experimental studies of the heating temperature dependence of pyrite-containing ores' samples on the microwave exposure time and the content of the metal-containing minerals.

Description of experimental studies

The following tools were used to perform the experimental tests:

- microwave oven «Electronics» (1300 Watt power, 2450 MHz frequency);
- DT-8868H high temperature pyrometer (temperature range from -50ºC to +1850ºC, 50: 1 optical resolution, ± 1.5% error, 0.1ºC resolution, double laser scope).

The tested specimen was placed in a microwave oven and subjected to repeated heating with a time step of 30 seconds. The temperature was fixed by the pyrometer at the time of completion of heating at an open door of the oven, whereby the pyrometer was mounted on a stand so that the spot of the beam was dropped into a fixed area of a stationary specimen containing pyrite grains. The tests were carried out by fixing the maximum of the measured temperature with an emission factor of 0.95. As a damper for protection from drilling the specimens with high content of pyrite, a 500 ml water cuvette was placed in all oven tests and the measurements were discontinued at the point when the water started to boil [4]. After the oven and the sample were completely cooled to room temperature (25° C), the measurements were repeated over a longer period of heating.

Figure 1 shows the installation with which the measurements were made. The results of the measurements are summarised in Table 1. 1 and shown in the graphs - Fig. 2.

The analysis of the temperature dependence of the sample on the microwave exposure time shows that with the general tendency to increase the temperature of the specimen with the increase of the microwave exposure time, at some of the intervals of impact there is a temporary temperature stabilization followed by a rise in temperature. The values of the stabilization temperature are shown in Table 2, and the microwave exposure time at which this stabilization occurs is in the range of 3 to 5 minutes, which coincides with the experimental data of other scientists who determined the optimal time for microwave exposure [3].

Fig. 1. Equipment for the experiments

Table 1.
Results from the experimental tests

Time for microwave exposure,s	Temperature of the sample, ºC			
	Sample № 3	Sample № 2	Sample № 6	Sample № 5
0	25	25	25	25
30	46.2	72.5	70.4	98.5
60	53.2	111	106.2	133.4
90	69.9	141.4	122.1	162.6
120	78	159.4	144.1	195.7
150	84.1	177.9	182.9	203.1
180	107.2	239	182.3	243.8
210	116.2	234	195.7	236.1
240	112.1	239	227.7	276.7
270	113.2	290.7	218.1	246.8
300	119.9	303.6	219.7	285.4
330	124.6	324.6	207.8	301

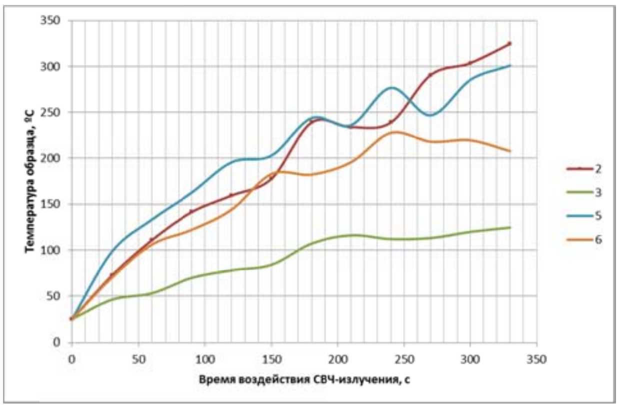


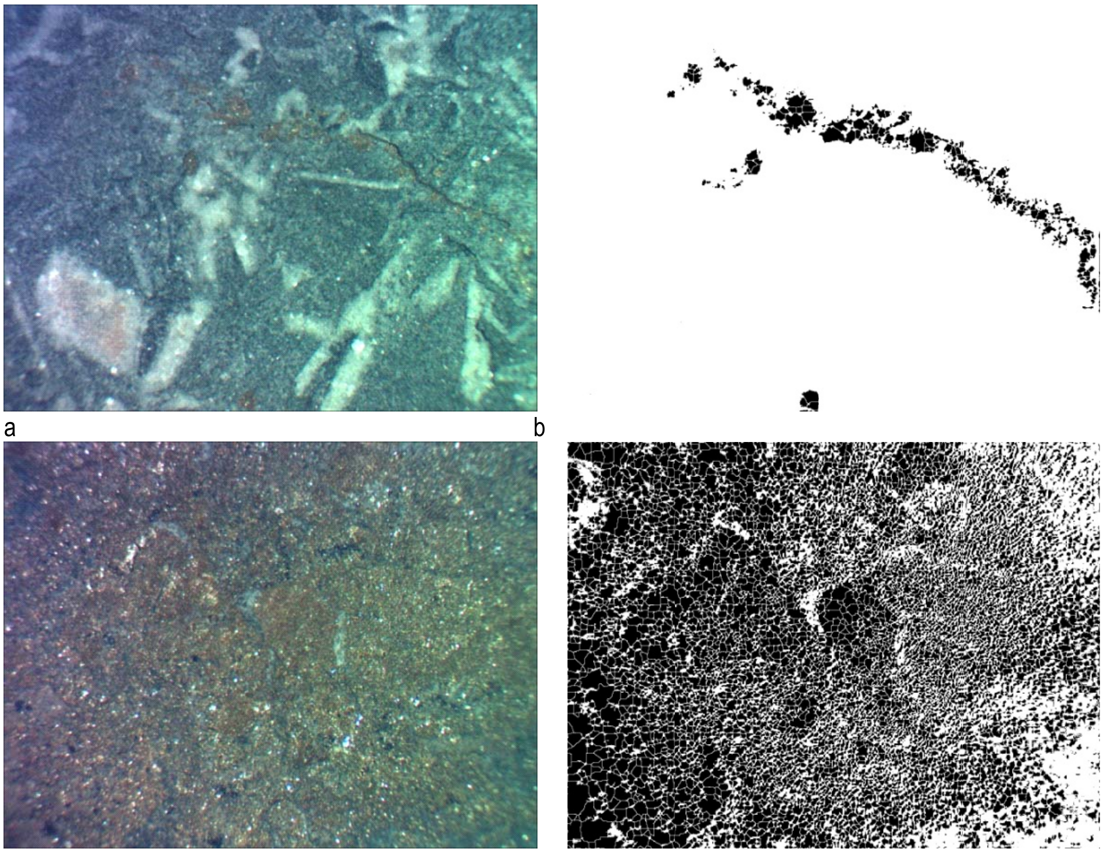
Fig. 2. Results from the experimental tests of samples of pyrite-containing ores №№ 2, 3, 5, 6

Since the specimens of the pyrite-containing ore contain different amounts of FeS2, it is necessary to determine the pyrite content in each specimen. Optical measurements were used for this purpose: in the microphotographs of the samples, the percentage of pyrite in the samples was determined using a set of Microanalysis programmes to create special masks. The results of the measurements are shown in Fig. 3 and Table. 2 and the dependence of the stabilization temperature on the pyrite content in the sample is shown in Fig. 4.

Table 2

Dependence of stabilization temperature on pyrite content

№ of the sample	3	2	6	5
Pyrite content, %	0.8	2.8	16.7	52.9
Stabilization temperature, ºC	115	140	180	235



a b

c d

Fig. 3. Microsamples of specimens of pyrite-containing ore (a, c) and masks on pyrite (b, d) of samples of pyrite-containing ore No 2 (a, b) and No 5 (c, d)

Discussing the results

As a result of the tests, it has been found that in case of microwave exposure of pyrite-containing ores their heating temperature increases with the increase of the duration of exposure. Exposure time intervals (from 3 to 5 minutes) have been found in which the temperature stabilizes in the specimen (the time for microwave exposure increases, the temperature of the sample practically does not change). From the point of view of the energy intensity of the disintegration, these time intervals coincide with the optimal ones and with the time intervals for microwave exposure of samples of different rock types. The dependence of the stabilization temperature of the specimens on the pyrite content is similar to that of 0.5. The coincidence of the range of stabilization temperature with the optimum exposure time may allow the difficult tests for determining the energy intensity of rock disintegration in case of microwave exposure to be replaced with easier, but not less informative, results.

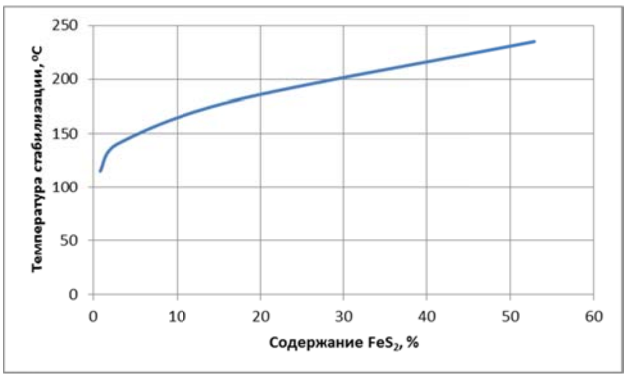


Fig. 4. Dependence of the stabilization temperature on the pyrite content of the sample

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