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A.K. Khassenov*, D.Zh. Karabekova, B.R. Nussupbekov, G.A. Bulkairova, A.S. Kudussov, G.K. Alpyssova, M.M. Bolatbekova

Karaganda University of the name of academician E.A. Buketov, Karaganda, Kazakhstan
*(*E-mail:* ayanbergen@mail.ru*)*

Investigation of the influences of pulsed electrical discharges on the grinding of quartz raw materials

The article considers a method for obtaining raw materials — quartz powder, used to increase the resistance of building materials to adverse natural facts (wind, rain, etc.). When obtaining raw materials necessary for construction from quartz mineral, it is pre-crushed to the desired size. New methods and technologies are proposed to improve the processes of grinding solid materials. One of these methods is the electric pulse method. This method is designed for grinding solid materials with the formation of pulsed electrical discharges in a liquid volume. When processing natural ores by the electric pulse method, the resulting products are not contaminated with metal in the working chamber. The paper analyzes the granulometric composition of quartz powder and determines the degree of grinding of raw materials depending on the parameters of electrical pulse discharges. The investigations on the processing of raw materials were carried out at various parameters of the number of pulse discharges and discharge voltage. In experiments, quartz fractions with a diameter of 10 mm were crushed by the electric pulse method and a product with a diameter of 0.4-1 mm was obtained. Since quartz is crushed in a liquid medium, the amount of water consumed was studied to obtain the necessary granulometric composition of raw materials. The dependences of the degree of quartz grinding on the number of pulse discharges and the discharge voltage are obtained. The results of grinding the material by pulsed electrical discharges allow us to evaluate the main parameters of the process implemented in the electro-pulse method of destruction of solid material.

Keywords: electrohydraulic effect, discharge voltage, quartz powder, electric pulse, degree of grinding, number of pulse discharges.

Introduction

Most quartz concentrates are obtained from natural quartz after its processing. The main types of natural quartz raw materials are: Rock crystal, quartzite, quartz sands [1]. The use of quartz sand, based in many industries, has a number of distinctive features that distinguish it from other materials. By its structure, this material is crushed quartz, which is formed in a natural environment or extracted after special processing. The following sizes of quartz sand fraction are assigned: fine-less than 0.1 mm; fine fraction-0.1-0.8 mm; the average fraction is 0.8-1.6 mm; the large fraction is 1.6-6.0 mm. The first two types of quartz sand are added to the composition of various building materials: putty, gypsum, mortar, abrasives, paint. Water purification of medium fraction is used, and is also added to mixtures for construction, finishing and decorative plasters, self-leveling floors [2-4]. Large quartz sand is used in the production of paving slabs, concrete blocks, as well as in the creation of landscape design. Various mechanical methods and mills (vibrating, cone, ball) are widely used in the enrichment and grinding of natural ores. Mechanical mills have the following disadvantages: a more complex and expensive design, more complex maintenance, the need for precise alignment of the rotors, wear of grinding bodies and contamination of raw materials with these wear products [5-7]. The solution of problems arising during the processing of quartz raw materials can be implemented using non-traditional grinding methods that do not introduce additional pollutants into the finished product. Since one of these methods is the electric pulse method of grinding natural minerals [8-10], the scientific work carried out works on grinding quartz raw materials in a liquid medium under the action of pulse discharges.

The experimental setup consists of a power supply and a working channel for grinding natural minerals [11, 12]. Electric pulse devices, unlike mechanical crushers, have no moving parts, are made of ordinary structural steel, and their body practically does not wear out. During operation, these devices do not emit dust, occupy relatively small production areas and allow grinding, mixing and flotation of materials. The process of electric pulse crushing is easy to automate, since the maintenance of electric pulse crushers does not require a large number of highly skilled workers. Under the influence of electrical impulses on a solid, process water was used as a pressure conductor, since it is the most accessible, economical and envi-

ronmentally friendly environment. The proposed method of ore crushing is based on the use of the energy of a pulsed shock wave resulting from a spark electric discharge in a liquid. As the experiments show, this method of crushing is efficient, economical, environmentally friendly, easily integrated into any technological chain. The essence und distinctive feature of the proposed technology is that ore processing using the pressure energy released during electrohydraulic action makes it possible to obtain a quickly crushed and purified from impurities dispersed product of a given size, which can then be used directly for subsequent enrichment [13-15].

Experimental

The object of the investigations was a quartz mineral from the Aktas deposit (Fig. 1). The initial diameter of the raw material fraction was 10 mm. For each experiment, the mass of the quartz mineral was constant (100 g). The granulometric composition of the crushed material was determined using standard sieves calibrated in accordance with GOST R 51568-99. The mass of the feedstock and the resulting product was determined using laboratory scales (maximum load — 1200 g; discreteness 0.1 g).

a) b) c)

Figure 1. Quartz: a) large piece; b) raw materials with a fraction diameter of 13-17 mm, c) quartz powder obtained by electric pulse method, fraction diameter 0.4 mm

In experimental investigations, the discharge voltage was changed to an interval of 18-24 kV and a quartz mineral was crushed at a discharge amount of 300-1500, a capacitor capacity of 0.5 μF (Tables 1-4). In experimental investigations, the degree of grinding of raw materials (K) was determined.

Table 1

Granulometric composition of the quartz mineral at a discharge voltage of 18 kV and a capacitor capacity of 0.4 μF

d, mm	N=300	N=600	N=900	N=1200	N=1500
	K, %				
d<0,4	-	-	3	4,8	3,6
d<0,7	0	2,4	8,9	6,5	18,2
d<1	66,3	57,6	47,7	63,2	49
d>1	33,7	40	40,4	25,5	29,2

Table 2

Granulometric composition of the quartz mineral at a discharge voltage of 20 kV and a capacitor capacity of 0.4 μF

d, mm	N=300	N=600	N=900	N=1200	N=1500
	K, %				
d<0,4	-	3,2	5,6	7,4	6,2
d<0,7	4,2	7,5	4,4	12	15,3
d<1	47	64,7	45,9	47,5	72,5
d>1	48,8	24,6	44,1	33,1	6

Table 3

Granulometric composition of the quartz mineral at a discharge voltage of 22 kV and a capacitor capacity of 0.4 μF

d, mm	N=300	N=600	N=900	N=1200	N=1500
	K, %				
d<0,4	2,1	5,6	8,9	13,3	10,9
d<0,7	4,3	3,1	13,6	11,2	22,6
d<1	45,7	30,8	46,2	29,7	43,7
d>1	47,9	60,5	31,3	45,8	22,8

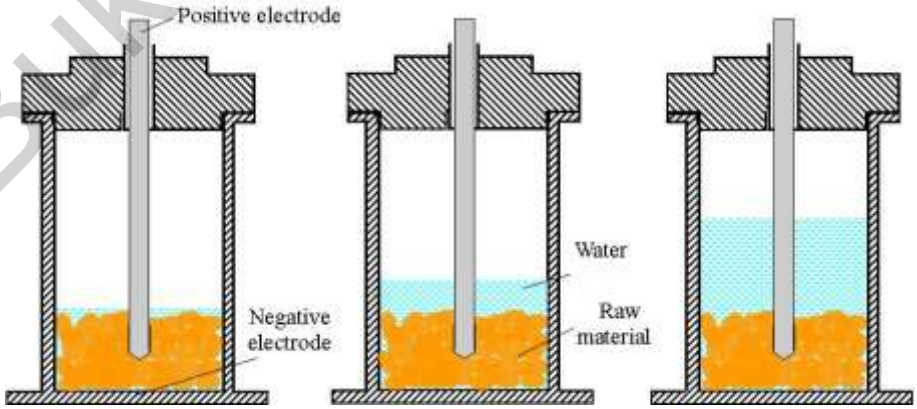
Table 4

Granulometric composition of the quartz mineral at a discharge voltage of 24 kV and a capacitor capacity of 0.4 μF

d, mm	N=300	N=600	N=900	N=1200	N=1500
	K, %				
d<0,4	2,8	3,2	6,7	10,5	14
d<0,7	5	6,4	12,5	18,7	24
d<1	54,2	42	54,3	49,7	41,1
d>1	37,3	47,5	25	19,3	18,7

It can be seen from the above results that quartz powder with a diameter of less than 1 mm is intensively extracted with an increase in the number of pulse discharges from 900 to 1500. But it is established that these indicators are achieved only at the breakdown voltage of the air medium in the intervals of the converter in the range of 22-24 kV.

In subsequent studies, the dependence of the processed product on the amount of process water was considered, since the work on grinding raw materials is carried out in a liquid medium. For this purpose, work was carried out on the treatment of various levels of liquid (process water) in the working channel. The experiments were carried out with the same volume of water (V_{water}) as the volume of processed raw materials ($V_{raw\ materials}$) in the working channel — $V_{raw\ materials} = V_{water}$, with an increase in the volume of water by 1.5-5 times ($1.5V_{water}$ — $5V_{water}$) (Fig. 2 a, b, c).



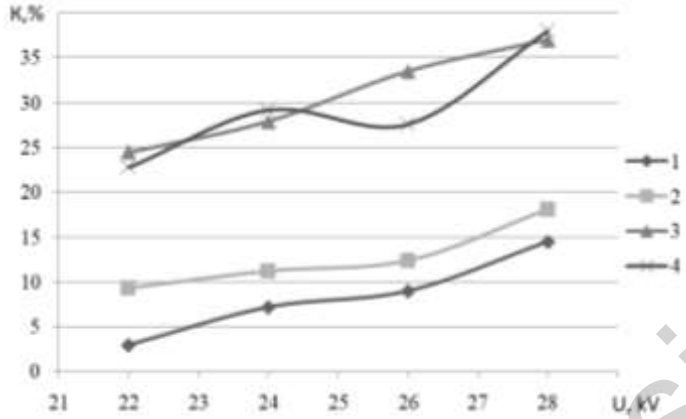
a) $V_{raw\ materials} = V_{water}$ b) $V_{raw\ materials} = 1{,}5V_{water}$ c) $V_{raw\ materials} = 5V_{water}$

Figure 2. Working channel

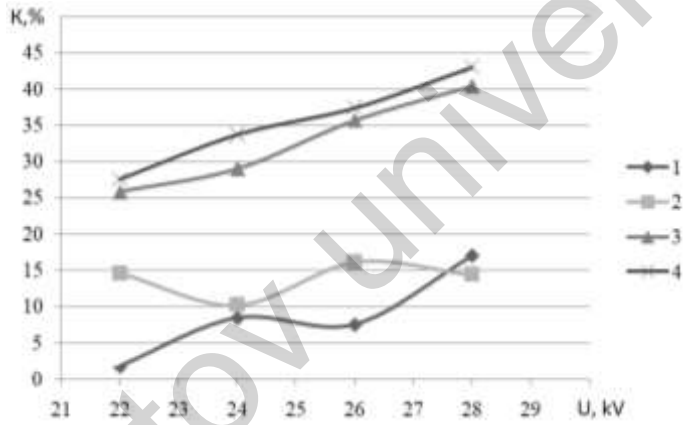
A metal cylindrical bowl was used as a working cell and performed the function of working electrodes in it — a metal rod (positive electrode) attached to the lid of the working cell and an inner tray of a metal

cylindrical bowl (negative electrode). Experimental investigations were carried out with the following parameters of the electric pulse unit (Fig. 3 a, b, c):

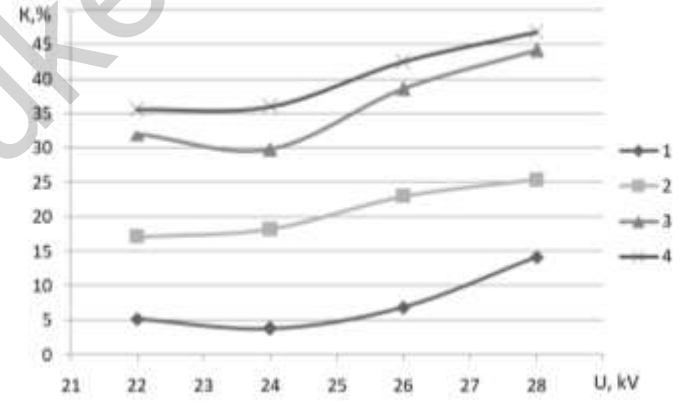
- number of pulse discharges (N) — 1000-1500;
- breakdown voltage of the air space in the intervals of the converter — 22-28 kV;
- the capacity of the energy storage capacitor — C = 0.5 μF.



a) N=1000; C=0,5 μF



b) N=1500; C=0,5 μF



c) N=2000; C=0,5 μF

Figure 3. The dependence of the degree of grinding of a quartz mineral on the amount of water: 1 — $V_{raw\ materials} = V_{water}$; 2 — $V_{raw\ materials} = 1{,}5V_{water}$; 3 — $V_{raw\ materials} = 3V_{water}$; 4 — $V_{raw\ materials} = 5V_{water}$

The dependence shown in the figures is the results after grinding the quartz mineral with a diameter of the initial fraction of 13-17 mm (the diameter of the resulting product is below 1 mm). It can be seen from the results that with an increase in the volume of water by 3-5 times compared to the volume of processed

raw materials ($3V_{water}$ — $5V_{water}$), the degree of grinding of the product increases. With an increase in the amount of water from the specified level, the output of the finished product changed at about the same level.

Conclusions

In the scientific work, the influence of electric pulse discharges on quartz mineral was considered, raw materials were obtained that are widely used in construction — quartz powder. Since the processing of raw materials is carried out in a liquid medium, the dependence of the quantity of finished products on the amount of liquid is investigated. From the results obtained, the amount of liquid required for intensive grinding of quartz mineral was determined. The experimental data can be used in obtaining the production of granulometric composition from natural ores by the electric pulse method.

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А.К. Хасенов, Д.Ж. Карабекова, Б.Р. Нусупбеков, Г.А. Булкаирова,
А.С. Кудусов, Г.К. Алпысова, М.М. Болатбекова

Кварц шикізатының ұнтақталуына импульсті электр разрядтарының әсерін зерттеу

Мақалада құрылыстық материалдардың табиғаттың қолайсыз факторларына (жел, жаңбыр және т.б.) төзімділігін арттыру мақсатында пайдаланылатын шикізат — кварц ұнтағын алу тәсілі қарастырылған. Кварц минералынан құрылысқа қажетті шикізатты алуда ол алдыменен керекті мөлшерге дейін ұнтақталады. Қатты материалдарды ұнтақтау процестерін жетілдіруде жаңа әдістер мен технологиялар ұсынылуда. Осындай әдістердің бірі — электроимпульсті әдіс. Аталмыш әдіс сұйықтық көлемінде импульсті электр разрядттарын қалыптастыра отырып, қатты материалдарды ұнтақтауға арналған. Электримпульсті әдіспен табиғи кедерді өңдеу кезінде алынатын өнім жұмыс камерасындағы металмен ластанбайды. Жұмыста кварц ұнтағының гранулометрлік құрамы талданып, электроимпульсті разрядтардың параметрлеріне тәуелді шикізаттың ұнтақталу дәрежесі анықталды. Шикізатты өңдеу зерттеулері импульсті разрядтар санының және разряд кернеуінің әртүрлі параметрлерінде орындалды. Тәжірибелерде электроимпульсті әдіспен фракция диаметрі 10 мм кварц кесектері ұнтақталып, диаметрі 0,4-1 мм ұнтақ алынды. Кварц сұйық ортада ұнтақталатындықтан, шикізаттың қажетті грануламетрлік құрамын алу үшін тұтынылатын су мөлшері зерттелді. Кварцтың ұнтақталу дәрежесінің импульсі разрядтар санына, разряд кернеуіне тәуелділіктері алынды. Материалды импульсті электр разрядтарымен ұнтақтау нәтижелері қатты материалды бұзуға арналған электроимпульсті әдісте іске асатын процестің негізгі көрсеткіштерін бағалауға мүмкіндік береді.

Кілт сөздер: электрогидравликалық эффект, разряд кернеуі, кварц ұнтағы, электроимпульс, ұнтақталу дәрежесі, импульсті разрядтар саны.

А.К. Хасенов, Д.Ж. Карабекова, Б.Р. Нусупбеков, Г.А. Булкаирова, А.С. Кудусов,
Г.К. Алпысова, М.М. Болатбекова

Исследование влияния импульсных электрических разрядов на измельчение кварцевого сырья

В статье рассмотрен способ получения сырья — кварцевого порошка, используемого с целью повышения устойчивости строительных материалов к неблагоприятным фактам природы (ветер, дождь и др.). При получении сырья, необходимого для строительства из кварцевого минерала, его предварительно измельчают до нужного размера. В совершенствовании процессов измельчения твердых материалов предложены новые методы и технологии. Одним из таких является электроимпульсный метод. Данный способ предназначен для измельчения твердых материалов с образованием импульсных электрических разрядов в объеме жидкости. При переработке природных руд электроимпульсным методом получаемая продукция не загрязняется металлом в рабочей камере. Авторами проанализирован гранулометрический состав кварцевого порошка и определена степень измельчения сырья в зависимости от параметров электрических импульсных разрядов. Исследования переработки сырья проводились при различных параметрах количества импульсных разрядов и напряжения разряда. В опытах кварц диаметром фракции 10 мм измельчался электроимпульсным методом и был получен продукт диаметром 0,4–1 мм. Поскольку кварц измельчался в жидкой среде, было изучено количество расходуемой воды для получения необходимого гранулометрического состава сырья. Получены зависимости степени измельчения кварца от количества импульсных разрядов и напряжения разряда. Результаты измельчения материала импульсными электрическими разрядами позволяют оценить основные параметры процесса, реализуемого в электроимпульсном методе разрушения твердого материала.

Ключевые слова: электрогидравлический эффект, напряжение разряда, кварцевый порошок, электроимпульс, степень помола, количество импульсных разрядов.

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