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Electric pulse method of processing cullet

The article considers the issue of obtaining a recycling resource during the processing cullet, which harms the environment. During the preparation of raw materials in the household waste recycling stages, the material is crushed to the right size. This is implemented in mills based on various methods of destruction. In this regard, analyses of the currently existing types of mechanical mills were carried out and their disadvantages were investigated. To solve glass recycling problem, this study presents the results of processing cullet by the electric pulse method. We provide a description of operation principle of the experimental setup and the design of the working chamber for processing the material under study. In this technology, the processing cullet is carried out with an increase in the discharge voltage of the storage from 25 kV to 35 kV, the capacitor capacity from 0,25μF to 1 μF, the number of pulse discharges from 100 to 600. By using the electric pulse method particles cullet with an initial fraction of 2 mm and 5 mm were crushed from 1 mm to 0.1 mm. The dependence of the output of the final product on the electrical parameters of the installation and the diameter of the obtained glass powder were received. The results of the grinding raw materials with the formation of pulsed electric discharges in a liquid medium allowed assessing the degree of grinding of the material. According to the obtained research data, optimal parameters of cullet grinding were established.

Keywords: electrohydraulic effect, coal powder, discharge energy, output of finished products, pulsed electrical discharges.

Introduction

In any industry, special attention is paid to the efficient use of natural resources in the production of various building materials. The problem of rational and integrated use of raw materials is closely related to the level of product development and is currently important for all industrialized countries. The creation and implementation of waste-free technologies for more complete use in the production of recycling resources and related products will improve the quality management of raw materials and final products, and reduce waste losses [1].

The cullet is one of those wastes that in natural conditions do not lose their properties for hundreds of years. The raw material is suitable for complete secondary processing with no waste. Cullet of various fractions (1–0.1 mm) is used as an additive to Portland cement and polymers. The average content of crushed glass in the composite material is about 20–50 %. These building materials are highly resistant to weather and are suitable for use as cladding materials. Another advantage of using recycled glass is that it reduces the number of landfills, contributing to reduce carbon dioxide emissions, which is an unwanted byproduct of cement production and the culprit in global warming [1–4].

The stages of processing cullet comprise processes that include crushing and grinding of raw materials. The grinding of raw materials is carried out depending on the purposes and production features of the subsequent use of the material. In these processes, various crushers are used as the main technological installations, and their intensity largely depends on the quality of products produced at the stages of recycling valuable material. The efficiency of the grinding process depends not only on the structure and technical characteristics of devices for obtaining the granulometric composition of glass powder of the required size, but also on the properties of the starting material and the solutions for obtaining the product.

For fine grinding of solids, the following equipment is most widely used [5]:

– ball mills, the productivity of material processing and energy consumption of which depend on the speed of rotation of the drum, the weight and size of the grinding bodies and the concentration of the suspension during wet grinding;

– rod mills, in which the grinding of the material is carried out by crushing, abrasion when rolling the rods in a rotating drum;

– cone crushers, based on crushing the material with the approximation of the gaps between the surfaces of internal movable and external stationary cones;

– drum mills, in which the material is crushed inside the rotating body under the action of grinding bodies or by self-grinding;

– jet mills, in which the material is crushed by feeding a jet of gas from sonic and supersonic injectors.

The above mills have several disadvantages: bulkiness, heavyweight, noise during operation, more complex and expensive design, installation complexity, high dust formation, wear of grinding bodies and contamination by-products of this wear, high energy consumption, and, as a consequence, the high energy intensity of processes [5–7]. The disadvantages of the methods used in glass recycling necessitate cause the use of improved technologies. The electrohydraulic effect can be used in the development and creation of new technologies. The essence of this method is that when carried out inside a volume of liquid in an open or closed vessel, a specially formed pulsed electric discharge is around the zone of its formation, ultra-high hydraulic pressures arise, able to commit useful mechanical work [8]. The electric pulse method finds application in the disintegration of diamond-bearing rocks, the processing of solutions for leaching uranium, the production of finely dispersed waters coal fuel, the disinfection of plant products and liquid raw materials, the descaling of heat exchangers [9–14].

The purpose of the work is to research the influence of electric discharges on the selective grinding of glass waste. We used a household cullet. The initial diameter (d_0) of the material before processing was 2 mm and 5 mm, and the obtained glass powder was d= 0,1–1 mm.

Experimental installation for crushing cullet

The experimental installation consists of a power supply unit providing constant voltage (control panel, generator, capacitors, spark gap) and a working chamber for grinding material in a liquid medium (Figure 1). The working chamber is equipped with a metal cylindrical corpus, which contains a mixture of glass fragments and industrial water (Figure 2). In the working environment, electric pulse discharges are formed between metal electrodes, with the tips of the electrodes arranged in a vertical direction against each other. The electrode (positive), powered by electric current, is fixed on the cover of the working channel made of caprolon, and the second electrode (negative) is placed on the grounded bottom of the metal vessel.

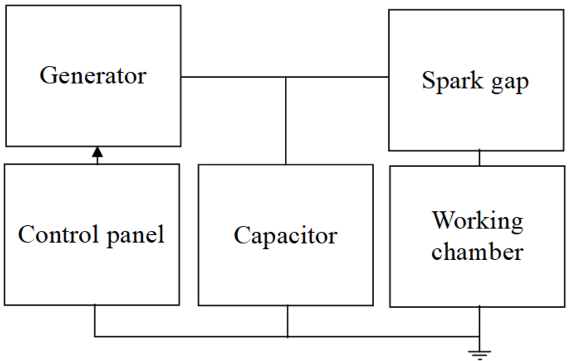


Figure 1. Flowchart of an electric pulse installation

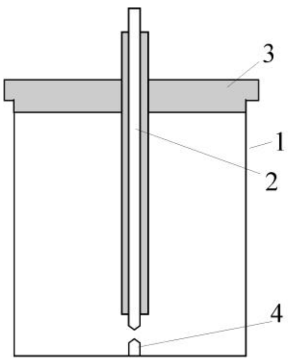


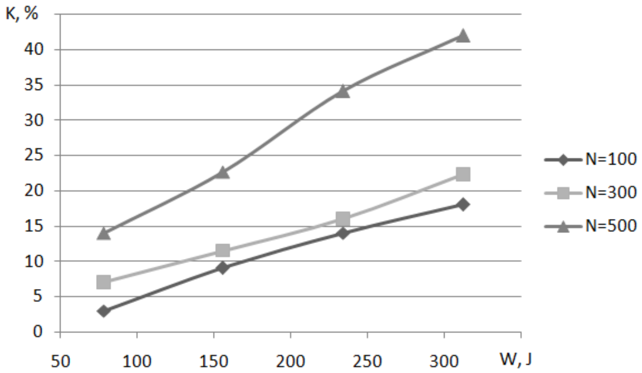
Figure 2. Working chamber: 1 — metal cylindrical corpus,
2 — positive electrode, 3 — working chamber cover, 4 — negative electrode

The installation for the grinding cullet works as follows. After the generator is powered by alternating current from the control unit, the amplified current from the generator accumulates in the capacitor until a value is reached that allows punching the air space between the metal hemispherical electrodes in the arrester. Further, the current in the form of a spark discharge formed in the spark gap is fed through a cable to the positive electrode of the working chamber. In the working chamber, when an electric explosion occurs between the ends of the positive and negative electrodes in a liquid medium, solid bodies are crushed due to shock waves and collisions of materials in them.

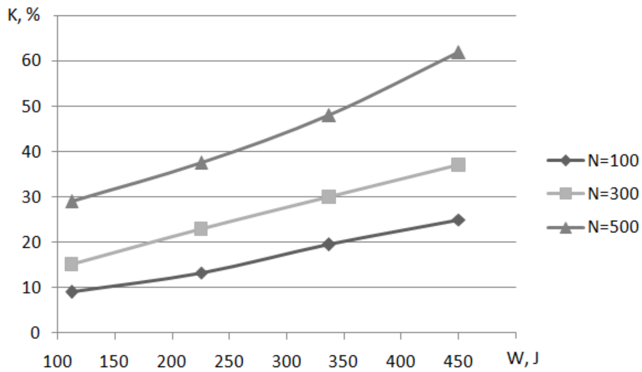
Methods of conducting experiments and analysis of the obtained results

The weight of the initial cullet was determined using electronic scales and for each experiment, the mass of the initial material and the volume of liquid was constant (the mass of the cullet was 100 g, the volume of industrial water – 400 ml). After drying at room temperature, the glass crushed by the electric pulse method was sieved through special standard sieves to analyze the granulometric composition of the resulting product. The yield of the required product (K, %) was determined by the ratio of the mass of the obtained product to the mass of the feedstock and was measured as a percentage.

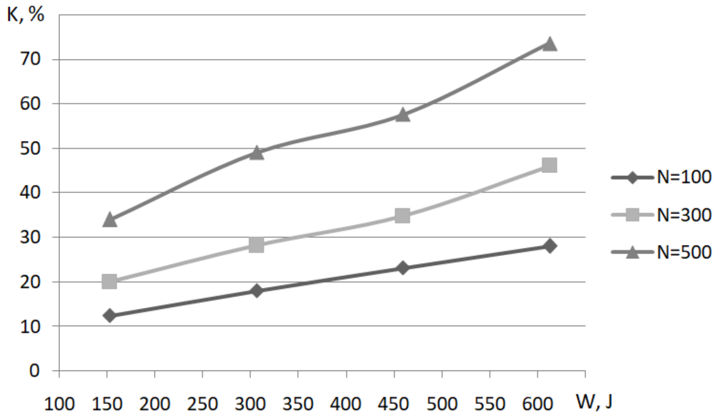
The work on grinding cullet was carried out depending on the different values of energy and the number of pulse discharges (Figure 3). Depending on the parameters of the bank, the pulse discharge energy varied. The discharge voltage of the storage was conversed by changing the gap of the metal electrodes in the spark gap. It was noted that with an increase in the electrical parameters of the installation, the output of the finished product increases.



a) d_0=5 mm, d=0.2 mm, C=0.25–1μF; U=25 kV



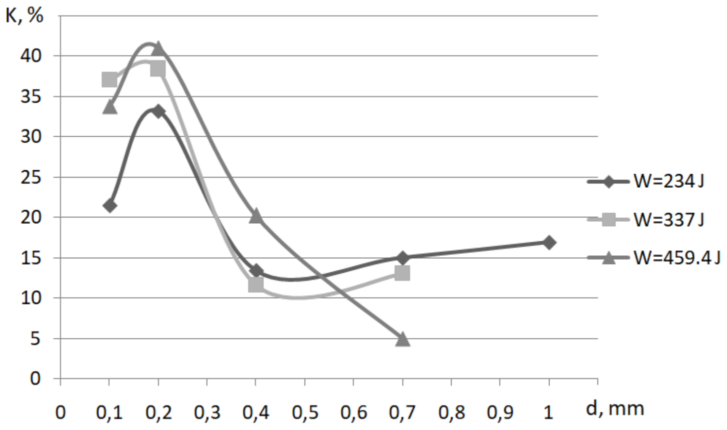
b) d_0=5 mm, d=0.2 mm, C=0.25–1 μF; U=30 kV



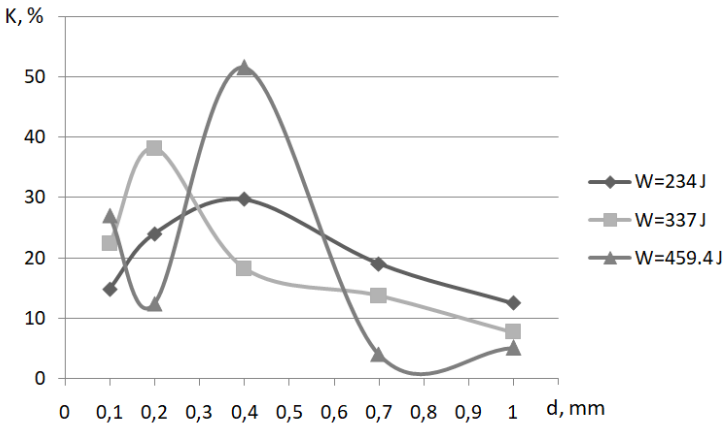
c) d_0=5 mm, d=0.2 mm, C=0.25–1 μF; U=35 kV

Figure 3. Dependence of the output of the finished product (powder diameter 0.2 mm) on the electrical parameters of the electric pulse installation

The following researches were devoted to the analysis of the granulometric composition of the material with a diameter of the initial fraction of 2 mm and 5 mm after electric pulse treatment (Figure 4). The experiment was carried out with the following parameters: storage discharge voltage is 25–35 kV, capacitance of the capacitor is 0,75μF, discharge energy is 237–459,4 J, the number of pulse discharges is 600.



a) d_0=2mm



b) d_0=5 mm

Figure4. Dependence of the output of the finished product on the diameter of the obtained glass powder

Figure 4 illustrates that as the discharge energy increased, the number of crushed cullet particles increased in the range from 0,1 mm to 0,4 mm. Thus, under the action of an electric pulse shock in a liquid medium, the granulometric composition of the destruction of glass waste was changed. The conversion of the parameters of pulse discharges into different values made it possible to increase the thin classes in the coarseness of the necessary raw materials.

Conclusions

The results of the experiment showed that the electric pulse method can be used for the disintegration of cullet. Received a powder product with a diameter of 0,1–0,4 mm, used as an additive to Portland cement and polymers. The fractional composition of the material and the degree of the output of final product were regulated by the selection of parameters of pulse discharges. The following values are accepted as effective parameters of pulsed discharges when grinding glass waste: capacitor of the capacity 0,75 μF, storage discharge voltage 30 kV, discharge energy 337 J.

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Шыны сынықтарын қайта өңдеудің электримпульстік әдісі

Мақалада қоршаған ортаға теріс әсер ететін әйнек сынықтарын өңдеу кезінде қайталама ресурстарды алу мәселесі қарастырылған. Тұрмыстық қалдықтарды өңдеу кезеңдерінде шикізатты дайындау процесінде материал қажетті мөлшерге дейін ұсақталады. Бұл әртүрлі әдістерге негізделген ұнтақтағыштарда іске асуда. Осыған байланысты қазіргі уақытта қолданыстағы механикалық диірмендердің түрлеріне талдаулар жүргізіліп, олардың кемшіліктері зерттелді. Аталған мәселені шешу үшін ғылыми жұмыста шыны сынықтарын электрлік импульсті әдіспен өңдеудің нәтижелері берілген. Тәжірибелік қондырғының жұмыс істеу принципі сипатталған, зерттелетін материалды өңдеуге арналған жұмыс камерасының құрылымы келтірілген. Аталмыш технологияда шыны сынықтарын өңдеу жинағыштың разряд кернеуін 25 кВ–тан 35 кВ–қа дейін, конденсатордың сыйымдылығын 0,25 мкФ–тан 1 мкФ–қа дейін, импульстік разрядтардың санын 100-ден 600-ге дейін арттыру арқылы орындалды. Электримпульстік әдістің көмегімен, бастапқы фракциясы — 2 және 5 мм болатын шыны бөлшектері 1 мм–ден 0,1 мм–ге дейін ұсақталды. Дайын өнімнің түсімінен электрлік параметрлік анықталды және ұсақталған шыны ұнтақтың диаметріне тәуелділігі алынды. Сұйық ортада импульстік электр разрядтарын қалыптастыру үшін шикізатты ұнтақтау нәтижелері материалды ұнтақтау дәрежесін бағалауға мүмкіндік берді. Зерттеу жұмыстарынан алынған мәліметтерге сәйкес шыны сынықтарын ұнтақтаудың оңтайлы параметрлері белгіленді.

Кілт сөздер: электргидравликалық эффект, көмір ұнтағы, разряд энергиясы, дайын өнімнің түсімі, импульстік электр разрядтары.

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Электроимпульсный метод переработки стеклобоя

В статье рассмотрен вопрос получения вторичного ресурса при переработке стеклобоя, оказывающий негативное воздействие на окружающую среду. В процессе подготовки сырья на этапах переработки бытовых отходов материал измельчается до нужного размера. Данный процесс осуществляется на мельницах, основанных на различных методах разрушения. В связи с этим был проведен анализ существующих в настоящее время типов механических мельниц и исследованы их недостатки. Для решения указанной проблемы в научной работе приведены результаты обработки стеклобоя электроимпульсным методом. Описан принцип работы экспериментальной установки, приведена конструкция рабочей камеры для обработки исследуемого материала. В данной технологии переработка стеклобоя выполнена с увеличением разрядного напряжения накопителя от 25 кВ до 35 кВ, емкости конденсатора от 0,25 мкФ до 1 мкФ, числа импульсных разрядов от 100 до 600. С помощью электроимпульсного метода частицы стеклобоя с исходной фракцией — 2 и 5 мм — измельчались от 1 мм до 0,1 мм. Получена зависимость выхода готового продукта от электрических параметров установки и диаметра измельченного стеклянного порошка. Результаты измельчения сырья с образованием импульсных электрических разрядов в жидкой среде позволили оценить степень измельчения материала. По полученным данным исследовательских работ установлены оптимальные параметры измельчения стеклобоя.

Ключевые слова: электрогидравлический эффект, угольный порошок, энергия разряда, выход готовой продукции, импульсные электрические разряды.

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