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ANALYSIS OF THE INFLUENCE OF THE SIZE OF PARTICLES ON THE CHOICE OF DESIGN AND MODE PARAMETERS OF THE VIBRO-IMPACT SCREEN DURING DEHYDRATION AND SEPARATION OF TECHNOGENIC RAW MATERIALS

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АНАЛІЗ ВПЛИВУ РОЗМІРУ ЧАСТИНОК НА ВИБІР КОНСТРУКТИВНИХ ТА РЕЖИМНИХ ПАРАМЕТРІВ ВІБРОУДАРНОГО ГРОХОТА ПРИ ЗНЕВОДНЕННІ Й РОЗДІЛЕННІ ЗА КРУПНІСТЮ ТЕХНОГЕННОЇ СИРОВИНИ

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АНАЛИЗ ВЛИЯНИЯ РАЗМЕРА ЧАСТИЦ НА ВЫБОР КОНСТРУКТИВНЫХ И РЕЖИМНЫХ ПАРАМЕТРОВ ВИБРОУДАРНОГО ГРОХОТА ПРИ ОБЕЗВОЖИВАНИИ И РАЗДЕЛЕНИИ ПО КРУПНОСТИ ТЕХНОГЕННОГО СЫРЬЯ

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Abstract. The article is aimed at the development of new methods of separation by size and dehydration of technogenic raw materials during vibro-impact screening.

About 1 billion tons of coal enrichment waste with high coal content (25-70%) with up to 45% humidity have been accumulated in ash dumps and sludge settlers of Ukraine. A useful component can be removed from such waste. But traditional methods allow you to effectively separate only materials with particle sizes greater than 1 mm, and reduce the humidity of the finished product to 18-22% depending on the size

The reasons for the decrease in the efficiency of these processes with a decrease in the particle size of the raw materials are analyzed. The conditions for increasing the intensification of these processes for raw materials of various sizes have been determined.

The author analyzes the effect of particle size on the choice of mode and design parameters of a vibroimpact screen, which make it possible to intensify the loosening of raw materials and thereby increase the efficiency of separation by size and dehydration.

Research data on dehydration and separation of materials with a size of + 0.4-1.0 mm are presented; + 0-0.4 mm and + 0-10.0 mm, where the average values of the results of five experiments in each mode are given.

The proposed new method of vibroimpact screening is especially useful in the processing of technogenic raw materials of a wide range of sizes, when it is necessary to separate thin classes (as a rule, substandard product) and to dehydrate the finished (oversize) product as much as possible. The use of this method will increase the yield undersize product (-0.1 mm) to 75-80%, and reduce the humidity of the positive product to 4-7%

As a result of the analysis for different classes of size the conditions provided are determined under which the maximum decrease in humidity and increase of minus product output is provided.

The results obtained will be used to improve the process of separation by size and dehydration of technogenic raw materials, as well as to create a new vibro-impact screen.

Keywords: vibrating screen, vibroimpact mode, separation by size, dehydration, technogenic raw materials.

Topicality. As a result of the activity of industrial enterprises on the territory of Ukraine, a huge amount of flooded fine-grained waste has been accumulated, consisting mainly of particles smaller than 1 mm, and which due to a significant amount of useful component are essentially man-made deposits.

These deposits usually have a unique mineral composition and are a potential source of various minerals, including ores, energy raw materials, building materials, as well as non-ferrous, rare and precious metals. About 1 billion tons of coal enrichment waste with high coal content (25-70%) have been accumulated in ash dumps and sludge settlers of Ukraine.

The difficulty of solving the problem of their processing is exacerbated by the fact that the waste after storage in the collector and long-term storage, due to the presence of a certain number of clay particles are a colloidal mixture with up to 45% humidity. Such high humidity is due to the presence of capillary moisture.

The water in the sludge is in a bound state, difficult to separate by gravity. The problem of processing is also complicated by the presence of a useful component in different classes of size, increasing the ash share towards the smallest classes, lack of equipment and technology for additional enrichment of raw materials of this size and the requirements of rail transport to transport raw materials with limited humidity not more than 10-12% solutions in this area [1-6].

The objective of the paper. To achieve this goal, the analysis of the results of experimental studies of the design and mode parameters on the efficiency of dehydration and separation of raw materials of different sizes.

Statement of basic materials. One of the ways to extract a useful component from wet man-made raw materials is their separation by size on the sifting surface, by using vibration, which intensifies the processes of segregation and separation. However, in most cases, with decreasing particle size, these processes become more complicated. The greatest difficulty is the separation of fine and thin particles, because the products formed from them retain a significant amount of water due to the highly developed surface of the particles, which actively interacts with water, and the active capillary forces.

The porosity and permeability of these media are usually low. As the particle size decreases, the binding energy of the liquid and solid surface increases, i.e. the resistance to water flow in the pore space. The more is this energy, the harder it is to separate the liquid. Therefore, the most difficult is to remove to remove water bound by capillary forces (surface tension forces) and located in capillary-joint bridges between particles [7-9].

Results of previous studies. Traditional methods, as practice has shown, allow you to effectively separate only materials with particle sizes greater than 1 mm, and reduce the humidity of the finished product to 18-22% depending on the size. Screening of materials with a size of 0.5-1 mm by traditional methods does not give high results, and with a particle size of less than 0.2 mm it is almost impossible [7-9].

Therefore, to overcome the influence of capillary forces requires special methods of impact on both raw materials and the surface that sifts, for example, combined excitation, a combination of vibrational and pulsed dynamic effects. The use of the combined effect on raw materials and sifting surface allows to increase the efficiency of processing of man-made raw materials and reduce the amount of production waste [7-9].

Sequence of studies. The choice of rational technology and equipment for dehydration and processing of man-made waste stored in storage (tailings) should be made with taking into account the properties of raw materials: particle size distribution, humidity, amount of useful component and waste (for example, in coal sludge - carbon and ash in classes), etc. [3-6].

A large variety of raw materials processed with different physical and mechanical properties and particle size distribution requires an individual approach in each case. In one case, to obtain a marketable product, it is necessary to separate the thinnest classes, in another - to make a sample of the most promising classes (for example, in coal sludge with the maximum content of useful product and minimum content of substandard). In both cases, it is necessary to establish a minimum maximum size of the separation, which ensures compliance with these conditions. Therefore, effective dehydration and size separation should be provided for both narrow and wide size classes [3-6].

All this must be taken into account when choosing technology and equipment for separation by size and dehydration of man-made raw materials. Therefore, the aim of the work is to analyze the impact of the particle size of raw materials on the choice of equipment and modes of operation for its dehydration to 10% (according to the requirements of rail transport for raw materials) and below and effective separation.

Among the **factors influencing the efficiency of the process**, the following should be noted:

– dehydration of raw materials occurs as a result of the passage of liquid through its layer and cells of the sieving surface. When divided into a class smaller than the capillary constant, this process is hindered by surface tension forces (capillary forces) acting at the phase boundary and which can be overcome by dynamic influence;

– the material that is on the sieving surface also reduces the effectiveness of the impact on the particles and water that are in its cells.

Means to increase the efficiency of dehydration and separation by size:

– expansion of the spectrum of action on the screening surface and the raw material being processed. A wide range provides excitation of natural oscillations of particles, liquids and surfaces. For these purposes, as a rule, one uses a blow directly on the screening surface, or through the intermediate element;

– expansion of the spectrum of action on the surface when the raw material does not come into contact with it, i.e. at the stage of its flight as a result of impact;

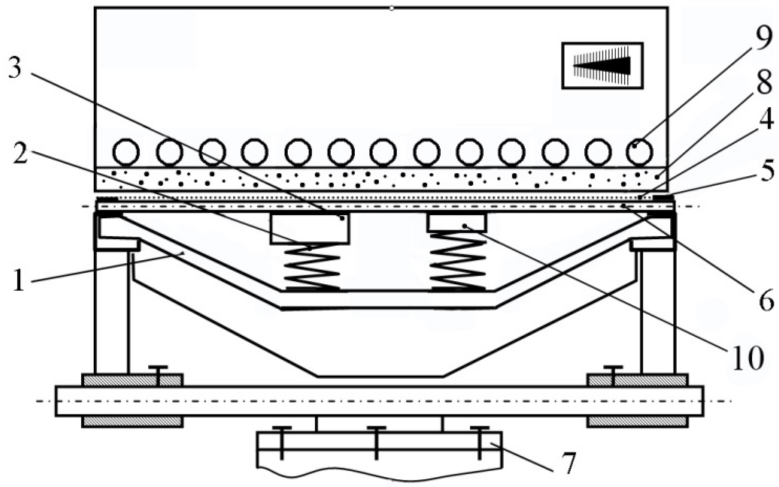
– when designing or adapting equipment for a particular type of raw material, it is necessary to be able to choose and calculate its rational design and mode parameters;

– expanding the possibilities of operational control, increasing the stability of work, automatic control and simplicity of design.

Analysis of technical solutions for dehydration of beneficiation products on vibrating screens and areas of their use showed that to further improve efficiency it is necessary to intensify the loosening of raw materials and sieving surface during the flight of raw materials inducing of additional accelerations without additional power supply. This will destroy the aqueous film in the surface cells due to the surface tension and viscosity of the liquid and the capillary-joint bridges between particles between the particles, which will facilitate the free passage of fine solid particles through the surface with the liquid and ensure high efficiency of fine particle separation and dehydration.

Determination of the expedient direction. The analysis in this area showed that to overcome the forces of surface tension and increase the efficiency of dehydration and separation by size, the most promising is vibration impact directly on the sieving surface or through the intermediate element.

The M. S. Poliakov Institute for Geotechnical Mechanics of the National Academy of Sciences of Ukraine developed new methods of vibratory impact screening [10 - 15], in which, in order to increase the efficiency of dehydration and separation by size, it is proposed to excite the sieving surface with «double» blows (Fig. 1).



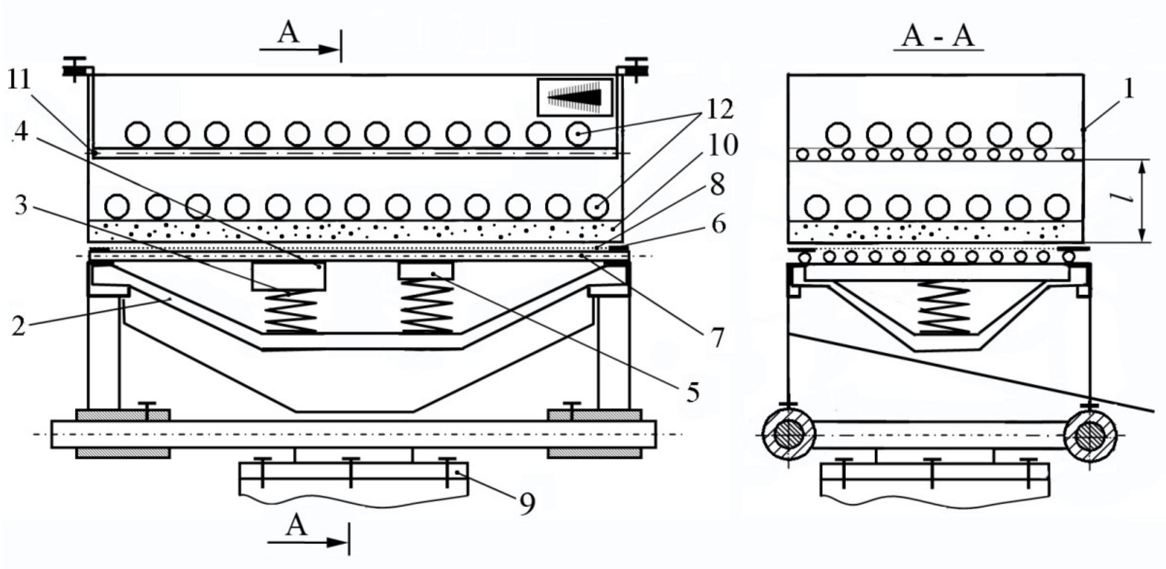
1 – beam; 2 – elastic element; 3 – drummer 1; 4 – sieving surface;
5 – elastic gasket; 6 – rods; 7 – the base; 8 – layer of raw materials;
9 – disintegrating elements; 10 – drummer 2

Figure 1 – Model of screen with two drums

To create a vibro-impact effect on the screen model (see Fig. 1), beam 1 with elastic element 2 and drummer 3 are installed, and rods 6 are mounted on the elastic gaskets 5 under the sieving surface 4. When the base 7 is harmonically excited, a variable force of inertia acts on the drummer variable force of inertia, which leads to periodic ruptures of the contact of the drummer 2 with the rods 6. As a result, shock pulses are generated, which are transmitted through the rods 6 to the sieving surface 4, the material being processed 8, disintegrating elements 9. When using "double blows" an additional drummer 10 was installed on the model of the screen with stiffness with a stiffness of the elastic element different from the stiffness of the elastic element of the drummer 3 [12 - 15].

First, the first blow is applied, which contributes to the separation of raw materials from the surface and its loosening, then during the flight, a second blow is applied, which induces additional acceleration of the surface, It is important to note that when applying the second blow, the processed raw material does not prevent the removal of particles and liquid from the holes. To intensify the loosening of the material, the disintegrating elements (DE) were used , presented by coarse particles of material were used, as well as by spherical, ellipsoidal bodies made of different materials.

Additionally, an activator was used to intensify the loosening of the material. In fig. 2, a model of a screen with two drums and an activator is shown.



1 – screen box; 2 – beam; 3 – elastic element; 4 – the main drummer; 5 – additional drummer; 6 – elastic gasket; 7 – rods; 8 – surface, sifting (metal mesh); 9 – vibrator table; 10 – layer of raw materials; 11 – activator; 12 – disintegrating elements

Figure 2 – Screen model with two drums and activator

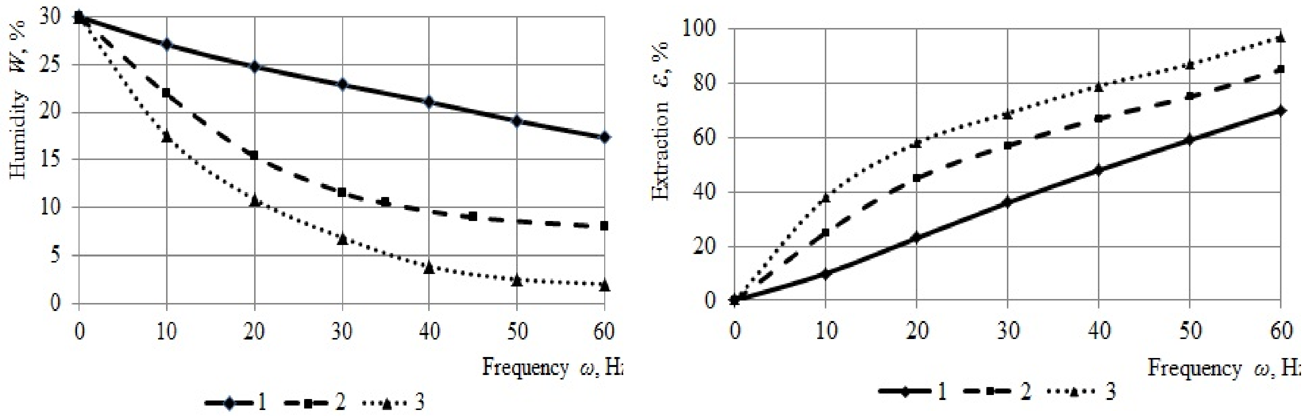
According to the set goal for different classes of size the influence on the humidity W of the positive product (on the sieving surface) and extraction ε of the negative product (under the sifting surface) from the vibration excitation parameters ω and amplitude A (used modes with «single» and «double blows», the amplitude varied from 1 mm to 9 mm, the frequency varied from 5 Hz to 60 Hz, the duration of dehydration was up to 180 s, the specific load was 12.5 kg/m^2, the humidity of the initial product was 30%).

Research data on dehydration and separation of materials with a size of + 0.4-1.0 mm are presented; + 0-0.4 mm and + 0-10.0 mm, where the average values of the results of five experiments in each mode are given.

In experiments, it was found that the increase in screening indicators (humidity of the positive product decreases to 4-6%, the yield of the negative product increases to 75-80%) are achieved at a frequency ω more than 30 Hz and an amplitude A more than 7 mm. However, there are overloads of more than 15 g (acceleration of vibration excitation to acceleration of free fall). Such accelerations are not typical for serial screens. Ensuring such regimes requires the creation of particularly strong structures. It is necessary to find such conditions under which effective dehydration and separation of material at smaller accelerations (at an overload of 6-8 g) is provided.

Therefore, further experiments were performed at amplitudes *A* = 2 and 4 mm, and various disintegrating elements (DE) and an activator installed above the sieving surface were used to intensify the loosening of raw materials, destroy capillary bridges and increase the efficiency of dehydration and separation [10, 11] .

The fig. 3 shows the patterns of changes in humidity *W* and extraction of ε minus class for raw materials with a size of + 0.4-1.0 mm from the frequency *ω* of vibration excitation (modes with «single blows», amplitude *A* = 2 mm, dehydration time 300 s, specific load 12,5 kg/m^2, humidity of the initial product 30%) on the sieving surface, with a cell of 0.63 mm, mesh wire diameter of 0.2 mm by using DE (coarse material with particle sizes + 5.0-10.0 mm, which was used in different proportions to the shares of raw materials («small» – shares of raw materials, «coarse» particles – DE).



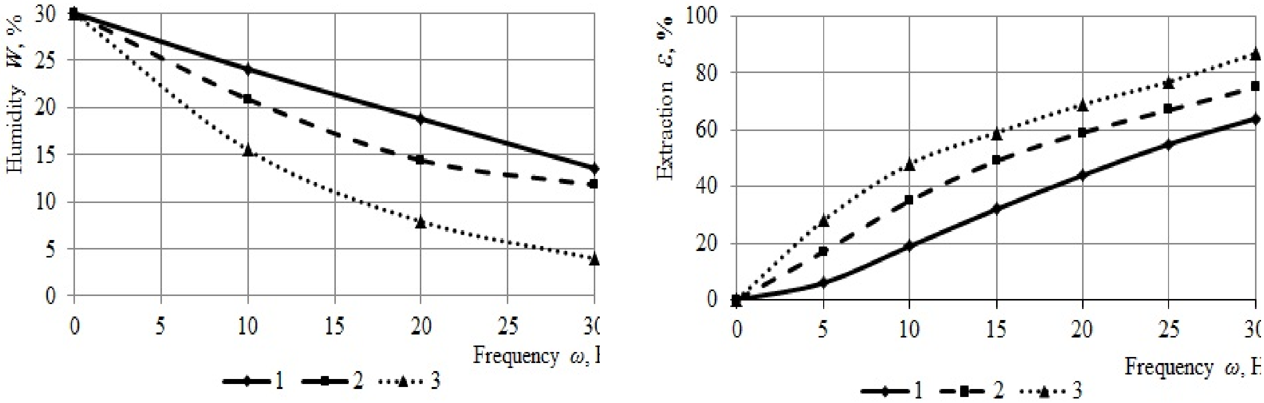
the ratio of material to coarse particles: 1 – 1/0; 2 – 1/1; 3 – 1/3

Figure 3 – Change in humidity *W* and extraction of *ε* negative class for raw materials with a size of + 0.4-1.0 mm from the frequency *ω* of vibration excitation (modes with «single blows», amplitude *A* = 2 mm, dehydration time 300 s)

From fig. 3 it follows that at *ω* = 30 Hz and *A* = 2 mm the use of coarse particles in the ratio of «fine-coarse» 1/3 when sifting raw materials with a size of + 0.4-1.0 mm can increase the yield of undersize product (-0.63 mm) up to 95-97%, and reduce the humidity of the positive product to 2-3%.

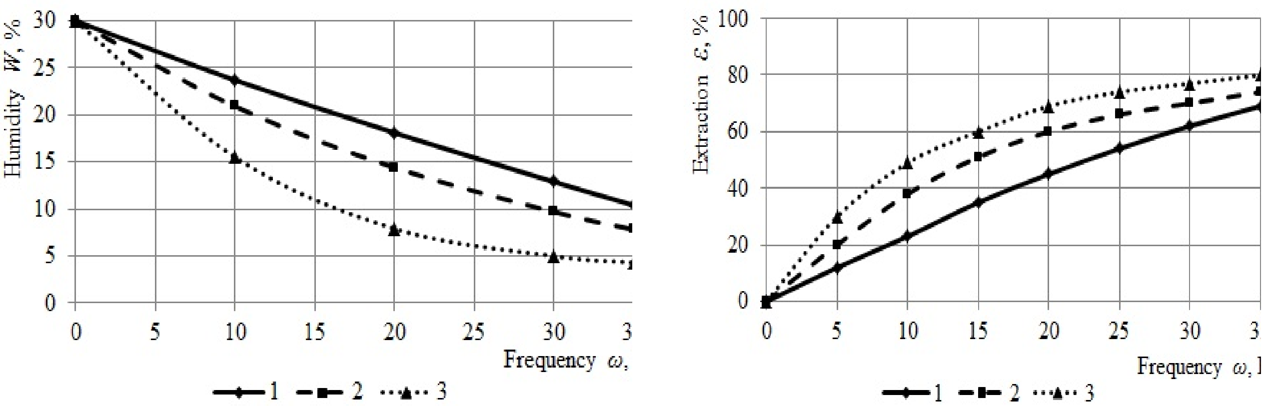
Figure 4 shows the patterns of changes in humidity *W* and extraction *ε* minus class for raw materials with a size of + 0-0.2 mm from the frequency *ω* of vibration excitation (modes with «double blows», amplitude *A* = 4 mm, dehydration time 180 s, specific load 12,5 kg / m^2, humidity of the initial product 30%) on the sieving surface, with a cell of 0.1 mm, mesh wire diameter of 0.1 mm with DE. In fig. 4 shows that at *ω* = 30 Hz and *A* = 4 mm the use of modes with «double blows» and DE in the form of coarse particles in the ratio of «fine-coarse» 1/3 allows to increase the yield of the undersize product (-0.1 mm) to 84-85%, and reduce the humidity of the positive product to 3-4%.

In fig. 5 presents the patterns of changes in humidity *W* and extraction *ε* minus class for raw materials with a size of + 0-10.0 mm from the frequency *ω* vibration excitation (modes with «double blows», amplitude *A* = 2 mm, dehydration time 180 s, specific load 12.5 kg/m^2, humidity of the initial product 30%) on the sieving surface, with a cell of 0.1 mm, wire diameter of 0.1 mm mesh with DE in the form of ellipsoids of rotation, metal layers and coarse particles). When dehydrating raw materials with a wide range of sizes with a particle size of + 0-10 mm, an activator was used together with the use of DE.



the ratio of material to coarse particles: 1 – 1/0; 2 – 1/1; 3 – 1/3

Figure 4 – Change in humidity *W* and extraction of *ε* negative class for raw materials with a size of + 0-0.4 mm from the frequency *ω* of vibration excitation (modes with «double blows», amplitude *A* = 4 mm, dehydration time 180 s)



disintegrating elements: 1 – ellipsoid of rotation; 2 – metal layers; 3 – metal layers and large particles

Figure 5 – Change in humidity *W* and extraction of *ε* minus class for raw materials with a size of + 0-10.0 mm from the frequency *ω* of vibration excitation (modes with «double blows», amplitude *A* = 2 mm, dehydration time 180 s)

It is established that when screening raw materials with a size of + 0-10.0 mm at *ω* = 35 Hz and *A* = 2 mm, the use of modes with «double blows», activator and DE (metal layers and coarse particles in the ratio of «fine-coarse» 1 / 3) allowed to increase the yield undersize product (-0.1 mm) to 75-80%, and reduce the humidity of the positive product to 4-7% (Fig. 5).

Conclusions. Thus, as a result of the analysis for different classes of size the conditions provided are determined under which the maximum decrease in humidity and increase of minus product output is provided. The influence of design and mode parameters on the intensity of dehydration and size separation was studied. The results of these studies will be taken into account when improving existing screens and creating a new vibratory blows screen.

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Анотація. Стаття спрямована на розробку нових методів розділення за крупністю та зневоднення техногенної сировини при віброударному грохоченні.

Показано, що в золовідвалах і шламовідстойниках України накопичено близько 1 млрд. т. відходів вуглезбагачення з високим вмістом вугілля (25-70%) і вологістю 45 % і більше. Із таких відходів може бути вилучено корисний компонент. Але традиційні методи дозволяють ефективно розділяти тільки матеріали з розмірами частинок більше 1 мм, а вологість готового продукту знизити до 18-22% в залежності від крупності, що неефективно для вищезгаданої техногенної сировини.

Проаналізовано причини зниження ефективності цих процесів у разі зменшення крупності частинок сировини. Визначено умови підвищення інтенсифікації цих процесів для сировини різної крупності.

У статті проаналізовано вплив розміру частинок на вибір режимних та конструктивних параметрів віброударного грохоту, які дозволяють інтенсифікувати розпушування сировини й за рахунок цього підвищувати ефективність розділення за крупністю та зневоднення.

Представлено дані експериментальних досліджень із зневоднення і розділення матеріалів крупністю +0,4-1,0 мм; +0-0,4 мм та +0-10,0 мм, де наведені середні значення за результатами п'яти дослідів при кожному режимі.

Запропоновано новий спосіб віброударного грохочення особливо корисний при переробці техногенної сировини широкого спектру крупності, коли необхідно відокремити тонкі класи (як правило, некондиційний продукт) і максимально зневодити готовий продукт. Застосування такого способу дозволить підвищити вихід підрешітного продукту (-0,1 мм) до 75-80 %, а вологість плюсового продукта знизити до 4-7 %

В результаті аналізу для різних класів крупності визначено умови, при яких забезпечується максимальне зниження вологості і підвищення виходу мінусового продукту.

Отримані результати будуть використані при вдосконаленні процесу розділення за крупністю та зневоднення техногенної сировини, а також при створенні нового віброударного грохоту.

Ключові слова: вібраційний грохот, віброударний режим, розділення за крупністю, зневоднення, техногенна сировина.

Аннотация. Статья направлена на разработку новых методов разделения по крупности и обезвоживания техногенного сырья при виброударном грохоте.

Показано, что в золоотвалах и шламоотстойниках Украины накоплено около 1 млрд т отходов углеобогащения с высоким содержанием угля (25-70%) и влажностью 45% и более. Из таких отходов может быть извлечен полезный компонент. Но традиционные методы позволяют эффективно разделять только материалы с размерами частиц более 1 мм, а влажность готового продукта снизить до 18-22% в зависимости от крупности, что неэффективно для вышеупомянутого техногенного сырья.

Проанализированы причины снижения эффективности этих процессов при уменьшении крупности частиц сырья. Определены условия повышения интенсификации этих процессов для сырья разной крупности.

В статье проанализировано влияние размера частиц на выбор режимных и конструктивных параметров виброударного грохота, позволяющих интенсифицировать разрыхление сырья и за счет этого повышать эффективность разделения по крупности и обезвоживанию.

Представлены данные экспериментальных исследований по обезвоживанию и разделению материалов крупностью +0,4-1,0 мм; +0-0,4 мм и +0-10,0 мм, приведены средние значения по результатам пяти опытов при каждом режиме.

Предложен новый способ виброударного грохочения, который особенно полезен при переработке техногенного сырья широкого спектра крупности, когда необходимо отделить тонкие классы (обычно некондиционный продукт) и максимально обезводить готовый продукт. Применение такого способа позволит повысить выход подрешетного продукта (-0,1 мм) до 75-80%, а влажность плюсового продукта снизить до 4-7%.

В результате анализа для разных классов крупности определены условия, при которых обеспечивается максимальное понижение влажности и повышение выхода минусового продукта.

Полученные результаты будут использованы при совершенствовании процесса разделения по крупности и обезвоживании техногенного сырья, а также при создании нового виброударного грохота.

Ключевые слова: вибрационный грохот, виброударный режим, разделение по крупности, обезвоживание, техногенное сырье.

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