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(54) MINERAL DRY SEPARATION DEVICE

(57) The present disclosure provides a mineral dry separation apparatus, including: a feeding system, a distribution device, an identification device and an actuator. The feeding system is located upstream of the distribution device and is configured to supply a mineral raw material to the distribution device, the identification device includes a pulsed X-ray source located above the distribution device and an X-ray detector located below the distribution device, the identification device is configured to identify a mineral raw material information, and the actuator is configured to separate the mineral raw material according to the mineral raw material information. By using the pulsed X-ray source, the mineral dry separation apparatus in the present disclosure may image clearly and correct an afterglow in the detector, so that detection data is more accurate, a separation accuracy and a processing ability of the apparatus may be improved, and a good separation effect may be ensured.

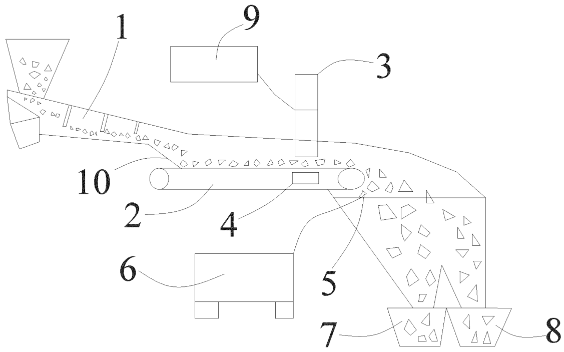

FIG. 1

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Description

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims priority to Chinese Patent Application No. 202210315627.0, entitled "Mineral Dry Separation Apparatus" and filed with the CNIPA on March 28, 2022, which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure generally relates to a field of mineral dry separation technology, and in particular to a mineral dry separation apparatus.

BACKGROUND

[0003] Wet gravity coal washers are widely used for coal separation at home and abroad, with a large demand for circulating water and a significant amount of water taken away by clean coal, which results in a large consumption and waste of water resources. Dry separation has advantages of no need for water, simple process, low investment and low production cost. Compared with wet coal separation, dry separation may better meet coal separation requirements in most regions.

[0004] At present, coal mine separation technology based on radiation identification technology has been disclosed in related art. However, practical productions show that existing dry separation apparatuses based on radiation identification technology have problems of poor separation accuracy, high requirements for coal types, and gangue being entrained in clean coal or clean coal being entrained in gangue, and are thus difficult to be widely applied and promoted.

SUMMARY

[0005] In order to solve at least one of the above-mentioned defects or deficiencies in the related art, the present disclosure provides a mineral dry separation apparatus with a simple structure, clear imaging, accurate detection results, and high production efficiency, which is suitable for large-scale and extensive use.

[0006] Embodiments of the present disclosure provide a mineral dry separation apparatus, including: a feeding system, a distribution device, an identification device, and an actuator; where the feeding system is located upstream of the distribution device and is configured to supply a mineral raw material to the distribution device, the identification device includes a pulsed X-ray source located above the distribution device and an X-ray detector located below the distribution device, the identification device is configured to identify a mineral raw material information, and the actuator is configured to separate the mineral raw material according to the mineral raw material information.

[0007] As an optional solution, the mineral dry separation apparatus further includes an electronic control system configured to receive the mineral raw material information and control the actuator to perform a separating operation according to the mineral raw material information.

[0008] As an optional solution, a beam emission frequency of the pulsed X-ray source is determined according to a transmission speed of the distribution device, a crystal size of the X-ray detector and a number of rows of X-ray detectors.

[0009] As an optional solution, the beam emission frequency of the pulsed X-ray source ranges from 20 Hz to 500 Hz.

[0010] As an optional solution, the actuator is provided as an air nozzle.

[0011] As an optional solution, in case that two adjacent pulses of the pulsed X-ray source are referred to as a first pulse beam and a second pulse beam, and two adjacent samplings performed by the X-ray detector are referred to as a first sampling and a second sampling, the X-ray detector is configured to perform the first sampling in a first time period and perform the second sampling in a second time period, the first time period is any time period from a time instant after an end of the first pulse beam to a time instant before a start of the second pulse beam, and the second time period is any time period including a complete beam emission time period of the second pulse beam from the time instant before the start of the second pulse beam to a time instant after an end of the second pulse beam.

[0012] As an optional solution, a sum of the first time period and the second time period is less than or equal to a beam emission cycle of the pulsed X-ray source.

[0013] As an optional solution, the feeding system is configured to uniformly supply the mineral raw material to the distribution device at a predetermined speed, and a slide groove is provided between the feeding system and the distribution device.

[0014] As an optional solution, the distribution device includes one or a combination of two or more of a first conveyor belt arranged horizontally, a second conveyor belt arranged obliquely, and an inclined slide plate arranged at an angle, and the distribution device is configured to receive and transmit the mineral raw material from the feeding system.

[0015] As an optional solution, a plurality of air nozzles are provided and arranged in an array, each of the plurality of air nozzles is connected to a high-frequency electromagnetic valve, and the high-frequency electromagnetic valve is configured to turn on the air nozzle at a corresponding position according to the mineral raw material information.

[0016] As an optional solution, the mineral dry separation apparatus further includes an air supply system connected to the high-frequency electromagnetic valve via an air duct, where the high-frequency electromagnetic valve is connected to each of the plurality of air nozzles via a branch pipe.

[0017] In the mineral dry separation apparatus according to embodiments of the present disclosure, a pulsed X-ray source is adopted. Different from existing continuous X-ray sources, in a same sampling cycle, an ore may be considered to be in a stationary state in a beam emission time period (microsecond level) of the pulsed X-ray source, so that the detector may image more clearly, and the detection data may be more accurate. Furthermore, by controlling a sampling time period of the X-ray detector, it is possible to eliminate an influence of residual fluorescence of a previous X-ray beam remaining in the detector, and thus correct an afterglow in the X-ray detector, so that a detection result may be more accurate, and a separation accuracy and efficiency of the dry separation apparatus may be improved.

[0018] Additional aspects and advantages of the present disclosure may be partially provided in the following description, or partially become clear from the following description, or may be understood through practice of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] Other features, objectives and advantages of the present disclosure will become clear through reading of detailed description of non-restrictive embodiments provided with reference to the accompanying drawings. In the accompanying drawings:

FIG. 1 shows a schematic structural diagram of a mineral dry separation apparatus provided by embodiments of the present disclosure;

FIG. 2 shows a schematic diagram of sampling time periods of an X-ray detector and a pulsed X-ray source in embodiments of the present disclosure;

FIG. 3 shows a detection image obtained in Embodiment 1; and

FIG. 4 shows a detection image obtained in Embodiment 2.

[0020] In the accompanying drawings, 1 represents a feeding system, 2 represents a distribution device, 3 represents a pulsed X-ray source, 4 represents an X-ray detector, 5 represents an air nozzle, 6 represents an air supply system, 7 represents a first collection tank, 8 represents a second collection tank, 9 represents an electronic control system, and 10 represents a slide groove.

DETAILED DESCRIPTION OF EMBODIMENTS

[0021] The present disclosure will be further described in detail below with reference to accompanying drawings and embodiments. It may be understood that specific embodiments described herein are just used to explain the relevant invention rather than to limit the present disclosure. It should be noted that, for the convenience of description, only parts related to the present disclosure are shown in the accompanying drawings.

[0022] It should be noted that, in a case of no conflicts, embodiments and features in embodiments of the present disclosure may be combined with each other. The present disclosure will be described in detail below with reference to the accompanying drawings and in conjunction with embodiments.

[0023] Terms used herein are just for the purpose of describing particular embodiments and are not intended to limit the present disclosure. Singular forms "a", "an", "said" and "the" used in the present disclosure and the appended claims are intended to include plural forms, unless the context clearly indicates otherwise. It should also be understood that the term "and/or" used herein refers to and includes any and all combinations of one or more of the listed related items.

[0024] A mineral dry separation apparatus according to embodiments of the present disclosure will be described below with reference to FIG. 1.

[0025] The mineral dry separation apparatus according to embodiments of the present disclosure may include a feeding system 1, a distribution device 2, an identification device and an actuator, as shown in FIG. 1. The feeding system 1 is located upstream of the distribution device 2, and is used to uniformly supply a mineral raw material to the distribution device 2. The identification device includes a pulsed X-ray source 3 located above the distribution device 2 and an X-ray detector 4 located below the distribution device 2, and the identification device is used to identify a mineral raw material information. The actuator is used to separate the mineral raw material according to the mineral raw material information. In addition, the mineral dry separation apparatus in embodiments of the present disclosure may further include an electronic control system 9, which is used to receive the mineral raw material information sent by the identification device and control the actuator to perform a separating operation according to the mineral raw material information. The actuator may be provided as a plurality of air nozzles 5.

[0026] The mineral dry separation apparatus in embodiments of the present disclosure may build analysis models suitable for different mineral features. The identification device may distinguish mineral raw materials, such as clean coal and gangue, according to physical properties of minerals, and transmit a detected physical property of a mineral and a position information of the mineral on the distribution device 2 to the electronic control system 9. The electronic control system 9 may control a corresponding air nozzle 5 of the actuator to blow. The mineral dry separation apparatus in embodiments of the present application is applicable to separation of various minerals, such as coal ores or metal minerals, and may separate coal ores or metal minerals from impurities contained in the coal ores or metal minerals, thereby improving a quality of separated minerals.

[0027] It should be noted that before separating the mineral raw material, the mineral dry separation apparatus in embodiments of the present disclosure may usually pre-process and remove powdered impurities in the mineral raw material (for example, by using a mineral classifying screen with sieve pores as the feeding system 1), so that the mineral raw material is generally in block or granular form when entering the distribution device 2, thereby reducing dust in a separation process and improving a separation accuracy.

[0028] The feeding system 1 may be a mineral classifying screen, a vibrating feeder or a belt feeder, etc., which is used to receive or store a mineral raw material from outside and output the mineral raw material to the distribution device 2. The feeding system 1 may output the mineral raw material at an arbitrary speed, and may also output the mineral raw material at a predetermined uniform speed.

[0029] The distribution device 2 may receive mineral raw materials from the feeding system 1. The mineral raw materials may be laid flat on the distribution device 2 as much as possible without overlapping, so that the identification device may accurately identify each of the mineral raw materials and distinguish impurities and target minerals, thereby ensuring the separation accuracy. The distribution device 2 may be provided as various types of conveyors or belts according to actual needs, and a setting direction is determined according to a positional relationship between the feeding system 1 and a collection device.

[0030] The identification device includes a pulsed X-ray source 3 provided above the distribution device 2 and an X-ray detector 4 provided below the distribution device 2. The pulsed X-ray source 3 may be an accelerator or an X-ray machine. Unlike a continuous X-ray source that constantly emits the same dose of rays, a pulsed X-ray source may emit rays at a particular frequency (for example, tens of Hz to hundreds of Hz), and each pulse has a very short duration, which is generally several microseconds, such as 2 to 1000 microseconds, 20 to 500 microseconds or 50 to 300 microseconds, and usually 100 to 200 microseconds. Compared to the continuous X-ray source, the pulsed X-ray source has a short beam emission time period, which may be several microseconds, such as a few microseconds. In such time period, the mineral raw material moves very little, and it is equivalent to that the detected ore is stationary, so that the imaging is clearer, and the detection data is more accurate. The X-ray detector 4 may include a digital board and an analog board, and each analog board has a plurality of detector channels. In order to ensure a detector accuracy, detectors may be arranged sequentially with negligible spacing. A plurality of analog boards may be closely arranged to form a detector linear array matched with the distribution device 2 in terms of width. Rays may pass through detected ores and reach the detector. According to a signal received by the detector, it is possible to obtain one of an equivalent atomic information, a density information, a particle size information, an image information or other physical property information of a substance, and also obtain a position information. According to the above equivalent atomic information, density information, particle size information or image information, it is possible to identify and classify the substances (for example, distinguish clean coal and gangue according to the equivalent atomic information), and determine a position of each type of substance by using the position information of the substance. In addition, a crystal size of a detection unit of the X-ray detector 4 may be determined according to a particle size of the mineral raw material, so that the detector may reliably receive the signal and the accuracy of the detection data may be ensured. Generally, a detector with a small crystal size may be used for small mineral particles, and a detector with a large crystal size may be used for large mineral particles. For example, in an embodiment, when the mineral raw materials are coal ore particles with particle sizes of 50 mm to 300 mm, the crystal size of the X-ray detector may be 2.5 mm; when the mineral raw materials are metal ore particles with particle sizes of 10 mm to 80 mm, the crystal size of the X-ray detector may be 1.6 mm.

[0031] The actuator may include a plurality of air nozzles 5. The plurality of air nozzles 5 may have different blowing volumes and may be independently controlled to blow. The plurality of air nozzles 5 may be arranged in an array or uniformly arranged at intervals at an end of the distribution device 2. The identification device may send the identified physical property information and position information of the mineral raw material to the electronic control system 9. The electronic control system 9 may control the air nozzle 5 at a corresponding position to blow according to the received physical property information and position information of the mineral raw material, so as to achieve a separation of the mineral raw material. For example, for the separation of coal minerals, a flow meter thrust of the air nozzle 5 in embodiments of the present disclosure meets a design and selection of a maximum particle size of gangue in the mineral raw material, and a shape of the air nozzle meets a selection of a minimum particle size of a single gangue. In practical use, when the mineral raw material has a small size, the small air nozzle is turned on, and when the mineral raw material has a large size, the large air nozzle is turned on, which may reduce air consumption, save energy and separate more accurately compared with the existing method of using large air nozzles for both large and small mineral raw materials.

[0032] The mineral dry separation apparatus in embodiments of the present disclosure may solve the problem of poor separation accuracy of existing dry separation apparatuses. By providing the pulsed X-ray source and the X-ray detector, the mineral dry separation apparatus in embodiments of the present disclosure may image clearly and detect data more accurately. Moreover, by controlling the sampling time period of the detector, it is possible to eliminate the influence of residual fluorescence of the previous X-ray beam remaining in the detector, thus enabling the correction of an afterglow in the detector, so that the detection result may be more accurate, and the separation accuracy and efficiency of the dry separation apparatus may be improved.

[0033] As an implementable manner, a beam emission frequency of the pulsed X-ray source 3 may be determined according to a transmission speed of the distribution device 2, the crystal size of the X-ray detector 4, and the number of rows of X-ray detectors 4. The number of rows of X-ray detectors 4 refers to the number of rows or columns of X-ray detectors 4 arranged in a transmission direction of the distribution device 2. Specifically, there is the following relation: beam emission frequency=transmission speed/(crystal size of X-ray detector*number of rows of X-ray detectors). In practical use, after the mineral raw materials to be separated are determined, the crystal size of the X-ray detector is fixed. The transmission speed affects a production efficiency on one hand, and affects an imaging effect of the X-ray detector on the mineral raw materials on the other hand. The number of rows of X-ray detectors affects a production cost on one hand, and affects an effect of detecting the mineral raw materials on the other hand. Therefore, considering an optimization of production efficiency and cost, a range of the beam emission frequency determined according to such embodiments is conductive to imaging clearly, and may also help accurately detect each mineral to ensure the accuracy of the detection data.

[0034] It may be understood that the above-mentioned relation may also be expressed as: transmission speed=crystal size of X-ray detector*number of rows of X-ray detectors*beam emission frequency. Therefore, when the beam emission frequency and the crystal size of the X-ray detector are fixed, increasing the number of rows of detectors may increase the transmission speed of the distribution device 2 (such as a movement speed of the belt), which may help increase a separation speed and thus improve the production efficiency.

[0035] As a preferred embodiment, the beam emission frequency of the pulsed X-ray source ranges from 20 Hz to 500 Hz, such as from 50 Hz to 250 Hz, or from 100 Hz to 150 Hz. The beam emission frequency in such embodiments has no special requirements for the particle size of the mineral raw material and may be applied to mineral raw materials with a wide range of particle sizes.

[0036] For example, when the transmission speed is 3 m/s, the number of rows of X-ray detectors is 4 and the crystal size is 2.5 mm, beam emission frequency=transmission speed/(crystal size of detector *number of rows of detectors)=(3 m/s)/(4*2.5 mm)=300 Hz.

[0037] As an implementable manner, two adjacent pulses of the pulsed X-ray source 3 are respectively recorded as a first pulse beam and a second pulse beam, and two adjacent samplings performed by the X-ray detector 4 are respectively recorded as a first sampling and a second sampling. In this case, the X-ray detector 4 is used to perform the first sampling in a first time period and perform the second sampling in a second time period. The first time period is any time period between a time instant after an end of the first pulse beam and a time instant before a start of the second pulse beam, and the second time period is any time period, including a complete beam emission time period of the second pulse beam, between the time instant before the start of the second pulse beam and a time instant after an end of the second pulse beam. In such embodiments, the first sampling is performed by the X-ray detector 4 between two adjacent pulse beams to acquire a detection result of residual fluorescence remaining on crystal of the detector after the end of the first pulse beam, and the second sampling is performed by the X-ray detector 4 to acquire a detection result of the second pulse beam. Therefore, by taking the detection result of the first sampling of the X-ray detector 4 as a background and subtracting the detection result of the first sampling from the detection result of the second sampling, it is possible to eliminate an influence of the residual fluorescence of the pulsed X-ray source remaining in the X-ray detector. Therefore, the use of the pulsed X-ray source may correct an afterglow in the detector (the afterglow refers to the residual fluorescence remaining on the crystal of the detector after the beam emission of the radiation source stops, and the fluorescence may reduce an imaging quality) to ensure that the detection result is more accurate.

[0038] Specifically, as shown in FIG. 2, for a pulse beam P1, the X-ray detector 4 performs the first sampling in a time period t_{10} between a time instant after an end of a pulse beam P0 and a time instant before a start of the pulse beam P1, and a first detection result is obtained. The X-ray detector 4 performs the second sampling in a time period t_{11} including a complete beam emission time period of the pulse beam P1 between the time instant before the start of the pulse beam P1 and a time instant after an end of the pulse beam P1, and a second detection result is obtained. By subtracting the first detection result from the second detection result, it is possible to eliminate an influence of residual fluorescence of the pulse beam P0 remaining in the detector. The time period t_{10} may be equal to the time period t_{11}. Similarly, for a pulse beam P2, the X-ray detector 4 performs a third sampling in a time period t_{20} between the time instant after the end of the pulse beam P1 and a time instant before a start of the pulse beam P2, and a third detection result is obtained. The X-ray detector 4 performs a fourth sampling in a time period t_{21} including a complete beam emission time period of the pulse beam P2 between the time instant before the start of the pulse beam P2 and a time instant after an end of the pulse beam P2, and a fourth detection result is obtained. By subtracting the third detection result from the fourth detection result, it is possible to eliminate an influence of residual fluorescence of the pulse beam P1 remaining in the detector. The time period t_{20} may be equal to the time period t_{21}.

[0039] As an implementable manner, a sum of the first time period and the second time period of the X-ray detector 4 is less than or equal to a beam emission cycle of the pulsed X-ray source. In specific embodiments, a time period between two adjacent samplings of the X-ray detector may be 100 to 500 microseconds, or even longer. It should be noted that, for example, a sampling time period of the first sampling may be less than the first time period, and a sampling time period of the second sampling may be less than the second time period.

[0040] In a preferred embodiment, the feeding system 1 is used to receive mineral raw materials from an external apparatus such as a silo gate, and the feeding system 1 may uniformly supply the mineral raw materials to the distribution device 2 at a predetermined speed. A slide groove 10 is provided between the feeding system 1 and the distribution device 2. In such embodiments, the feeding system 1 may output the mineral raw materials to the distribution device 2 at a predetermined uniform speed, and the slide groove 10 provided between the feeding system 1 and the distribution device 2 may ensure that the mineral raw materials may fall reliably on the distribution device 2 without flying around, thereby reducing waste.

[0041] As an implementable manner, the distribution device 2 includes one or a combination of two or more selected from: a first conveyor belt horizontally arranged, a second conveyor belt obliquely arranged, and an inclined slide plate arranged at an angle. The distribution device 2 is used to receive and transmit the mineral raw materials from the feeding system 1. In such embodiments, a specific structure of the distribution device 2 may be determined according to a positional relationship between the feeding system 1 and a collection device in practical production and processing. In such embodiments, an arrangement of the conveyor belts of the distribution device 2 may meet most operating modes, so that the mineral raw materials may be transmitted reliably and separated into the collection device.

[0042] As an implementable manner, the X-ray detector 4 includes a plurality of rows of detectors, which are uniformly arranged in a length direction of the first conveyor belt. Such embodiments may be implemented to reliably detect the mineral raw material and identify the physical property and substance information of the mineral raw material.

[0043] As an implementable manner, the plurality of air nozzles 5 are arranged in an array, and each air nozzle 5 is connected to a high-frequency electromagnetic valve. The high-frequency electromagnetic valve is connected to the electronic control system 9 and is used to turn on the air nozzle 5 at a corresponding position according to a signal sent by the electronic control system 9. In such embodiments, the air nozzles 5 being distributed in an array may ensure that the electronic control system may control to turn on one or more air nozzles 5 at the corresponding position to achieve the separation after an accurate position of the mineral raw material is detected by the pulsed X-ray source 3 and the X-ray detector 4 in cooperation, no matter where the mineral raw material is located on the distribution device 2. Moreover, providing the high-frequency electromagnetic valve is conducive to achieving reliable turning on and turning off of the air nozzle 5.

[0044] As an implementable manner, the mineral dry separation apparatus further includes an air supply system 6. The air supply system 6 is connected to the high-frequency electromagnetic valve via an air duct, and the high-frequency electromagnetic valve is connected to the air nozzle 5 via a branch pipe. The air supply system 6 in such embodiments is used to provide an air source to the air nozzle 5 to ensure a reliable turning on of the air nozzle 5.

[0045] A specific operating process of the mineral dry separation apparatus of the present disclosure will be described below by examples.

Embodiment 1

[0046] As shown in FIG. 1, the mineral raw materials are supplied to the distribution device 2 through the feeding device 1, and a distribution is completed on the distribution device 2 to achieve a single-layer arrangement of the mineral raw materials, with each mineral block being distanced from adjacent mineral blocks in all directions. The physical property of the mineral block (for example, clean coal or gangue) is determined by the pulsed X-ray source 3 and the X-ray detector 4. The pulsed X-ray source 3 has a beam emission frequency of 300 Hz, a cycle of 3333 microseconds, and a pulse duration of 100 microseconds. Here, the pulse duration is short, so that the imaging is clearer, and the detection data is more accurate. The X-ray detector 4 is provided with eight rows of detectors below the distribution device 2, with a crystal size of 2.5 mm, and the transmission speed of the distribution device 2 is set to 6 m/s. It should be noted that in this case, the distribution device 2 has a greater transmission speed compared with the case that the transmission speed is 3 m/s, the number of rows of detectors for the X-ray detector is 4 and the crystal size is 2.5 mm, which may help improve the separation efficiency and thus improve the production efficiency. A time instant when the first pulse beam is emitted from the pulsed X-ray source 3 is recorded as a time instant t0, a time period of a first sampling is from the time instant t0 to a time instant of t0+1000 microseconds, and a time period of a second sampling is from a time instant of t0+3333 microseconds to a time instant of t0+4333 microseconds. Each sampling result is directly used as a detection result without correction. A detection image obtained by continuously sampling according to the above-mentioned sampling rule is shown in FIG. 3. The obtained physical property and position information of the mineral raw material are output to the electronic control system 9. The electronic control system 9 controls, according to the received physical property and position information, the high-frequency electromagnetic valve to turn on one or more air nozzles at a corresponding position among the air nozzles 5 arranged in an array. The blown gangue is collected in a second collection tank 8, and the clean coal keeps an original movement trajectory and is collected in a first collection tank 7, so that the mineral dry separation process is completed.

Embodiment 2

[0047] Different from Embodiment 1 described above, in this embodiment, the time period of the first sampling of the X-ray detector 4 is from a time instant of t0+2300 microseconds to a time instant of t0+3300 microseconds, the time period of the second sampling of the X-ray detector 4 is from the time instant of t0+3300 microseconds to a time instant of t0+4300 microseconds, and the detection result of the first sampling is subtracted from the detection result of the second sampling. A detection image obtained by continuously sampling according to the above-mentioned sampling rule is shown in FIG. 4.

[0048] As shown in FIG. 3 and FIG. 4, the detection image obtained in Embodiment 2 is clearer than that obtained in Embodiment 1, and the image of the mineral raw material under X-rays is clearly shown inFIG. 4. Therefore, by adopting the sampling time periods in Embodiment 2 and subtracting the detection result of the first sampling from the detection result of the second sampling, it is possible to eliminate the influence of the afterglow of the first pulse beam remaining on the crystal of the detector, so that the captured image is clearer and the detection result is more accurate.

[0049] In summary, the mineral dry separation apparatus in embodiments of the present disclosure has at least the following advantages.

(1) By using the pulsed X-ray source and the X-ray detector, the imaging is clearer and the detection data is more accurate compared with the existing continuous X-ray sources.

(2) The use of pulsed X-rays may help control the sampling time period of the detector. By properly controlling the sampling time period, it is possible to eliminate the influence of residual fluorescence of the previous X-ray beam remaining in the detector, and thus correct the afterglow in the detector, so that the detection result is more accurate, and the separation accuracy and efficiency of the mineral dry separation apparatus may be improved.

[0050] The above descriptions are just preferred embodiments of the present disclosure and explanations of technical principles used. It should be understood by those skilled in the art that the scope of invention involved in the present disclosure is not limited to the technical solutions formed by a specific combination of the above technical features and should also cover other technical solutions formed by any combination of the above technical features or their equivalent features without departing from the inventive concept, such as the technical solutions formed by replacing the above features with technical features having similar functions disclosed in the present disclosure (but not limited thereto).

Claims

1. A mineral dry separation apparatus, comprising: a feeding system, a distribution device, an identification device, and an actuator, wherein the feeding system is located upstream of the distribution device and is configured to supply a mineral raw material to the distribution device, the identification device comprises a pulsed X-ray source located above the distribution device and an X-ray detector located below the distribution device, the identification device is configured to identify a mineral raw material information, and the actuator is configured to separate the mineral raw material according to the mineral raw material information.

2. The mineral dry separation apparatus according to claim 1, further comprising an electronic control system configured to receive the mineral raw material information and control the actuator to perform a separating operation according to the mineral raw material information.

3. The mineral dry separation apparatus according to claim 1, wherein a beam emission frequency of the pulsed X-ray source is determined according to a transmission speed of the distribution device, a crystal size of the X-ray detector and a number of rows of X-ray detectors.

4. The mineral dry separation apparatus according to claim 3, wherein the beam emission frequency of the pulsed X-ray source ranges from 20 Hz to 500 Hz.

5. The mineral dry separation apparatus according to claim 1, wherein the actuator is provided as an air nozzle.

6. The mineral dry separation apparatus according to any one of claims 1 to 5, wherein in case that two adjacent pulses of the pulsed X-ray source are referred to as a first pulse beam and a second pulse beam, and two adjacent samplings performed by the X-ray detector are referred to as a first sampling and a second sampling, the X-ray detector is configured to perform the first sampling in a first time period and perform the second sampling in a second time period, the first time period is any time period from a time

instant after an end of the first pulse beam to a time instant before a start of the second pulse beam, and the second time period is any time period comprising a complete beam emission time period of the second pulse beam from the time instant before the start of the second pulse beam to a time instant after an end of the second pulse beam.

7. The mineral dry separation apparatus according to claim 6, wherein a sum of the first time period and the second time period is less than or equal to a beam emission cycle of the pulsed X-ray source.

8. The mineral dry separation apparatus according to any one of claims 1 to 5, wherein the feeding system is configured to uniformly supply the mineral raw material to the distribution device at a predetermined speed, and a slide groove is provided between the feeding system and the distribution device.

9. The mineral dry separation apparatus according to any one of claims 1 to 5, wherein the distribution device comprises one or a combination of two or more of a first conveyor belt arranged horizontally, a second conveyor belt arranged obliquely, and an inclined slide plate arranged at an angle, and the distribution device is configured to receive and transmit the mineral raw material from the feeding system.

10. The mineral dry separation apparatus according to claim 5, wherein a plurality of air nozzles are provided and arranged in an array, each of the plurality of air nozzles is connected to a high-frequency electromagnetic valve, and the high-frequency electromagnetic valve is configured to turn on the air nozzle at a corresponding position according to the mineral raw material information.

11. The mineral dry separation apparatus according to claim 10, further comprising an air supply system connected to the high-frequency electromagnetic valve via an air duct, wherein the high-frequency electromagnetic valve is connected to each of the plurality of air nozzles via a branch pipe.

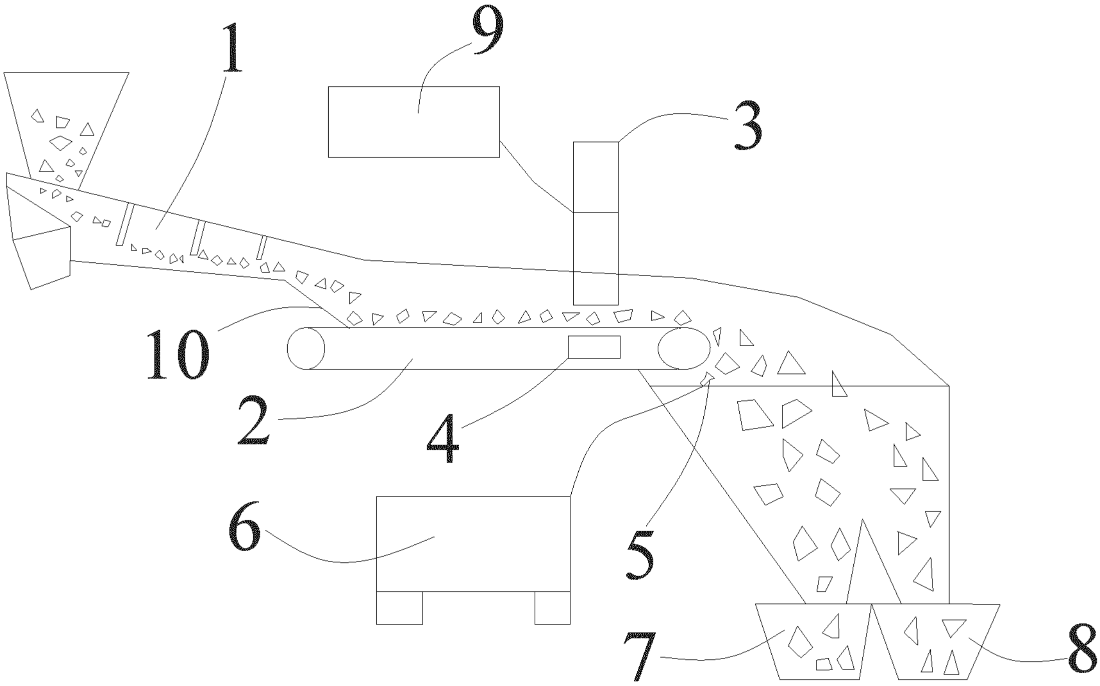

FIG. 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/080757

A. CLASSIFICATION OF SUBJECT MATTER

B07C5/34(2006.01)i;B07C5/36(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC：B07C5

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CJFD, CNTXT, DWPI, ENTXTC, WPABSC: 同方威视技术股份有限公司, 矿物, 干选, 分选, X光, X线, 射线, 脉冲, 脉动, 频率, 荧光, 余辉, 余晖, 噪声, 矫正, 校正; mineral, mine, separat+, sort+, X, ray, pulse, afterglow

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 114602822 A (TSINGHUA NUCTECH TECHNOLOGY CO., LTD.) 10 June 2022 (2022-06-10) claims 1-11	1-11
PX	CN 218502690 U (TSINGHUA NUCTECH TECHNOLOGY CO., LTD.) 21 February 2023 (2023-02-21) claims 1-11	1-11
Y	CN 105268634 A (TIANJIN MEITENG TECHNOLOGY CO., LTD.) 27 January 2016 (2016-01-27) description, paragraphs 0007-0028, and figures 1-2	1-11
Y	RU 10120 U1 (Открытое акционерное общество "Научно-производственное предприятие "Буревестник") 16 June 1999 (1999-06-16) description, page 5 line 19 to page 8 line 25, and figures 1-2	1-11
Y	CN 101937093 A (TSINGHUA NUCTECH TECHNOLOGY CO., LTD.) 05 January 2011 (2011-01-05) description, paragraphs 0007-0034, and figures 1-8	6-7

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 May 2023	**23 May 2023**

Name and mailing address of the ISA/CN	Authorized officer
China National Intellectual Property Administration (ISA/CN) **China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088**	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/080757

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 102958621 A (RESEARCH AND PRODUCTION ENTERPRISE "BOUREVESTNIK") 06 March 2013 (2013-03-06) entire document	1-11
A	CN 112986297 A (COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION) 18 June 2021 (2021-06-18) entire document	1-11
A	US 5666393 A (ANNIS, M.) 09 September 1997 (1997-09-09) entire document	1-11

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/080757

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	114602822	A	10 June 2022	None			
CN	218502690	U	21 February 2023	None			
CN	105268634	A	27 January 2016	WO	2016165442	A1	20 October 2016
				AU	2016249176	A1	30 November 2017
RU	10120	U1	16 June 1999	None			
CN	101937093	A	05 January 2011	None			
CN	102958621	A	06 March 2013	RU	2437725	C1	27 December 2011
				CA	2794395	A1	24 May 2012
				WO	2012067542	A1	24 May 2012
				AU	2011329904	A1	23 August 2012
				GB	2491313	A	28 November 2012
				US	2013126400	A1	23 May 2013
				DE	112011101917	T5	06 June 2013
				JP	5354235	B2	27 November 2013
CN	112986297	A	18 June 2021	CA	3103188	A1	17 June 2021
				AU	2020289837	A1	01 July 2021
				US	2021208087	A1	08 July 2021
US	5666393	A	09 September 1997	None			

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REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- CN 202210315627 **[0001]**