

Description

The present invention pertains to improvement in bulk material analyzers.

Bulk material analyzers are used to measure the elemental content of bulk material. Such analyzers have been developed primarily to measure the quantitative content of materials, such as ash, in batches of coal, but also are useful for measuring the elemental content of the bulk materials. Such development is described in US-A-3942003; US-A-4362939; and US-A-4171485; and the following publications: Stewart and Hall, "On Line Monitoring of Major Ash Elements in Coal Conversion Process," Reprint 789671, October 1978, 13th Intersociety Energy Conversion Engineering Conference, Society of Automotive Engineers, Inc. Warrendale, PA, pp. 586-591; Cekorich et al "Development of an Elemental Analyzer for Coal, Oil and Similar Bulk Streams—A Status Report", 1979 Symposium on Instrumentation and Control Fossil Energy Processes, August 20, 1979, Denver, Colorado, pp 297-313; Yeager "R. & D Status Report, Coal Combustion Systems Division," EPRI Journal; June 1981, pp 32-24; Cooper, "Progress in On-Line Coal Quality Measurement," CQ, January 1984, pp 16-23; and NOLA 1 Data Sheet, "Neutron Activation Analysis for Industrial Process Control, Model NA 79," Texas Nuclear Division of Ramsey Engineering Company, Austin, Texas.

In a typical prior art bulk material analyzer, the bulk material is placed in an activation region between a radiation source and a gamma ray detector, and the detector produces signals which are processed to provide a measurement of the elemental content of the bulk material. Typically the radiation source is a neutron source. When the bulk material is bombarded by the radiation, secondary emissions of gamma rays are produced from the bulk material. Different characteristic gamma ray energy spectra are produced from different elements in the bulk materials. Accordingly, by processing detected signals that are indicative of the gamma ray spectrum a measurement is provided of the elemental content of the bulk material. This measurement process is known in the art as prompt gamma ray neutron activation analysis (PGNAA).

In the bulk material analyzer described in US-A-3942003, the bulk material is received in an activation region within a portable container between a radiation source and a gamma ray detector. The gamma ray detector detects gamma rays that are secondarily emitted by bulk materials which are bombarded by radiation from the source, and produces signals in response to the detected gamma rays. The produced signals are characteristic of the elemental content of said received bulk material. The signals produced by the detector are processed by a processor within a separate compartment within the container to provide a measurement of the elemental content of the received bulk material. The separate com-

partment is shielded from radiation derived from the radiation source; and sealed from the environment outside the separate compartment to protect the processor.

Bulk material analyzers typically are used at the bulk material processing or utilizing facilities. Knowledge of the elemental content is important to determining those operating parameters which will provide optimum material processing. For example, coal analysis enables knowledgeable blending of batches of coal having excessive ash and sulfur content with batches of a coal having lower contents of ash and sulfur. In the prior art of coal processing several discontinuous elemental-content measurements are made for each batch of coal. These measurements are averaged to provide an averaged weighted measurement. Using conventional ASTM sampling and analysis techniques, the desired information typically is not available for several hours.

Such analyzers as have been described require a sample of material to be analyzed. This causes delay before any processing of the material can be carried out on the basis of the analysis. In order to solve this technical problem there have been proposed various systems which allow continuous analysis.

In the bulk material analyzer described in US-A-4362939, the bulk material is transported through an activation region within a chute between a radiation source and a gamma ray detector. The bulk material is fed into the chute from a hopper at the top of the chute and transported away from the chute by a conveyor at the bottom of the chute. Signals produced by the detector are processed to measure the moisture content of the bulk material.

In the system described by Stewart and Hall, which is also known as the Bureau of Mines system, the bulk material is fed through a hopper into a circular cross-section vertical chute. The radiation source is located within the vertical chute and the detector is located outside the chute at the same level as the radiation source.

The preamble of claim 1 is based on the disclosure of US-A-4 266 132, which system is also described in US-A-4 171 485, and by Cekorich et al, and is known as the MDH system. In this system the bulk material is channeled through the activation region in a container by an open-ended vertical chute; and two shielded radiation sources are symmetrically disposed outside the chute on one side of the chute. A single detector is centered outside the opposite side of the chute for detecting gamma rays secondarily emitted by materials that are bombarded by radiation from the radiation source and for producing signals in response to the detected gamma rays, whereby the produced signals are characteristic of the elemental content of the bulk material channeled through the activation region. The produced signals are processed to provide measurements of the elemental content of the channeled bulk material. The described processing technique accumulates gamma ray



counts over a measurement interval and computes the relative concentrations of various elements from this data. It is also proposed to measure the density from the same gamma ray spectrum so that the results can be normalized. If the results are to represent the elemental content of an average lot of bulk material the counts must be accumulated over this period before processing can begin.

In the Bureau of Mines systems the strength of the signals produced by the detector is dependent upon the lateral distribution of the bulk material in the chute. Since bulk materials may exhibit gross segregation by particle size and density as they pass through the chute, the distribution of elemental content is generally quite inhomogeneous. Thus there is a degree of inaccuracy in the measurements provided by processing the detector-produced signals. Such inaccuracy is proportional to the inhomogeneity of the bulk material multiplied by the spatial nonuniformity of the detector response. Therefore it is seen that the adoption of continuous processing to solve the technical problem of delay has introduced the possibility of a further technical problem, which may also arise from different causes, that parameters of the material being analyzed may vary due to the flow process as well as due to long term variations.

In order to solve this technical problem the present invention provides the features set out in the characterising clause of claim 1.

These continuous, real-time, weighted-average measurements are immediately available at the site of the portable bulk material analyzer of the present invention. As a result, batches of coal having different sulfur and ash contents can be blended on a timely basis and/or plant operating parameters can be quickly adjusted to optimize material processing.

The accuracy of the weighted-average measurements depends upon maintaining a nearly uniform cross-sectional density of bulk material within the activation region.

Preferably an input hopper is located at the top of a vertical chute for receiving bulk material that is channeled by the chute for receiving bulk material that is channeled by the chute through the activation region. A nearly uniform cross-sectional density of the bulk material within the activation region is maintained for so long as the level of the bulk material with the hopper is maintained at least a predetermined minimum distance above the activation region. A sensor senses the level of the bulk material within the hopper. A controller is coupled to the sensor and to an apparatus for feeding the bulk material from the bottom of the hopper for controlling the feed rate in order to maintain the level of the bulk material within the hopper at least the predetermined minimum distance above the activation region. When the bulk material is coal the minimum distance is approximately 1.2 m (four feet).

Additional features of the present invention are

discussed in relation to the description of the preferred embodiment.

Brief description of the drawing

Figure 1 is a partially cut away perspective view of a preferred embodiment of a portable bulk material analyzer according to the present invention.

Figure 2 is a cut-away side view of the bulk material analyzer of Figure 1, including block diagrams indicating the location of certain radiation sources and detectors.

Figure 3 is a cut-away top view of the bulk material analyzer of Figure 1, including block diagrams showing the locations of the PGNA radiation sources and detectors.

Figure 4 is a block diagram illustrating the processing and control functions of the signal processing equipment in the bulk material analyzer of Figure 1.

Description of the preferred embodiment

Referring to Figures 1, 2 and 3, the preferred embodiment of the bulk material analyzer of the present invention essentially includes a portable container 10. The container is approximately 2.40 m (eight feet) wide by 3 m (ten feet) long by 2.4 m (eight feet) high. The dimensions stated herein are particularly applicable to a coal analyzer and may differ for analyzers of other types of bulk materials in accordance with the physical characteristics of the bulk material, such as flowability.

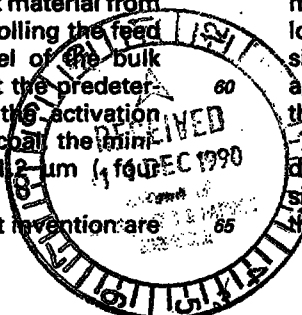
The bottom 11 of the container 10 is a steel platform which is equipped with mounting pads (not shown) on the underside. The container 10 can be lifted for movement from one installation to another.

An open-ended vertical chute 12 extends through the container 10. An input hopper 14 is fastened to the top of the chute 12 for receiving bulk material 16 that is channeled through the chute 12. The bulk material 16, such as coal, is fed into the hopper 14 by an input conveyor 18 and is fed away from the bottom of the chute 12 by an output conveyor 20.

The chute 12 is particularly dimensioned in accordance with the flow characteristics of coal; and thereby has a rectangular cross section of approximately 30 cm x 90 cm (one foot by three feet) to assure that coal which is up to 10 cm (4-inch) top size will flow therethrough without plugging or bridging within the chute 12. It has been found that coal can be channeled through a chute of these dimensions without having to first crush, riffle and dry the coal.

Three neutron radiation sources 22 are symmetrically disposed on and outside one of the long sides of chute 12 from one end of the one side 24 to the other end. The sources 22 are aligned (directionally collimated) normal to the three-foot long sides of the chute 12.

Two gamma ray detectors 26 are symmetrically disposed on and outside the other of the long sides of the chute between positions opposing the positions of the sources 22 on the one side 24



of the chute 12. The detectors 26 are aligned (directionally collimated) normal to the long sides of the chute 12.

The sources 22 and the detectors 26 are aligned in a common plane which is approximately 90 cm (three feet) above the bottom of the chute 12. The region between the sources 22 and the detectors 26 is referred to herein as the activation region 28.

The detectors 26 detect gamma rays that are secondarily emitted by materials in the activation region 28 that are bombarded by neutron radiation from the sources 22. The detectors 26 produce signals in response to the detected gamma rays. These produced signals are characteristic of the elemental content of the bulk material in the activation region 28.

The three sources 22 and two detectors 26 are relatively disposed as described above for causing the measurements to be independent of the lateral distribution of the bulk material 16 in the chute 12.

The bulk material analyzer further includes signal processing equipment 30 for combining and processing the signals produced by the detectors 26 to provide a measurement of the elemental content of the bulk material that is channeled through the activation region 28 by the chute 12. The signal processing equipment 30 is located within a separate compartment 32 within the container 10. The separate compartment 32 is sealed from the environment outside the separate compartment 32 to protect the signal processing equipment 30 from dust and weather conditions outside the separate compartment 32.

The container 10 further includes an air conditioner 34 which is coupled to the separate compartment 32 by ducts (not shown) for maintaining a predetermined temperature range within the separate compartment 32.

The container 10 further includes a room 36 which may be entered by a door 38 to admit an operator. The room 36 includes a display panels and controls (not shown) for operating the signal processing equipment 30 and connection points for remote display panels and controls.

In order to maintain a nearly uniform cross-sectional density of bulk material 16 in the activation region 28 within the chute 12, it is necessary to maintain the level of the bulk material 16 within the hopper 14 at least a predetermined minimum distance above the activation region 28. When the bulk material is coal, for a chute having a 30 cm by 90 cm (one-foot by three-foot) cross sectional dimension, this predetermined minimum distance is approximately 120 cm (four feet).

A level sensor 40 is positioned in the hopper 14 for sensing the level of the bulk material within the hopper 14. The level sensor 40 provides a signal on line 42 to flow rate controller 44 (Figure 4), which in turn provides control signals on lines 46 and/or 48 to motors 50 and 52 which respectively drive the input conveyor 18 and the output conveyor 20 at a variable rate in accordance with the control signals provided on lines 46 and 48. The flow rate controller 44 controls the feed rate

of the output conveyor 20 to maintain the level of the bulk material 16 within the hopper 14 at least the predetermined minimum distance above the activation region 28 in order to maintain a nearly uniform cross-sectional density of bulk material 16 within the activation region.

The flow rate controller 44 may control the feed rate of the input conveyor 18 to be approximately the same as that of the output conveyor 20 so as to maintain a continuous flow of bulk material through the chute 12.

The flow rate controller 44 further responds to the signal on line 42 from the level sensor 40 by controlling the feed rate of the conveyors 18, 20 to prevent the level of the bulk material 16 in the hopper 14 from exceeding a predetermined maximum level.

The signal processing equipment continuously processes the signals produced by the detectors 26 to provide periodic measurements of the elemental content of the bulk material 16 channeled through the activation region 28 by the chute 12. In the preferred embodiment these measurements are provided every one minute. The signal processing equipment 30 further provided a weighted average measurement of the elemental content of the bulk material over time periods representing average lots of the bulk material. To perform this function a measurement is made of the mass of bulk material 16 transported through the activation region 28 during each periodic measurement interval. To make this measurement of mass, measurements are made of the flow rate and density of the bulk material being channeled through the chute 12.

Density gauges are located adjacent the chute 12 approximately equidistant above and below the activation region 28. Each density gauge includes a gamma ray radiation source 54 and a gamma ray detector 56. The detectors provide signals indicating the density of the bulk material in the chute 12 and are hereinafter referred to as "density detectors" 56. The detectors 26 adjacent the activation region 28 are hereinafter referred to as "PGNAA detectors" 26.

Referring to Figure 4, the signals produced by the two PGNAA detectors 26 are provided on lines 57 to count rate circuits 58 and 59 which provide PGNAA count rate signals R_1 and R_2 on lines 60 and 61 respectively. The signals produced by the two density detectors 56 are provided on lines 62 to count rate circuits 63 and 64 which provide density count rate signals R_{d1} and R_{d2} on lines 65 and 66 respectively.

The flow rate controller 44 provides a velocity signal V on line 67 to indicate the feed rate of the output conveyor 20, which corresponds to the flow rate of the bulk material 16 through the chute 12.

The signal processing equipment 30 processes the PGNAA count rate signals R_1 and R_2 on lines 60 and 61, the density count rate signals R_{d1} and R_{d2} on lines 65 and 66 and the velocity signal on line 67 to provide a weighted average measurement W_{ia} of the elemental content of the

bulk material over measurement intervals $P=t_2-t_1$, as shown in Figure 4.

The elemental content measurement W_i is provided by processing the PGNAA count rate signals R_1 and R_2 on lines 60 and 61 together with an internally provided bulk material density measurement "d" in accordance with the following equation:

$$W_i = \left[\sum_{k=1}^N A_{ik} \sum_{j=1}^M Y_{ij} R_{ij} - B_{ik} \right] / [dN] \quad (\text{Equation 1})$$

where:

i =Element index;

j =Major gamma ray energies associated with element i ;

k =PGNAA detector index;

W_i =Percent by weight of element i in the total bulk material;

d =The density of the total bulk material;

N =Number of PGNAA detectors;

Y_{ij} =Yield factor of element i for production of gamma rays j which can be detected by the PGNAA detectors and discerned by the count rate circuits 58, 59 per unit of neutron source strength. The yield factor Y_{ij} is the product of the reaction probability factor for element i to emit prompt gamma rays j upon stimulus of a neutron source, the detector intrinsic and geometrical efficiency factors for gamma rays from element i , and any material attenuation factors influencing the transmission of the gamma rays j from the point of creation in the bulk material to the detector;

R_{ij} =Net count rate of gamma rays of energy j detected by the PGNAA detectors and discerned by the count rate circuits 58, 59 as possessing energy j and as emanating from element i ;

A_{ik} =Product of the overall system calibration factor from element i including effective neutron source of strength; and

B_{ik} =Element offset factor to account for the contribution of the measured signal from those elements which are also present in the constituents of the coal analyzer which surround the chute in the vicinity of the bulk material being measured.

Both A_{ik} and B_{ik} are determined by measuring bulk material standards and performing least square fit to the known weight percent of composite elements to the measured responses W_i of composite elements.

The density "d" measurement is provided by processing the density count rate signals R_{d1} and R_{d2} on lines 65 and 66 together with an internally provided indications "u" of the mean mass attenuation coefficient for the bulk material being measured in accordance with the following equation:

$$d = \sum_{k=1}^N \frac{A_k \ln [R_{ko}/R_{kt}]}{uDN}, \quad (\text{Equation 2})$$

where:

R_{kt} =Count rate measured by density detector k when bulk material is present in the chute;

R_{ko} =Count rate measured by density detector k when vertical chute is void of all material;

N =Number of density detectors;

A_k =Overall calibration constant for density gauge k including Compton Scattering buildup factor;

D =Inside dimensions of vertical chute between density detector 56 and gamma ray source 54 for density gauge k ; and

u =Mean mass attenuation coefficient for the bulk material being measured.

Coefficient "u" indication is provided by processing the elemental content measurements W_i in accordance with the following equation:

$$u = \sum_{i=1}^M \frac{W_i U_i}{100}, \quad (\text{Equation 3})$$

where:

W_i =Weight percent of the element i ;

U_i =Known mass attenuation coefficient for element i at the energy of the density gauge source gamma rays.

A periodic measurement T_p of the mass of the bulk material is provided by periodically processing the density indication d and the velocity signal V on line 67 over a measurement interval $p=t_2-t_1$ in accordance with the following equation:

$$T_p = KWh \int_{t_1}^{t_2} d(t) V(t) dt \quad (\text{Equation 4})$$

where:

$d(t)$ =Bulk material density over the interval t_1 to t_2 ;

$V(t)$ =Linear speed of outer conveyor;

W =Width of bulk material loading on the output conveyor;

h =Height of bulk material loading on the output conveyor; and

K =Calibration factor to compensate for the differences between density as measured in the chute and density of bulk material on the output conveyor.

Equation 4 is applicable only if the level of the bulk material 16 in the hopper 14 is maintained at least the aforementioned predetermined distance above the activation region 28.

The weighted average measurement W_{ia} of the elemental content of the bulk material over a time period NP representing an average lot of bulk material is provided by processing the measured periodic mass indication T_p together with the elemental content measurements W_i in accordance with the following equation:

$$W_{ia} = \sum_{p=1}^N W_{ip} T_p / \sum_{p=1}^N T_p \quad (\text{Equation 5})$$

where:

W_{ip} = Weight percentage for element i determined during measurement interval p ;

T_p = Mass of bulk material measured during interval p ; and

N = Number of measurement intervals p .

The signal processing equipment further processes the weighted average measurements of the elemental content of the bulk material to provide measurements of the bulk material characteristics.

Referring again to Figures 1, 2 and 3, a radiation shielding material 70 fills the volume of the compartment 72 within the container 10 surrounding the chute 12, the neutron sources 22, the gamma ray sources 54, the PGNAA detectors 26 and the density detectors 56 up to a height above the upper density gauge. The shielding material 70 shields the separate compartment 32 and the signal processing equipment 30 therein from radiation derived either primarily or secondarily from the radiation sources 22 and 54.

The compartment 72 is sealed from the environment outside the container 10 to protect the radiation sources 22, 54 and detectors 26, 56 from dust and weather conditions outside the container and from damage resulting from contact with the bulk material 16.

Claims

1. A bulk material analyzer comprising a radiation source (22); a gamma ray detector (26) for detecting gamma rays secondarily emitted by materials that are bombarded by radiation from the radiation source and for producing signals in response to the detected gamma rays; means (12) for continuously transporting bulk material through an activation region (28) between the radiation source (22) and the detector (26), whereby said produced signals are characteristic of the elemental content of said transported bulk material; means (54, 56, 62, 63, 64, 65, 66) for measuring and indicating the density (d) of said bulk material transported through the activation region (28); means (57, 58, 59, 60, 61) for processing said produced signals to provide measurements (W_i) of the elemental content of said transported bulk material; characterised in that the measurements of density (d) and elemental content (W_i) are produced continuously, and in that the analyzer further comprises means for continuously measuring the velocity (v) of transport of the bulk material, means for processing the density and velocity measurements (d , v) for providing periodic measurements (T_p) of the mass of said transported bulk material during a periodic measurement interval (P), and for further processing said elemental content measurements (W_i) during each periodic measurement interval

(P) together with said periodic measurements (T_p) of the mass over several (N) measurement intervals (P) to provide a weighted average measurement (W_{ia}) of the elemental content of said bulk material over time periods (NP) representing average lots of said bulk material.

2. An bulk material analyzer according to claim 1, wherein the transporting means comprises an open-ended vertical chute (12) through the container for channeling bulk material fed from outside the container through the activation region and hence to outside the container; characterized by

an input hopper (14) at the top of the chute for receiving the bulk material that is channeled through the chute;

means (40) for sensing the level of the bulk material within the hopper;

means (2) for feeding said bulk material from the bottom of the chute at a variable rate; and

means (44, 52) coupled to the sensing means and the feed means for controlling the feed rate of the feed means to maintain the level of the bulk material within the hopper at least a predetermined minimum distance above the activation region (28) in order to maintain a nearly uniform cross-sectional density of bulk material within the activation region.

Patentansprüche

1. Shüttgut-Analysiervorrichtung, die eine Strahlungsquelle (22), einen Gammastrahlungsdetektor (26) zum Detektieren der Gammastrahlen, die durch die Materialien sekundär emittiert werden, welche mit der Strahlung von der Strahlungsquelle getroffen werden, wobei der Detektor Signale in Abhängigkeit von den detektierten Gammastrahlen erzeugt, die eine Einrichtung (12) zum kontinuierlichen Fördern des Schüttguts durch einen Aktivierungsbereich (28) zwischen der Strahlungsquelle (22) und dem Detektor (26), wobei die erzeugten Signale für den Elementargehalt des geförderten Schüttgutes charakteristisch sind, eine Einrichtung (54, 56, 62, 63, 64, 65, 66) zum Messen und Anzeigen der Dichte (d) des durch den Aktivierungsbereich (28) geförderten Schüttgutes, und eine Einrichtung (57, 58, 59, 60, 61) zum Verarbeiten der erzeugten Signale aufweist, um Messungen (W_i) des Elementargehalts des geförderten Schüttgutes vorzunehmen, dadurch gekennzeichnet, daß die Messungen der Dichte (d) und des Elementargehalts (W_i) kontinuierlich vorgenommen werden, und daß die Analysiervorrichtung ferner eine Einrichtung zum kontinuierlichen Messen der Fördergeschwindigkeit (v) des Schüttgutes, eine Einrichtung zum Verarbeiten der Dichte- und Geschwindigkeitsmessungen (d , v) zur Bereitstellung von periodischen Messungen (T_p) der Masse des geförderten Schüttgutes während eines periodischen Meßintervalls (P), und ferner zum Verarbeiten der Elementargehaltsmessungen (W_i) während jedes periodischen Meßintervalls (P) zusammen mit den periodischen Messungen (T_p) der Masse über

$$W_{ia} = \sum_{p=1}^N W_{ip} T_p / \sum_{p=1}^N T_p \quad (\text{Equation 5})$$

where:

W_{ip} = Weight percentage for element i determined during measurement interval p ;

T_p = Mass of bulk material measured during interval p ; and

N = Number of measurement intervals p .

The signal processing equipment further processes the weighted average measurements of the elemental content of the bulk material to provide measurements of the bulk material characteristics.

Referring again to Figures 1, 2 and 3, a radiation shielding material 70 fills the volume of the compartment 72 within the container 10 surrounding the chute 12, the neutron sources 22, the gamma ray sources 54, the PGNAAs detectors 26 and the density detectors 56 up to a height above the upper density gauge. The shielding material 70 shields the separate compartment 32 and the signal processing equipment 30 therein from radiation derived either primarily or secondarily from the radiation sources 22 and 54.

The compartment 72 is sealed from the environment outside the container 10 to protect the radiation sources 22, 54 and detectors 26, 56 from dust and weather conditions outside the container and from damage resulting from contact with the bulk material 16.

Claims

1. A bulk material analyzer comprising a radiation source (22); a gamma ray detector (26) for detecting gamma rays secondarily emitted by materials that are bombarded by radiation from the radiation source and for producing signals in response to the detected gamma rays; means (12) for continuously transporting bulk material through an activation region (28) between the radiation source (22) and the detector (26), whereby said produced signals are characteristic of the elemental content of said transported bulk material; means (54, 56, 62, 63, 64, 65, 66) for measuring and indicating the density (d) of said bulk material transported through the activation region (28); means (57, 58, 59, 60, 61) for processing said produced signals to provide measurements (W_i) of the elemental content of said transported bulk material; characterised in that the measurements of density (d) and elemental content (W_i) are produced continuously, and in that the analyzer further comprises means for continuously measuring the velocity (v) of transport of the bulk material, means for processing the density and velocity measurements (d , v) for providing periodic measurements (T_p) of the mass of said transported bulk material during a periodic measurement interval (P), and for further processing said elemental content measurements (W_i) during each periodic measurement interval

(P) together with said periodic measurements (T_p) of the mass over several (N) measurement intervals (P) to provide a weighted average measurement (W_{ia}) of the elemental content of said bulk material over time periods (NP) representing average lots of said bulk material.

2. An bulk material analyzer according to claim 1, wherein the transporting means comprises an open-ended vertical chute (12) through the container for channeling bulk material fed from outside the container through the activation region and hence to outside the container; characterized by

an input hopper (14) at the top of the chute for receiving the bulk material that is channeled through the chute;

means (40) for sensing the level of the bulk material within the hopper;

means (2) for feeding said bulk material from the bottom of the chute at a variable rate; and

means (44, 52) coupled to the sensing means and the feed means for controlling the feed rate of the feed means to maintain the level of the bulk material within the hopper at least a predetermined minimum distance above the activation region (28) in order to maintain a nearly uniform cross-sectional density of bulk material within the activation region.

Patentansprüche

1. Schüttgut-Analysiervorrichtung, die eine Strahlungsquelle (22), einen Gammastrahlungsdetektor (26) zum Detektieren der Gammastrahlen, die durch die Materialien sekundär emittiert werden, welche mit der Strahlung von der Strahlungsquelle getroffen werden, wobei der Detektor Signale in Abhängigkeit von den detektierten Gammastrahlen erzeugt, die eine Einrichtung (12) zum kontinuierlichen Fördern des Schüttguts durch einen Aktivierungsbereich (28) zwischen der Strahlungsquelle (22) und dem Detektor (26), wobei die erzeugten Signale für den Elementargehalt des geförderten Schüttgutes charakteristisch sind, eine Einrichtung (54, 56, 62, 63, 64, 65, 66) zum Messen und Anzeigen der Dichte (d) des durch den Aktivierungsbereich (28) geförderten Schüttgutes, und eine Einrichtung (57, 58, 59, 60, 61) zum Verarbeiten der erzeugten Signale aufweist, um Messungen (W_i) des Elementargehalts des geförderten Schüttgutes vorzunehmen, dadurch gekennzeichnet, daß die Messungen der Dichte (d) und des Elementargehalts (W_i) kontinuierlich vorgenommen werden, und daß die Analysiervorrichtung ferner eine Einrichtung zum kontinuierlichen Messen der Fördergeschwindigkeit (v) des Schüttgutes, eine Einrichtung zum Verarbeiten der Dichte- und Geschwindigkeitsmessungen (d , v) zur Bereitstellung von periodischen Messungen (T_p) der Masse des geförderten Schüttgutes während eines periodischen Meßintervalls (P), und ferner zum Verarbeiten der Elementargehaltsmessungen (W_i) während jedes periodischen Meßintervalls (P) zusammen mit den periodischen Messungen (T_p) der Masse über



einige (N) Meßintervalle (P) hinweg dient, um eine gewichtete Durchschnittsmessung (W_{ia}) des Elementargehalts des Schüttguts über Zeitperioden (NP) hinweg zu erhalten, die Durchschnittsmengen des Schüttguts wiedergibt.

2. Schüttgut-Analysiervorrichtung nach Anspruch 1, bei der die Fördereinrichtung eine offenendige, vertikale Schüttrinne (12) durch den Behälter zum Führen des von der Außenseite des Behälters zugeführten Schüttgutes durch den Aktivierungsbereich und somit zu der Außenseite des Behälters aufweist,

gekennzeichnet durch

einen Aufgabetrichter (14) am oberen Ende der Schüttrinne zur Aufnahme des Schüttgutes, das durch die Schüttrinne geführt wird,

eine Einrichtung (40) zum Erfassen der Standhöhe des Schüttgutes im Trichter,

eine Einrichtung (2) zur Förderung des Schüttguts von der Bodenseite der Schüttrinne mit einer variablen Rate, und

eine Einrichtung (44, 52), die mit der Erfassungseinrichtung und der Fördereinrichtung zum Steuern der Aufgaberate der Fördereinrichtung verbunden ist, um die Standhöhe des Schüttgutes in dem Trichter wenigstens auf einem vorbestimmten, minimalen Abstand oberhalb des Aktivierungsbereiches (28) zu halten und eine nahezu gleichmäßige Querschnittsdichte des Schüttgutes in dem Aktivierungsbereich aufrechtzuerhalten.

Revendications

1. Analyseur de matériau en vrac comprenant une source de rayonnement (22), un détecteur de rayons gamma (26) pour détecter les rayons gamma émis secondairement par les matériaux bombardés par le rayonnement en provenance de la source de rayonnement et pour produire des signaux en réponse aux rayons gamma détectés, des moyens (12) pour transporter de façon continue un matériau en vrac à travers une région d'activation (28) entre la source de rayonnement (22) et le détecteur (26) d'où il résulte que les signaux produits sont caractéristiques de la teneur élémentaire du matériau en vrac transporté, des moyens (54, 56, 62, 63, 64, 65, 66) pour

mesurer et indiquer la densité (d) du matériau en vrac transporté à travers la région d'activation (28), des moyens (57, 58, 59, 60, 61) pour traiter les signaux produits et produire des mesures (W_i) de la teneur élémentaire du matériau en vrac transporté, caractérisé en ce que les mesures de densité (d) et de teneur élémentaire (W_i) sont effectuées en continu et en ce que l'analyseur comprend en outre des moyens pour mesurer de façon continue la vitesse (v) du transporteur de matériau en vrac, des moyens pour traiter les mesures de densité et de vitesse (d, v) pour produire des mesures périodiques (T_p) de la masse du matériau en vrac transporté pendant un intervalle de mesure périodique (P) et pour traiter en outre les mesures de teneur élémentaire (W_i) pendant chaque intervalle de mesure périodique (P) avec les mesures périodiques (T_p) de la masse sur plusieurs (N) intervalles de mesure (P) pour procurer une mesure moyenne pondérée (W_{ia}) de la teneur élémentaire du matériau en vrac sur des périodes de temps (NP) représentant des lots moyens de ce matériau en vrac.

2. Analyseur de matériau en vrac selon la revendication 1, dans lequel les moyens de transport comprennent une goulotte verticale à extrémités ouvertes (12) à travers le conteneur pour canaliser la matière en vrac amené de l'extérieur du conteneur à travers la région d'activation et de là, à l'extérieur du conteneur, caractérisé par:

—un trémie d'amenée (14) en haut de la goulotte pour recevoir le matériau en vrac qui est canalisé à travers la goulotte;

—des moyens (40) pour détecter le niveau du matériau en vrac à l'intérieur de la trémie;

—des moyens (20) pour évacuer le matériau en vrac du bas de la goulotte à un débit variable; et

—des moyens (44, 52) couplés aux moyens de détection et aux moyens d'amenée pour régler le débit des moyens d'amenée afin de maintenir le niveau du matériau en vrac à l'intérieur de la trémie à au moins une distance minimale prédéterminée au-dessus de la région d'activation (28) afin de maintenir à l'intérieur de la région d'activation une densité du matériau en vrac pratiquement uniforme en section transversale.

