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(54) **A GRINDING MILL AND MATERIAL WEIGHT DETERMINING METHOD FOR THE SAME**
TROMMELMÜHLE UND VERFAHREN ZUM ERMITTELN DES MATERIALGEWICHTS DAFÜR
BROYEUR TUBULAIRE ET PROCÉDÉ ASSOCIÉ POUR DÉTERMINER LE POIDS DE MATÉRIAU

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Description**TECHNICAL FIELD**

5 **[0001]** The present invention relates to a method and device for measurement of amount of material inside a grinding mill.

PRIOR ART

10 **[0002]** Comminution operations for the mineral ores may require a series of subsequent operations to be performed, e.g. pre-crushing, grinding to obtain a final product. Jaw crushers, disc crushers, hammer mills or roller ball mills are used to gradually comminute ore. Milling operations require great amount of energy for example 2.2 kwh/tonne for crushing and 11.6 for grinding operations.

15 **[0003]** US5551639 explain a method and apparatus for crushing and fine grinding of solid particulate materials used in cement utilizing a conventional ball mill to decrease energy consumption. Particulate material is fed to a first chamber of the grinding mill where the crushing takes place, then the material is fed to the second chamber for a secondary crushing down to the required fineness appropriate for a jet mill (e.g. down to $S=1.200-1.300 \text{ cm}^2/\text{gr}$ or $3.600 \text{ cm}^2/\text{gr}$ for conventional ball mills). Then the material fed to the filter system via pipe and delivered to the silos.

20 **[0004]** Defining the material amount inside a grinding mill is necessary to design a better controller for the system which is required for energy efficiency. In order to obtain material amount, microphone systems are widely used. DE19933995 discloses a measurement system for observing a mass inside a ball mill using microphones directly attached to the wall of the mill shell.

25 **[0005]** The system analyzes intensity and spectra of the noise and combines it with measurements of the phase angle of the mill to gain additional information about the movement of balls inside the mill. System does not provide accurate information due to the interferences of other noises such as an additional grinding mill arranged next to the current one. US-3253744-A and US-6619574-B1 disclose drum mills comprising support structures with strain gauge weight sensors.

BRIEF DESCRIPTION OF THE INVENTION

30 **[0006]** The object of the present invention is providing instant and accurate weight information from a grinding mill.

35 **[0007]** In order to realize the abovementioned object, a grinding mill according to claim 1 is provided. The grinding mill comprises a drum wherein a plurality of balls are disposed in a freely movable manner having an inlet to feed particulate material inside the drum and an outlet to transfer fine material after grinding. A strain sensor is adapted to the drum so that providing a data to determine weight information of the drum. Strain sensor will determine any weight changes on the drum by measuring deflection of the drum due to the loads, e.g. balls or the material to be grinded. According to the invention the strain sensor is mounted at an outer periphery of the drum. Outer periphery show the more deflection than the inner periphery therefore strain sensor can provide more accurate data based on higher deflection value. The strain sensor may be attached on a mounting plate which is secured to the outer periphery of the drum. Mounting plate provide modularity to easily secure the strain sensor to the drum and also in some aspects protects strain sensor, e.g. strain gauge, as a heat shield to reduce heat transfer from outer periphery to the strain sensor.

40 **[0008]** The strain sensor is connected to a transmitter which is transmitting the data to a receiver in data communication with a controller. The data provided by the strain sensor to the transmitter is a voltage value which has a linear change while the drum is rotating. After a calibration, e.g. comparing the known weight value of the balls with the output signal of the strain sensor, material weight inside the drum during the grinding process can be estimated by the voltage difference.

45 **[0009]** The transmitter has a wireless signal module which is in communication with the receiver having a corresponding wireless module to transmit the data from drum to a remote location. The remote location can be an operation room where various types of operations value for optimization of the processes are collected.

50 **[0010]** A power module may be connected to the strain sensor energize the strain sensor upon start of the grinding process. Power module prevents use of cable harness or any other relevant installation and simplify construction to reduce maintenance requirement. The power module may comprise a regenerative power source. This could be solar panels, kinetic or thermal power generator. Considering the heat on the drum which can be as high as 70°C thermal energy generator or combination of other types can recharge power module which comprises batteries. The power module may be electrically connected to the wireless signal module providing electricity to the wireless signal module during data transmission.

55 **[0011]** The drum may be divided into a first chamber and at least one second chamber wherein the strain sensor is having a first measurement element and a second measurement element corresponding to each of the first chamber and the second chamber to provide the data independent from each other. Alternatively, drum can be one chamber or can be divided more than two chambers. For the latter, each one of the chambers has its own strain sensor provided at

the outer periphery of the corresponding chamber.

[0012] The distance between the transmitter and the first measurement element or the second measurement element may be substantially equal. This provide any signal losses between two chambers during the transmission of the signal are similar to each other so that information obtained using the data from each one of the chambers is more reliable.

[0013] The strain sensor may be arranged on the drum at a vicinity of the center of gravity of the drum or each one of center of gravity of the first chamber or the second chamber. The center of gravity has the maximum deflection on the drum which will provide more accurate measurement by the strain sensor. In a possible embodiment, strain sensor is aligned at the middle of the length direction. In a possible embodiment, number of the chambers can be more than two, for example three, and more than one strain sensor can be adapted to the each one of the chambers. Distribution of the strain sensors in each chamber can be equal. For example, if there are two strain sensors available for each one of the chambers of the drum, the angle between strain sensors will be 180°. On the other hand, one strain sensor can be utilized for more than one chambers, e.g. two chambers.

[0014] The strain sensor may be mounted on a plate of the drum by means of a mounting plate having a fastening device adapted to the corresponding holes on the plate. Plate can be one of the plates forming the drum which is known as liners for the grinding mills which is better understood by a reference to US3804346.

[0015] In order to achieve above mentioned objective, invention provides also a method according to claim 9. Hence the system is ready and the drum can be loaded with the material to be grained. Strain sensor term in the description cover particularly, strain gauges of any suitable type or piezosensors or similar other types of the sensors not listed in here.

BRIEF DESCRIPTION OF THE FIGURES

[0016]

Figure 1 is the partial cross-sectional view of a drum with two chambers according to a representative embodiment of a subject matter grinding device.

Figure 2a is a schematic view of a transmitter mounted on the drum of Fig. 1

Figure 2b is a schematic view of a receiver wirelessly communicating with the transmitter of Fig. 2a.

Figure 2c is a partial cross-section of a mounting plate on the drum of a grinding device where the strain sensor is mounted with a fastening element.

Figure 3 is a cross-sectional view of the drum from transverse direction where the plates of the drum and the strain sensor mounted is shown.

THE DETAILED DESCRIPTION OF THE INVENTION

[0017] In this detailed description, the subject matter improvement is explained with references to examples without forming any restrictive effect only in order to make the subject more understandable.

[0018] In Figure 1, a drum (10) of a grinding device is shown from a side view. The drum (10) is rotated by an electric motor (not shown) in the longitudinal axis. The drum (10) is fed intermittently with clinkers, gypsum and other additives from a feeding device via an inlet (12) providing access inside the drum (10). The drum (10) is in a tube form defining an inner space which is separated to a first chamber (11) and a subsequent second chamber (13) by means of a diaphragm (20) which is a vertical wall allowing semi-grinded particles to move from the first chamber (11) to the second chamber (13). A plurality of metal balls (30) are disposed inner volume of the drum (10) in a freely movable manner. The first chamber (11) contain large balls (32) which have outer diameters between 90 to 60 mm. Second chamber (13) contain small balls (34) have outer diameters between 40 to 20 mm. Due to the weight of the balls (30), they are accumulated at a bottom side (15) of the inner volume of the drum (10). Ground fine product is removed from an outlet (14) of the drum (10). The inlet (12) and the outlet (14) are arranged at the two opposite ends of the drum (10).

[0019] A strain sensor (80) is mounted on the outer periphery (18) of the drum (10) by means of a mounting plate (40). In an alternative embodiment strain sensor (80) can also be directly mounted over the outer periphery (18) of the drum (10). Strain sensor (80) is comprising two separate components, namely a first measurement element (82) and a second measurement element (84). Each one of the components are known strain sensor (80) devices suitable for harsh environmental conditions. A transmitter (90) is also secured on the outer periphery (18) of the drum (10). A cable (86) connect the first measurement element (82) and the second measurement element (84) to the transmitter (90). The cable (86) is a signal transmission cable such as a copper wire coaxial cable or an optical cable.

[0020] In Figure 2a, s schematic view the transmitter (90) is shown. The transmitter (90) comprises a power module

(94) which is a rechargeable battery such as Lithium ion type and a power generator of regenerative type, transform kinetic, solar or heat energy into the electricity to charge the battery. One of the convenient regenerative methods of can be selected based on the installation location and availability of the selected type of the energy. A wireless signal module (92) is connected to an antenna (96) and the power module (94). In the representative embodiment, power module (94) supply 24 V electricity to the first measurement element (82) and the second measurement element (84). Strain sensor (80) respond with a voltage in millivolts and amplified a voltage value up to 10 volts. Amplified voltage value of the strain sensor (80) transmitted to the wireless signal module (92).

[0021] In Figure 2b, a receiver (70) suitable to collect information provided with the transmitter (90) is shown. The receiver (70) has a data connection to a controller (72) having a CPU. Voltage value output data of a corresponding strain sensor (80) is collected by the receiver (70) by means of the wireless module (74). In order to ensure reliable transfer of the voltage value data is amplified by a suitable electronic module, i.e. amplifier, before transmitting the data to the receiver (70).

[0022] In Figure 2c, strain sensor (80) assembly to the outer periphery (18) of the drum (10) by means of a metal mounting plate (40) is shown in cross-section. A mounting bolt (85) engaged to a hole on a base (44) of the mounting plate (40) and secure strain sensor (80) from two opposing ends. The cable (86) extend from one end of the strain sensor (80) to the transmitter (90). The cable (86) both supply input voltage provided by the power module (94) to the strain sensor (80) and transfer output voltage back to the transmitter (90).

[0023] In Figure 3, a number of plates (17) next to each other form inner liner of the drum (10) and fixed to the drum (10) by means of bolts (60). Each plate (17) having the bolt (60) to mount the plate (17) to the drum (10) in a removable manner. In case of damage on the plate (17) due to the friction, bolt (60) allow replacing the damaged plate (17) with a new one and allow maintenance. Modular structure of the plates (17) make easy installation of the strain sensor (80) on a plate (17) using the same bolts (60) over the plate (17). A base (44) is arranged over a plate (17) and secured on the plate (17) using the fastening elements (42) that are used to fix the plates (17). The fastening elements (42) are in the form of bolts extending between the base (44) and upper side of the plate (17) partially forming outer periphery (18).

The base (44) is made of a metal element, i.e. steel, where the strain sensor (80) is installed.

[0024] After mounting the strain sensor (80) at the center of gravity of each chamber (11, 13) and transmitter (90) in the middle of the chambers (11, 13) the weight measurement system needs to be calibrated before first use. Input voltage is provided by power module (94) to obtain an output voltage difference of the strain sensor (80) during rotation of the drum (10). This will provide a first data set (d0) which is output voltage value when the drum (10) is empty. In the preferred application, calibration of the measurement system can be done by providing a second data set (d2) after charge of the balls (30) inside the drum (10).

[0025] In an alternative calibration method, the balls (30) are charged inside the inner volume of the drum (10) before grinding operation. Afterwards, the drum (10) is rotated to obtain an output voltage difference for each rotation. This define a calibration data as the first data set (d1) and difference between a preliminary data (d0) of empty drum (10) and the first data set (d1) can be compared with known weight value of the balls (30) so that correlation between voltage difference and weight can be calculated to complete calibration. During the grinding operation, drum (10) is loaded from inlet (12) and grinded fine product is exit through the outlet (14). Amount of material inside the drum (10), i.e. in tonnes, can be calculated by instant output voltage value of the strain sensor (80).

[0026] System can be designed to continuous data flow from transmitter (90) to the receiver (70) so that a controller (72), e.g. a remote computer can calculate material weight amount inside the drum (10) while the grinding operation takes place. Otherwise, two way data flow between the transmitter (90) and receiver (70) can be provided to send request from the receiver (70) to transmitter (90) to obtain instant output voltage value of the strain sensor (80). In another alternative, transmitter (90) send intermittent signals, e.g. 1 per minute to the receiver (70) which is preliminary defined before the operation.

[0027] In the current embodiment, the first measurement element (82) and the second measurement element (84) will provide output voltage information independent from each other to the transmitter (90). Therefore, it will be possible to understand first chamber (11) and second chamber (13) material weight by calculating output voltage with corresponding calibration data obtained by comparison of each output voltage value and weight of the large balls (32) inside the first chamber (11) and small balls (34) inside the second chamber (13).

[0028] Based on the weight information calculated by controller (72) based on the data provided by the receiver (70), empty volume inside the drum (10) can also be estimated using additional information such as inner volume of the drum (10) and average density of the material and weight information.

REFERENCE NUMBERS

10 Drum	60 Bolt
11 First chamber	70 Receiver
12 Inlet	72 Controller

(continued)

	13 Second chamber	74 Wireless module
	14 Outlet	80 Strain sensor
5	15 Bottom side	82 First measurement element
	17 Plate	84 Second measurement element
	18 Outer periphery	85 Mounting bolt
	20 Diaphragm	86 Cable
10	30 Balls	90 Transmitter
	32 Large balls	92 Wireless signal module
	34 Small balls	94 Power module
	40 Mounting plate	96 Antenna
	42 Fastening element	
15	44 Base	

Claims

- 20 1. A grinding mill comprising a drum (10) wherein a plurality of balls (30) are disposed in a freely movable manner having an inlet (12) to feed particulate material inside the drum (10) and an outlet (14) to transfer fine material after grinding **characterised in that** it comprises a strain sensor (80) mounted at an outer periphery (18) of the drum (10) so that providing a data to determine weight information of the drum (10) wherein the strain sensor (80) is connected to a transmitter (90) which is transmitting the data to a receiver (70) in data communication with a controller (72) and the transmitter (90) has a wireless signal module (92) which is in communication with the receiver (70) having a corresponding wireless module (74) to transmit the data from the drum (10) to a remote location.
- 25 2. A grinding mill according to claim 1, wherein the strain sensor (80) is attached on a mounting plate (40) which is secured to the outer periphery of the drum (10).
- 30 3. A grinding mill according to any one of the preceding claims, wherein a power module (94) is connected to the strain sensor (80) to energize the strain sensor (80) upon start of the grinding process.
4. A grinding mill according to claim 3, wherein the power module (94) comprises a regenerative power source.
- 35 5. A grinding mill according to claim 3 or 4, wherein the power module (94) is electrically connected to the wireless signal module (92) providing electricity to the wireless signal module (92) during data transmission.
- 40 6. A grinding mill according to any one of the preceding claims, wherein the drum (10) is divided into a first chamber (11) and at least one second chamber (13) wherein the strain sensor (80) has a first measurement element (82) and a second measurement element (84) corresponding to each of the first chamber (11) and the second chamber (13) to provide the data independent from each other.
- 45 7. A grinding mill according to claim 6, wherein the distance between the transmitter (90) and the first measurement element (82) or the second measurement element (84) is substantially equal.
8. A grinding mill according to any one of the preceding claims, wherein the strain sensor (80) is arranged at a vicinity of the center of gravity of the drum (10) or each one of center of gravity the first chamber (11) and the second chamber (13).
- 50 9. A weight measuring method for a grinding mill according to any one of the preceding claims, comprising the steps of obtaining a first data set (d1) from the strain sensor (80) when the drum (10) is empty; then obtaining a second data set (d2) while the drum (10) is being charged with the balls (30) calibrating the measurement system based on the first and second data sets (d1, d2).
- 55

Patentansprüche

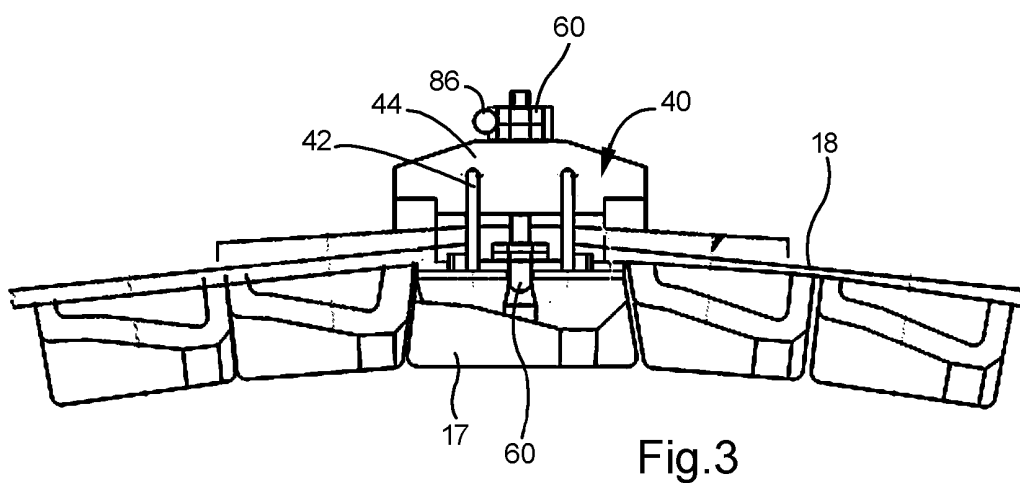
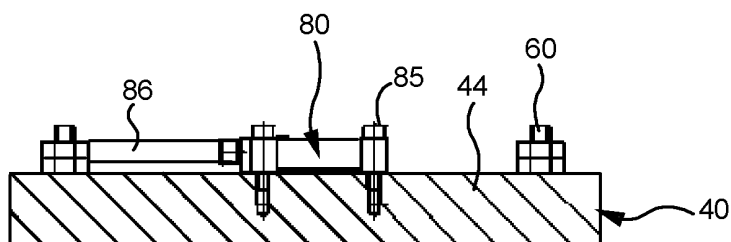
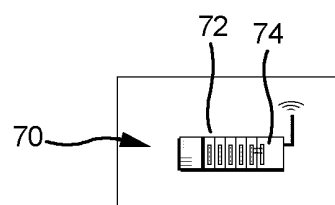
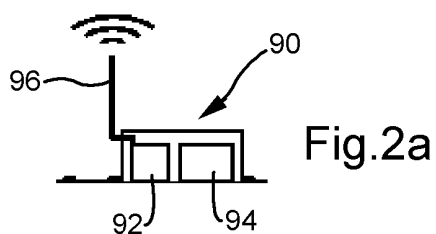
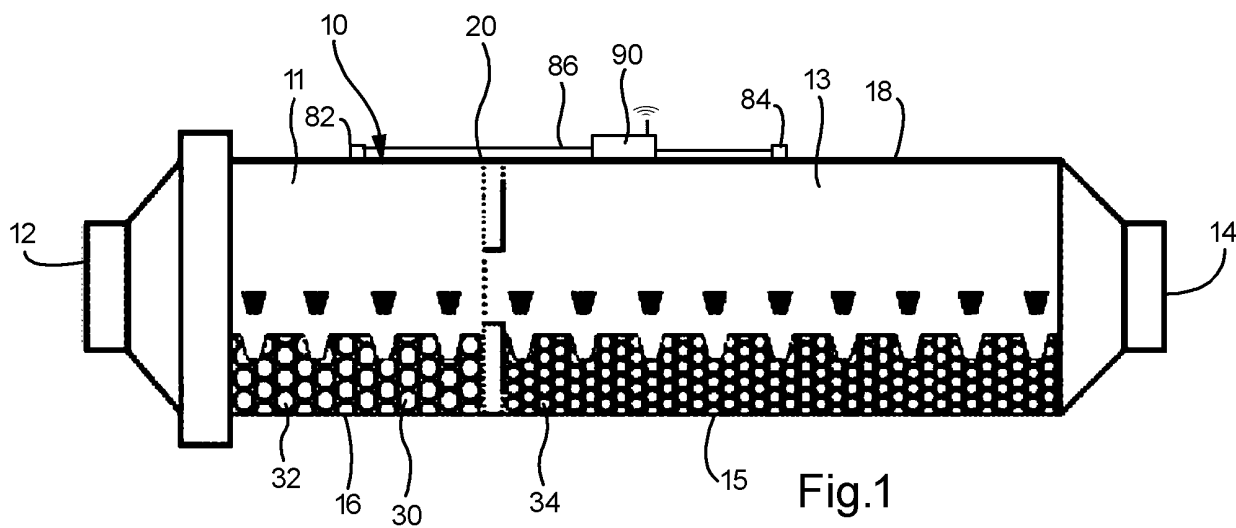
1. Mahlmühle mit einer Trommel (10), in der mehrere Kugeln (30) frei beweglich angeordnet sind, mit einem Einlass (12) zum Zuführen von partikelförmigem Material in das Innere der Trommel (10) und einem Auslass (14) zum Übertragen von feinem Material nach dem Mahlen, **dadurch gekennzeichnet, dass** sie einen Dehnungssensor (80), der an einem Außenumfang (18) der Trommel (10) so angebracht ist, dass er Daten zur Bestimmung des Gewichts Informationen der Trommel (10) feststellt, wobei der Dehnungssensor (80) mit einem Sender (90) verbunden ist, der die Daten an einen Empfänger (70) in Datenkommunikation mit einer Steuerung (72) überträgt, und der Sender (90) ein drahtloses Signalmodul (92) aufweist, das in Kommunikation mit dem Empfänger (70) steht, der ein entsprechendes drahtloses Modul (74) aufweist, um die Daten von der Trommel (10) an einen entfernten Ort zu übertragen.
2. Mahlmühle nach Anspruch 2, bei der der Dehnungssensor (80) an einer Montageplatte (40) angebracht ist, die am Außenumfang der Trommel (10) befestigt ist.
3. Mahlmühle nach einem der vorhergehenden Ansprüche, wobei ein Leistungsmodul (94) mit dem Dehnungssensor (80) verbunden ist, um den Dehnungssensor (80) beim Start des Mahlvorgangs zu aktivieren.
4. Mahlmühle nach Anspruch 4, wobei das Leistungsmodul (94) eine regenerative Energiequelle umfasst.
5. Mahlmühle nach Anspruch 3 oder 4, wobei das Leistungsmodul (94) mit dem Funksignalmodul (92) elektrisch verbunden ist und das Funksignalmodul (92) während der Datenübertragung mit Strom versorgt.
6. Mahlmühle nach einem der vorhergehenden Ansprüche, wobei die Trommel (10) in eine erste Kammer (11) und mindestens eine zweite Kammer (13) unterteilt ist, wobei der Dehnungssensor (80) ein erstes Messelement (82) und ein zweites Messelement (84) aufweist, die jeweils der ersten Kammer (11) und der zweiten Kammer (13) entsprechen, um die Daten unabhängig voneinander zu liefern.
7. Mahlwerk nach Anspruch 6, wobei der Abstand zwischen dem Sender (90) und dem ersten Messelement (82) oder dem zweiten Messelement (84) im Wesentlichen gleich ist.
8. Mahlmühle nach einem der vorhergehenden Ansprüche, wobei der Dehnungssensor (80) in der Nähe des Schwerpunktes der Trommel (10) oder jeweils des Schwerpunktes der ersten Kammer (11) und der zweiten Kammer (13) angeordnet ist.
9. Gewichtsmessverfahren für eine Mahlmühle nach einem der vorhergehenden Ansprüche, mit den Schritten: Erhalten eines ersten Datensatzes (d1) von dem Dehnungssensor (80), wenn die Trommel (10) leer ist; dann Erhalten eines zweiten Datensatzes (d2), während die Trommel (10) mit den Kugeln (30) beschickt wird; Kalibrieren des Messsystems auf der Grundlage des ersten und zweiten Datensatzes (d1, d2).

Revendications

1. Un broyeur comprenant un tambour (10) dans lequel plusieurs balles (30) sont placées de manière librement déplaçable ayant une entrée (12) à alimenter le matériau particulaire à l'intérieur du tambour (10) et une sortie (14) à transférer le matériau fin après le broyage **caractérisé en ce qu'il** comprend un capteur de contrainte (80) monté à la périphérie extérieure (18) du tambour (10) de sorte que les données sont fournies pour déterminer l'information de poids du tambour (10) où le capteur de contrainte (80) est connecté au transmetteur (90) qui transmet les données au récepteur (70) en communication de données avec un contrôleur (72) et le transmetteur (90) a un module de signaux sans fil (92) qui est en communication avec le récepteur (70) ayant un module sans fil (74) correspondant à transmettre les données du tambour (10) à un endroit éloigné.
2. Un broyeur selon la revendication 2, dans lequel le capteur de contrainte (80) est attaché sur la plaque de fixation (40) qui est fixée à la périphérie extérieure du tambour (10).
3. Un broyeur selon l'une quelconque des revendications précédentes, dans lequel un module de puissance (94) est connecté au capteur de contrainte (80) à énergiser le capteur de contrainte (80) au moment du démarrage du processus de broyage.

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4. Un broyeur selon la revendication 4, dans lequel un module de puissance (94) comprend une source de puissance régénérative.
- 5 5. Un broyeur selon la revendication 3 ou 4, dans lequel un module de puissance (94) est connecté électriquement au module de signaux sans fil (92) fournissant l'électricité au module de signaux sans fil (92) pendant la transmission des données.
- 10 6. Un broyeur selon l'une quelconque des revendications précédentes, dans lequel le tambour (10) est divisé en premier compartiment (11) et au moins un deuxième compartiment (13) dans lequel le capteur de contrainte (80) a un premier élément de mesure (82) et un deuxième élément de mesure (84) correspondant à chacun du premier compartiment (11) et du deuxième compartiment (13) à fournir les données indépendantes l'un de l'autre.
- 15 7. Un broyeur selon la revendication 6, dans lequel la distance entre le transmetteur (90) et le premier élément de mesure (82) ou le deuxième élément de mesure (84) est sensiblement égale.
8. Un broyeur selon l'une quelconque des revendications précédentes, dans lequel le capteur de contrainte (80) est arrangé à proximité du centre de gravité du tambour (10) ou chacun des centres de gravité du premier compartiment (11) et du deuxième compartiment (13).
- 20 9. Une méthode de mesure du poids pour un broyeur selon l'une quelconque des revendications précédentes, comprenant les étapes d'obtention d'un premier ensemble de données (d1) du capteur de contrainte (80) lorsque le tambour (10) est vide ; ensuite l'obtention du deuxième ensemble de données (d2) lorsque le tambour (10) est chargé avec les balles (30) calibrant le système de mesure basé sur le premier et deuxième ensemble des données (d1, d2).



REFERENCES CITED IN THE DESCRIPTION

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