

Specification

SILICIC ACID-CONTAINING POWDER PRODUCTION METHOD AND SILICIC ACID-CONTAINING POWDER PRODUCTION SYSTEM

Technical Field

[0001] The present invention relates to a silicic acid-containing powder production method and a silicic acid-containing powder production system suitable for obtaining natural silicic acid contained in materials such as rice hull, rice straw and straw of barley for the purpose of reuse, by changing properties thereof.

Background Art

[0002] It has been conventionally known that silicic acid is effective in improving an upstanding property of rice and preventing its diseases. In recent years, however, the silicic acid percentage contents for rice paddies have been reduced, thus requiring additional application of silicic acid. Currently, there is a growing tendency to employ silicic acid which is artificially extracted from mineral materials or burned hull carbon for the application to rice paddies. However, the silicic acid extraction process involves serious problems with efforts, time and costs, as referred to the extraction from mineral materials with complicated processes such as for ore-mining and pulverizing. Meanwhile, the use of hull carbon significantly reduces silicic acid content due to the extent of carbonization, resulting in higher processing costs.

[0003] Meanwhile, categorized as industrial wastes, rice hulls and straws normally require a proper treatment, but its high processing costs cause unattended field heaping and therefore a problem of spontaneous fire.

[0004] Japanese Unexamined Patent Publication No. 8 224488 discloses an invention of a conventional hull pulverization to efficiently reuse silicic acid contained in rice hulls. This invention, which is characterized by the pulverization of dried rice hulls by means of an impact pulverizer, extracts compositions from rice hulls by granulating a mixture of the pulverized material and natural aluminosilicate or its chemically treated substances. Then, the application of these compositions to rice paddies will contribute to the agricultural reuse of silicic acid.

Disclosure of the invention

Problems to be solved by the invention

[0006] However, the invention in Japanese Unexamined Patent Publication No. 8 224488 is unable to efficiently and solely extract silicic acid due to its

pulverizing-oriented approach. More specifically, the possible extraction of other unwanted compositions from rice hulls inevitably lowers the purity of silicic acid, and hazardous polymer compounds in the rice hulls might also be untreated. In addition to hard maintenance work and its high costs for the impact pulverizer, the high hardness of rice hulls, despite their small size, can damage machine parts in short operation hours. Furthermore, although a mixture of chemical substances such as natural aluminosilicate is granulated in the conventional invention, the reduction in such chemical substances applied to rice paddies is strongly demanded. It is consequently found that the conventional technique fails to efficiently extract silicic acid from rice hulls, thus such materials must be ordinarily incinerated.

[0007] It is, therefore, one object of the present invention to solve the aforementioned problems by providing a silicic acid-containing powder production method and silicic acid-containing powder production system which can pulverize rice hulls and straws by requiring removal of no silicic acid therefrom and reducing its processing time and costs to obtain natural silicic acid-containing powder for the use as straight fertilizers.

Means for solving the problem

[0008] The silicic acid-containing powder production method of the present invention is characterized by a treatment in which rice hulls or straws are fed to a treatment container, the steam is injected into this treatment container to increase internal pressure and temperature and the rice hulls or straws are processed with the steam pressure being maintained for material pulverization but no combustion. In operation, the pressure on rice hulls and straws, the heating caused by this high steam pressure and steam's hydrolysis compress said rice hulls and straws. Subsequently, the gradual pressure reduction in the container will cause bonded molecules to be separated and decomposed, thereby providing rice hulls and straws with property changes such as initial carbonization and atomization.

[0009] Preferably in the present invention, the steam pressure within said treatment container is maintained ranging from 1.45 to 1.96 to pulverize rice hulls and straws.

[0010] In addition, it is more desirable that this invention pulverize rice hulls and straws for a more efficient silicic acid-containing powder production by maintaining the steam pressure within said treatment container, ranging from 1.65 to 1.85MPa, for 5 to 30 minutes.

[0011] The silicic acid-containing powder production system according to the present invention is characterized by a treatment container, agitating means within said treatment container, steam injecting means for injecting high-pressure steam onto rice hulls or straws which are fed to said treatment container, and controlling means for

controlling the steam injection amount by means of said steam injecting means by maintaining the steam pressure within said treatment container for pulverization but no combustion of said rice hulls or straws. According to this structural function, the pressure on the rice hulls and straws within the treatment container, the heating caused by this high steam pressure and steam's hydrolysis compress the rice hulls and straws in all directions. Subsequently, the gradual pressure reduction in the container will cause bonded molecules to be separated and decomposed, thereby providing rice hulls and straws with property changes such as initial carbonization and atomization.

[0012] Moreover, it is preferable in this invention that said controlling means controls the steam injection amount adjusted by said steam injecting means in such a manner that the steam pressure within said treatment container is maintained ranging from 1.45 to 1.96MPa, and more preferably ranging 1.65 to 1.85MPa for 5 to 30 minutes.

Advantageous effect of the invention

[0013] Accordingly, it is, of course, that this invention can produce powdery rice hulls by requiring removal of no silicic acid from rice hulls and straws and reducing its processing time and costs to obtain natural silicic acid-containing powder for using as a straight fertilizer.

Best mode for carrying out the invention

[0014] A preferred embodiment of the silicic acid-containing powder production system according to the present invention will be described with reference to the accompanying drawings.

[0015] Figure 1 is a pattern diagram of the embodiment illustrating the silicic acid-containing powder production system 1. The silicic acid-containing powder production system 1 of this embodiment comprises a treatment container 2 for accommodating and treating rice hulls and straws, agitating means 3 for agitating rice hulls and straws which are fed to this treatment container 2, steam injecting means 4 for injecting high-pressure steam onto the rice hulls and straws within the treatment container 2, pressure regulating means 5 for adjusting the pressure within the treatment container 2, and controlling means 6 for controlling the agitating means 3, the steam injecting means 4 and the pressure regulating means 5.

[0016] Here, each component of the silicic acid-containing powder production system in this embodiment will be described in further detail. The treatment container 2 is a Class A pressure vessel with pressure resistance to treat rice hulls or straws therein. The treatment container 2 is provided with an injection port 21 and a discharge port 22 for rice hulls or straws on the upper and lower portions thereof, respectively. The injection port 21 and the discharge port 22 are designed in a sealed structure to maintain

a proper pressure range within the treatment container 2 for treating the rice hulls or straws. In addition, the injection port 21 and the discharge port 22 include a sealing mechanism (not shown) to maintain airtightness between a horizontal rotating shaft 31 of the agitating means 3 to be described later and the treatment container 2. In consideration of operational safety, the injection port 21 and discharge port 22 have a system control by which a switching operation cannot be performed until the pressure within the treatment container 2 reaches 0.015MPa or under. Moreover, the treatment container 2 includes an upper temperature sensor 23a, a lower temperature sensor 23b and a pressure sensor 24 to detect the temperature and pressure within the treatment container 2.

[0017] Next, the agitating means 3 thoroughly pressurizes and heats the entire rice hulls or straws. This agitating means 3 comprises a horizontal rotating shaft 31, and an agitating vane 32 which is rotatably supported by the horizontal rotating shaft 31 in the longitudinal direction within the treatment container 2, mounted on this horizontal rotating shaft 31 and slanted forward relative to a vertical plane thereof. Additionally, there is provided a driving motor 33 connecting to the horizontal rotating shaft 31 to achieve normal and reverse rotation thereof. The agitating means 3, extending from the injection port 21 to the discharge port 22, gradually transfers the rice hulls or straws which are fed to the treatment container 2 as the material is agitated. On the other hand, the driving motor 33 can control the number of revolutions and rotation direction by means of inverter control and provide the rice hulls or straws with a reciprocating motion within the treatment container 2 until the material is pulverized so as to have desired and necessary properties.

[0018] The steam injecting means 4 includes a boiler 41 which generates high-pressure steam and an air feed pipe 42 which feeds the steam generated in this boiler 41 to the treatment container 2. The steam pressure in the boiler is maintained at a constant level and the pressure within the treatment container 2 is adjusted by the high-pressure steam injection amount. In this embodiment, the high-pressure steam injection employs saturated steam. Being determined by this saturated steam pressure, the temperature within the treatment container 2 is maintained at a high value. The air feed pipe 42 which is positioned above the horizontal rotating shaft 31, is connected to the treatment container 2 in a nearly horizontal direction. Obviously, this design can obtain a high processing efficiency due to the most preferable high-pressure steam injection into rice hulls or straws, just before no external pressure is given on the rice hulls or straws accumulated within the treatment container 2 or the materials floating by the agitation fall on one after another.

[0019] The pressure regulating means 5 comprises a pressure regulating valve 51 which can open and close by means of electric control and an exhaust pipe 52 which releases the steam within the treatment container 2 via this pressure regulating valve 51. If the pressure within the treatment container 2 exceeds a predetermined value, the

pressure regulating valve 51 will open and the steam within the treatment container 2 will be released to maintain a desired pressure level. Also, the exhaust pipe 52 is connected to a cooling unit 8 via a silencer 7 to cool and liquefy the steam transported from the treatment container 2, which will be distributed to a waste water processing unit 9. Additionally, by incorporating the silencer 7 into the system to meet noise-control regulations, this type of plant can be constructed in the urban district.

[0020] The controlling means 6 is electrically connected to and controls the agitating means 3, the steam injecting means 4 and the pressure regulating means 5. This controlling means 6 controls the rotation direction and number of revolutions for the driving motor 33 to regulate the agitating and transferring time for the rice hulls or straws within the treatment container 2. Furthermore, the controlling means 6 controls the steam injection amount determined by the steam injecting means 4 in such a manner that the processing pressure is maintained for a certain period of time to pulverize but not to burn the rice hulls or straws within the treatment container 2. In this embodiment, the pressure within the treatment container 2 is maintained ranging from 1.45 to 1.96MPa, based on the experimental results of examples to be described later. If the temperature or pressure within the treatment container 2 declines, the temperature or pressure will be increased by raising the high-pressure steam injection amount by the steam injecting means 4. Conversely, the increase in the temperature or pressure within the treatment container 2 will be compensated by the release of high-pressure steam by opening the pressure regulating valve 51 of the pressure regulating means 5. The controlling means 6 is electrically connected to a temperature sensor 23a, a temperature sensor 23b and pressure sensor 24 within the treatment container 2, which, based on these detection results, will feedback-control the temperature and pressure within the treatment container 2 for keeping these measures at predetermined values.

[0021] Next, the silicic acid-containing powder production method according to the silicic acid-containing powder production system 1 of this embodiment will be described.

[0022] Firstly, rice hulls or straws are fed to the injection port 21 leading to the treatment container 2. In this operation, the pressure within the treatment container 2 is preset ranging from 1.45 to 1.96MPa for the controlling means 6. In addition, the time for holding this set pressure, and the temperature within the container determined by the agitating time and the set pressure are set, respectively. Preferably in this case, the pressure holding time is given sufficiently long so as to start hydrolysis of the rice hulls or straws, and the agitating time is set as the duration sufficient for completing the pulverization of the rice hulls or straws. The temperature within the container is the temperature determined by the saturated steam pressure.

[0023] As the rice hulls or straws being fed to the treatment container 2 is highly agitated by the agitating vane 32, the materials are gradually transferred toward the discharge port 22. In case of an incomplete one-cycle transportation of the rice hulls or

straws due to their large amount, the driving motor 33 is reversely rotated to transport the material toward the injection port 21 in a reciprocating motion, thereby obtaining a sufficient agitating time even in a small treatment container 2.

[0024] During the agitation, high-pressure steam is injected to the treatment container 2 from the air feed pipe 42 which is placed above the horizontal rotating shaft 31. Therefore, when the rice hulls or straws are dispersed over the horizontal rotating shaft 31 by the agitation according to the agitating means 3, high-pressure steam is injected to the rice hulls or straws in an efficient manner. Thus, the heating caused by the steam pressure rise and the steam hydrolysis are encouraged to compress the rice hulls and straws.

[0025] In addition, as the rice hulls or straws are agitated, the controlling means 6 controls the steam injecting means 4 and the pressure regulating means 5 in such a manner that the temperature within the treatment container 2 is maintained at a set value and the pressure remains from 1.45 to 1.96MPa, based on the detected values in the temperature sensor 23a, the temperature sensor 23b and the pressure sensor 24.

[0026] After the set pressure holding time elapses, the controlling means 6 will control the steam injecting means 4 to stop steam injection, while controlling the pressure regulating means 5 to open the pressure regulating valve 51. Then, the high-pressure steam within the treatment container 2 is released via the exhaust pipe 52 to reduce the pressure within the treatment container 2. This pressure reduction causes bonded molecules for the rice hulls or straws to be separated and decomposed, thereby providing the materials with property changes such as initial carbonization and atomization. In this initial carbonization, most silicic acid compositions are not removed from the rice hulls or straws. The powdery rice hulls or straws are delivered to and discharged from the discharge port 22, and the waste water is sent to the waste water processing unit 9 to be purified.

[0027] Secondly, specific examples of this embodiment will be described. In each of the following examples, an experiment is performed to find out the conditions for manufacturing silicic acid-containing straight fertilizers extracted from the rice hulls by a short-time treatment. By changing the pressure within the treatment container 2 and the pressure holding time in each experiment, the results of respective hull treatments were examined. Figure 2 shows the treatment conditions and results. Figures 3 – 8 show digital photographic images of rice hull shapes prior to and after the treatment.

[0028] Each experiment in the examples employs the treatment container 2 with a volume of 3,000 liter, with the container temperature maintained at around 200 degrees of Celsius determined by a saturated steam pressure and a hull filling rate ranging from 65 to 95%. In order to agitate the rice hulls more uniformly, the agitation rate is set as 2 to 18rpm until the lower temperature sensor 23b shows the value identical that of the upper temperature sensor 23a, and thereafter until the pressure is reduced to 0.15MPa, it

was set as 5 to 15rpm.

[0029] In the example 1, the processing pressure within the treatment container 2 is kept under 1.0MPa. Figure 4 illustrates the rice hulls treated by this example 1. Consequently, the rice hulls show no change in shape but slightly dark brown even if the materials are treated for 10 to 90 minutes, indicating an unfavorable treatment.

[0030] Next, in the example 2, the processing pressure within the treatment container 2 is maintained at 1.45MPa. Figure 5 shows the rice hulls after the treatment. It is found that with the pressure holding time from 10 to 90 minutes, the rice hulls are successfully treated until its volume was reduced to approximately half. According to an observation of treated rice hulls, the rice hulls are black in color but not powdered, showing a withered state in each of the rice hulls. With the water content of treated rice hulls being a favorable value of 5.8% and the residual silicon being a sufficient level of 14.25%, the rice hulls can be reused as straight fertilizers.

[0031] In the example 3, the processing pressure within the treatment container 2 is maintained at 1.65MPa. Figure 6 shows the rice hulls after the treatment. As a result, the pulverization is achieved for a short pressure holding time from 10 to 30 minutes. The water content for treated rice hulls is 43.5%, and the residual silicon is detected 11.96%, showing a preferable property of straight fertilizers. The resulting pulverization can enhance fusibility, thereby using as fertilizers in more various ways.

[0032] In the example 4, the rice hulls are treated, with processing pressure within the treatment container 2 maintained at 1.85MPa. Figure 7 shows the rice hulls after the treatment. The treatment with an extremely short pressure holding time from 5 to 10 minutes generated considerably pulverized powder. The water content of treated rice hulls is reduced to a small level of 25.5% and the residual silicon is detected at 9.56%, showing a favorable property of straight fertilizers.

[0033] In this example 5, the treatment is conducted by the steam injection with the pressure within the treatment container 2 maintained at 1.96MPa. Figure 8 shows the rice hulls after the treatment. Consequently, the treatment with the pressure holding time 5 to 15 minutes generates pulverized powder. The water content for the treated rice hulls is 25.0% and the residual silicon detected is 9.0%, showing a possibility of using as straight fertilizers. Meanwhile, the residual silicon is reduced due to initial carbonization. Although the pressure holding time to reach a target pressure can be saved, the pressure rise operation requires a long time, thus serving not so favorable practical use.

[0034] By taking into consideration the experimental results of the above examples, to obtain natural silicic acid for the use as straight fertilizers in a short-short hull treatment without removing any silicic acid, it is preferable that the pressure within the treatment container 2 be maintained ranging from 1.45 to 1.96MPa, and more preferably ranging from 1.65 to 1.85MPa for 5 to 30 minutes. This higher temperature and pressure treatment for a certain period of time constitutes advantageous conditions

for hull decomposition. This benchmark is determined to cause hull decomposition as gradually as possible and thereafter the decomposition continues as the pressure declines. During this process, the water and steam contained in the rice hulls will be cooled, causing condensed water to be diffused outside the container as the pressure changes from pressured to non-pressure states, whereby the material property will change so as to have a proper water content level.

[0035] In addition, hull decomposition by microorganisms in nature requires a long period of time, normally 6 to over 36 months to make composts. However, the use of the system in this embodiment can achieve composting in a remarkably short period of time, 60 to about 90 minutes, including the duration for pressure rise, in sterile and safe manners.

[0036] Each component of this embodiment is not intended as a definition of the limits of the above description, but may be modified accordingly.

[0037] As shown in the above mentioned embodiment, the air feed pipe 42 and the exhaust pipe 52 are provided as distinct elements, but they may have a common conduit part. This structure can overcome the problem of valve clogging caused by treated powdery rice hulls which are delivered through the exhaust pipe 52, together with the steam, as the pressure within the treatment container 2 declines. More specifically, by providing a common conduit part for steam injection and release, the steam injection operation also serves as removing (or cleaning) unwanted treated hull powder from the valves. As shown in Figure 9, two steam injection conduits may be formed from the boiler 41 to the treatment container 2, through which the steam is also released in the opposite traveling direction. Additionally, a different conduit is provided so as to branch off into the exhaust pipe 52 in the system, with the air feed valve 43 and the exhaust valve 53 mounted in the air feed pipe 42 and the exhaust pipe 52, respectively. There is mounted the check valve 10 in the conduit leading to the boiler 41, and the common conduit part includes the control valve 11 to control the steam flow rate. There is provided the switching valve 12 between the exhaust pipe 52 and the air feed pipe 42, thereby switching the steam injection and release operations. Specifically, as the switching valve 12 is opened for steam injection, the exhaust valve 53 in the exhaust pipe 52 will be closed to open the two conduits from the boiler 41 to the treatment container 2. On the other hand, the steam release operation will open the exhaust valve 53 and close the air feed valve 43 and switching valve 12 to release the steam from the two pipes leading to the treatment container 2, whereby the steam is delivered to the exhaust pipe 52 through the resultant one conduit. This operation might clog some of the valves with treated hull powder, but such powder can be removed or cleaned by the steam traveling through the valves leading to the treatment container 2 by the next steam injection.

Brief description of the drawings

[0038] The above and other objects of the invention will be seen by reference to the description taken in connection with the accompanying drawings, in which:

Figure 1 is a pattern diagram of the embodiment illustrating the silicic acid-containing powder production system according to the present invention;

Figure 2 is a table describing the conditions and results of examples 1 to 5 of this embodiment according to the present invention;

Figure 3 is a digital photographic image showing the rice hulls prior to the hull treatment;

Figure 4 is a digital photographic image showing the rice hulls after the hull treatment under the condition of the example 1;

Figure 5 is a digital photographic image showing the rice hulls after the hull treatment under the condition of the example 2;

Figure 6 is a digital photographic image showing the rice hulls after the hull treatment under the condition of the example 3;

Figure 7 is a digital photographic image showing the rice hulls after the hull treatment under the condition of the example 4;

Figure 8 is a digital photographic image showing the rice hulls after the hull treatment under the condition of the example 5; and

Figure 9 is a pattern diagram of the embodiment illustrating the valve switching system during the pressure rising and reduction for the silicic acid-containing powder production system according to the present invention.

Explanation of letters and numerals

1: silicic acid-containing powder production system

2: treatment container

3: agitating means

4: steam injecting means

5: pressure regulating means

6: controlling means

7: silencer

8: cooling unit

9: waste water processing unit

10: check valve

11: control valve

12: switching valve

21: injection port

22: discharge port

23a: upper temperature sensor

23b: lower temperature sensor

- 24: pressure sensor
- 31: horizontal rotating shaft
- 32: agitating vane
- 33: driving motor
- 41: boiler
- 42: air feed pipe
- 43: air feed valve
- 51: pressure regulating valve
- 52: exhaust pipe
- 53: exhaust valve

Figure 9

High-pressure steam injected, steam pressure rising

High-pressure steam released, steam pressure reduced

Scope of Claims

1. A silicic acid-containing powder production method, comprising the steps of:
feeding rice hulls or straws to a treatment container;
increasing the pressure and temperature within said treatment container by injecting the steam thereinto; and
pulverizing said rice hulls or straws by maintaining the steam pressure so as to achieve no combustion of said rice hulls or straws.
2. A silicic acid-containing powder production method to obtain silicic acid-containing powders from rice hulls or straws, comprising the steps of:
maintaining the steam pressure within said treatment container ranging from 1.45 to 1.96MPa by injecting high-pressure steam onto said rice hulls or straws which are fed to said treatment container; and
pulverizing said rice hulls or straws.
3. The silicic acid-containing powder production method set forth in Claim 2, wherein:
the steam pressure within said treatment container is maintained ranging from 1.65 to 1.85MPa for 5 to 30 minutes so as to achieve pulverization of said rice hulls or straws.
4. A silicic acid-containing powder production system, comprising:
a treatment container,
agitating means within said treatment container;
steam injecting means for injecting high-pressure steam onto rice hulls or straws which are fed to said treatment container; and
controlling means for controlling the steam injection amount by means of said steam injecting means by maintaining the steam pressure within said treatment container to achieve pulverization but no combustion of said rice hulls or straws.
5. A silicic acid-containing powder production system, comprising:
a treatment container;
agitating means within said treatment container;
steam injecting means for injecting high-pressure steam onto rice hulls or straws which are fed to said treatment container; and
controlling means for controlling the steam injection amount by means of said steam injecting means by maintaining the steam pressure within said treatment container ranging from 1.45 to 1.96MPa.
6. The silicic acid-containing powder production system set forth in Claim 5, wherein:
said controlling means controls the steam injection amount by means of said steam injecting means by maintaining the steam pressure within said treatment container ranging from 1.65 to 1.85MPa for 5 to 30 minutes.