

Description

Title of The Invention

HYDROTHERMAL TREATMENT SYSTEM

5

Field of The Invention

[0001]

The present invention relates to a hydrothermal treatment system for generating methane gas from waste containing organic matter.

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Background of The Invention

[0002]

Systems which: use high-temperature and high-pressure steam to hydrothermally react and solubilize (hydrothermal treatment) waste containing organic matter such as municipal solid waste which is comprised of kitchen waste (food waste) from households, paper and plant matter waste, livestock manure, and sludge; perform separation of the hydrothermally treated waste containing organic matter (hydrothermal treatment product) to obtain liquid such as a solution or slurry (hydrothermal treatment liquid); and perform gas production by utilizing the hydrothermal treatment liquid by means of microorganisms or bacteria, e.g., methane fermentation, have been developed (e.g., Patent Documents 1, 2). In order to separate the hydrothermal treatment liquid from the hydrothermal treatment product in this system, for example, a screen or a screw press as described in Patent Document 3 can be used.

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References Cited

Patent Literatures

[0003]

Patent Document 1: JP 2009-119378 A

Patent Document 2: JP 2019-181397 A

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Patent Document 3: JP 2011-200836 A

Summary of The Invention

Technical Problem

[0004]

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In general, waste containing organic matter which is collected by a garbage truck or waste containing organic matter stored in a waste pit of a garbage disposal facility contains: organic matter which contributes to gas production, organic matter which does not contribute or hardly contributes to gas

production (for example: plastic), and inorganic matter such as metal and glass which are not completely removed and still remain in the waste. The ratio of organic matter to inorganic matter in the waste containing organic matter, the ratio of kitchen waste to paper waste in the organic matter fraction, the ratio of organic matter which contributes to gas production to the organic matter which almost does not contribute to gas production (i.e., ratio among organic contents in the predetermined waste containing organic matter), and so forth, vary, depending on the region, season, day, and time.

[0005]

Furthermore, generally, regardless of the ratio among organic contents in the waste containing organic matter, a predetermined amount of the waste containing organic matter is hydrothermally treated in the hydrothermal treatment device for a certain period of time (a predetermined period of time) which is determined in advance, and when the predetermined period of time elapses, the hydrothermal treatment is terminated, and the hydrothermal treatment product is taken out from the hydrothermal treatment device. Because of this, the properties of the discharged hydrothermal treatment product vary depending on the ratio among the organic contents in the waste containing organic matter. For example, a sand-like or powdery hydrothermal treatment product having a low water content may be obtained, or a muddy or liquid hydrothermal treatment product having a high water content may be obtained.

[0006]

On the other hand, when methane gas is generated by means of methane fermentation by utilizing the hydrothermal treatment liquid as feedstock, it is desirable that the fragmented organic matter contained in the hydrothermal treatment product be in the hydrothermal treatment liquid as much as possible. Therefore, a pressure-type screw press as described in Patent Document 3 is preferably used to separate the hydrothermal treatment liquid from the hydrothermal treatment product. However, it is not preferable to apply pressure to the hydrothermal treatment product with low water content (for example: sand-like hydrothermal treatment product) using the screw press because it increases power consumption and may even lead to failure of the screw press.

[0007]

Furthermore, when methane gas is produced by utilizing hydrothermal treatment liquid, the concentration of fragmented organic matter contained in the hydrothermal treatment liquid is an important factor for achieving higher gas production efficiency. However, since the concentration of the organic matter in the hydrothermal treatment product greatly varies, from the hydrothermal

treatment product with high water content to the hydrothermal treatment product with low water content, it is difficult to achieve stable gas production in the methane fermentation device.

[0008]

- 5 Here, the objective of the present invention is to provide a hydrothermal treatment system which can stably generate methane gas regardless of the ratio among the organic contents contained in the waste containing organic matter.

Solution to The Problem

10 [0009]

- A hydrothermal treatment system of the present invention includes: a hydrothermal treatment device configured to perform a hydrothermal reaction of waste containing organic matter; an adjustment tank configured to wet a hydrothermal treatment product obtained from the hydrothermal reaction; a first
15 transport device configured to transport the hydrothermal treatment product wetted in the adjustment tank; a pressure-separation device configured to apply pressure to the hydrothermal treatment product transported by the first transport device to separate the hydrothermal treatment product into hydrothermal treatment liquid and residue; a solubilization tank configured to store and heat
20 up the hydrothermal treatment liquid separated by the pressure-separation device; a second transport device configured to transport the hydrothermal treatment liquid which is heated up and solubilized in the solubilization tank back to the adjustment tank; a methane fermentation device configured to generate methane gas and digestate by utilizing the hydrothermal treatment
25 liquid stored in the solubilization tank; a dehydrator configured to separate the digestate into dewatered sludge and separated liquid; and a waste liquid treatment device configured to perform at least nitrification and denitrification of the separated liquid to generate recycled water, wherein the second transport device transports the hydrothermal treatment liquid back to the adjustment tank
30 when a concentration of organic matter contained in the hydrothermal treatment liquid stored in the solubilization tank is less than a predetermined concentration which is a concentration of the organic matter suitable for methane gas generation using microorganisms or bacteria, and transports the hydrothermal treatment liquid to the methane fermentation device when the concentration of
35 the organic matter is equal to or more than the predetermined concentration.

Advantageous Effects of The Invention

[0010]

According to the present invention, stable methane gas production can be performed regardless of the ratio among the organic contents contained in the waste containing organic matter.

5 Brief Description of The Drawings

[0011]

FIG. 1 is a schematic diagram illustrating a hydrothermal treatment system according to an embodiment.

FIG. 2 is a schematic diagram illustrating an example of a second facility
10 of the hydrothermal treatment system according to the embodiment.

Description of The Embodiments

[0012]

A hydrothermal treatment system of the present invention will be
15 described below with reference to the drawings. The configuration and so forth described below are mere examples, and there is no intention to exclude various modifications and applications of the technologies which are not explicitly described. The configuration and so forth described below can be variously modified and implemented without deviating from the essential constituent
20 elements and the essence of the present invention.

[0013]

FIG. 1 shows a schematic diagram illustrating a hydrothermal treatment system 1 of the present embodiment. The hydrothermal treatment system 1 is a system in which waste containing organic matter is hydrothermally reacted with
25 high-temperature and high-pressure steam and solubilized (hereinafter referred to as "hydrothermal treatment"); and liquid (hereinafter referred to as "hydrothermal treatment liquid") such as a solution, mixed liquid, or a slurry separated from the hydrothermally treated waste containing organic matter (hereinafter referred to as "hydrothermal treatment product") is utilized for gas
30 production using microorganisms or bacteria.

The hydrothermal treatment system 1 includes at least a hydrothermal treatment device 10, an adjustment tank 11, a first transport device 21, a pressure-separation device 12, a solubilization tank 13, a second transport device 22, a methane fermentation device 14, a dehydrator 15, and a waste liquid treatment
35 device 16.

The whole configuration of the hydrothermal treatment system 1 illustrated in FIG. 1 will be described in detail below.

[0014]

The hydrothermal treatment device 10 is a device which performs hydrothermal treatment of waste containing organic matter. Some examples of the waste containing organic matter fed to the hydrothermal treatment device 10 are kitchen waste (food waste) discharged from households, woody waste, livestock excreta, and sludge. The waste containing organic matter collected by a garbage truck or stored in a waste pit of a garbage disposal facility may be directly fed to the hydrothermal treatment device 10, or may be fed to the hydrothermal treatment device 10 after removing the inorganic matter. Kitchen waste, paper waste, and plant waste containing organic matter which is suitable for gas production may be selectively extracted from the waste containing organic matter, and then those kitchen waste, paper waste, and plant waste may be fed to the hydrothermal treatment device 10. The hydrothermal treatment device 10 can also perform the hydrothermal treatment to treat a disposable diaper, for which disposal has recently been problematic in care facilities for the elderly and so forth.

As it will be revealed later, regarding the hydrothermal treatment system 1, although the hydrothermal treatment is performed multiple times wherein the ratio among the organic contents in a predetermined amount of waste containing organic matter for each time of hydrothermal treatment greatly varies, the methane fermentation device 14 can stably generate methane gas (biogas) as described below.

The hydrothermal treatment device 10 performs the hydrothermal treatment for a predetermined period of time, and the hydrothermal treatment product is discharged from the hydrothermal treatment device 10 and then stored in the adjustment tank 11.

[0015]

The adjustment tank 11 is a device which wets the hydrothermal treatment product discharged from the hydrothermal treatment device 10 to adjust the properties of the hydrothermal treatment product. The expression "wet" the hydrothermal treatment product not only means wetting the hydrothermal treatment product with water or liquid, but also means immersing the hydrothermal treatment product in water or liquid.

The hydrothermal treatment product stored in the adjustment tank 11 is wetted by injecting the hydrothermal treatment liquid stored in the solubilization tank 13 described below. In addition to the hydrothermal treatment liquid, tap water (not illustrated) or recycled water to be described later may be injected appropriately into the adjustment tank 11.

An agitation device may be installed in the adjustment tank 11 to agitate and mix the hydrothermal treatment product stored in the adjustment tank 11 and the injected or poured liquid or water. If the agitation device is installed, the properties of the hydrothermal treatment product in the adjustment tank 11 can be adjusted in a short period of time. For example, when the hydrothermal treatment product stored in the adjustment tank 11 is in a sand-like form, the hydrothermal treatment product can be converted into a slurry form in a short period of time by operating the agitation device while pouring or injecting liquid or water.

The agitation device may be any device such as that for air agitation or mechanical agitation as long as the hydrothermal treatment product stored in the adjustment tank 11 and the injected or poured liquid or water can be agitated.

[0016]

The hydrothermal treatment device 10 and the adjustment tank 11 are the equipment which performs hydrothermal treatment of the waste containing organic matter, and wet and store the hydrothermal treatment product obtained by the hydrothermal treatment, respectively; and they are components of a first facility 2 which performs a first stage treatment in the hydrothermal treatment system 1.

As will be described later, equipment which uses pressure to separate the hydrothermal treatment product stored in the first facility 2 and to obtain the hydrothermal treatment liquid (hereinafter referred to as "pressurized separation"); and solubilizes the hydrothermal treatment liquid obtained by the pressurized separation is a second facility 3 which performs a second stage treatment in the hydrothermal treatment system 1. A facility for producing gas by utilizing the hydrothermal treatment liquid solubilized in the second facility 3 is a third facility 4 which performs a third stage treatment in the hydrothermal treatment system 1.

[0017]

The first transport device 21 is a device which transports the hydrothermal treatment product wetted in the adjustment tank 11 in the first facility 2 to the second facility 3. When the first facility 2 and the second facility 3 are installed close to each other, for example, when the first facility 2 and the second facility 3 are installed in the same site or in adjacent sites with the distance between the first facility 2 and the second facility 3 being less than about 500 m, the first transport device 21 is preferably a pipeline. This pipeline connects the adjustment tank 11 in the first facility 2 and the pressure-separation device 12 in the second facility 3 and is equipped with a crushing pump for pressure-feeding

the hydrothermal treatment product whose properties have been adjusted in the adjustment tank 11, to the pressure-separation device 12. Generally, a pipeline is configured by connecting multiple pipes to form one path.

In this case, the hydrothermal treatment product stored in the adjustment tank 11 in the first facility 2 is transported to the pressure-separation device 12 in the second facility 3 through the pipeline while being crushed by the crushing pump. Since the hydrothermal treatment product can be crushed into a smaller size by the crushing pump while being transported, a load on the pressure-separation device 12 (for example: a screw press) to be described later can be decreased.

[0018]

Hereinafter, when two out of these facilities: the first facility 2, the second facility 3, and the third facility 4, are installed "close to each other", it means that the two facilities are installed at the same site or different sites with the distance between the two facilities being less than about 500 m.

[0019]

On the other hand, when the first facility 2 and the second facility 3 are installed far from each other, the first transport device 21 is preferably an automobile equipped with a storage tank and so forth (for example: a vacuum car and so forth). For example, if the first facility 2 and the second facility 3 are installed while being separated from each other by 500 m or more, they can be regarded as being "far from each other" regardless of whether they are in the same site or different sites. In this case, the hydrothermal treatment product stored in the adjustment tank 11 in the first facility 2 is loaded on the automobile and conveyed to the pressure-separation device 12 in the second facility 3, and the conveyed hydrothermal treatment product is then fed to the pressure-separation device 12.

[0020]

This automobile may be an automobile driven by a person, or may be an automatic driving automobile whose driving is controlled not by a person but by a computer such as artificial intelligence (AI).

The hydrothermal treatment system 1 may be equipped with a central control room and a person who controls the driving of the automobile through remote monitoring using a monitoring camera. In this case, when the monitoring cameras are installed in the equipment, devices, and facilities in the hydrothermal treatment system 1, the remote monitoring can be performed from the central control room, thus, the safety of the operation of the hydrothermal treatment system 1 can be improved.

Moreover, the hydrothermal treatment system 1 can be configured in such a manner so that the operation of each equipment, devices, and facilities included in the hydrothermal treatment system 1 can be controlled from the central control room. Furthermore, the operation of the hydrothermal treatment system 1 can be

5 fully automated by using AI.
[0021]

Hereinafter, when two out of these facilities: the first facility 2, the second facility 3, and the third facility 4, are installed "far from each other", it means that the two facilities are installed at the same site or different sites with the

10 distance between the two facilities being equal to or more than about 500 m.
In addition, hereinafter, when the term "automobile" is used, the automobile may be an automobile driven by a person or may be an automobile with automatic driving. The automobile may be an automobile which is controlled or operated by a person using remote monitoring.

15 [0022]

The pressure-separation device 12 in the second facility 3 is a device which applies pressure to the hydrothermal treatment product transported from the adjustment tank 11 in the first facility 2 using the first transport device 21, separates the hydrothermal treatment product into the hydrothermal treatment

20 liquid and residue (a remaining matter obtained after separating the hydrothermal treatment liquid from the hydrothermal treatment product). The hydrothermal treatment liquid is also referred to as a suitable fermentation feedstock, and the residue is also referred to as an unsuitable fermentation feedstock.
For example, as illustrated in FIG. 2, the pressure-separation device 12

25 may have a configuration in which a rotary drum screen 12A is configured in a preceding stage and a screw press 12B is configured in a following stage. The rotary drum screen 12A may be, for example, a perforated metal drum screen device described in JP 6384015 B granted to Mitsubishi Heavy Industries Environmental & Chemical Engineering Co., Ltd. The screw press 12B may be,

30 for example, a dewatering system described in FIG. 13 of JP 6734496 B granted to Mitsubishi Heavy Industries Environmental & Chemical Engineering Co., Ltd.
Since the recovery rate of the hydrothermal treatment liquid and the removal rate of the unsuitable fermentation feedstock are affected by the water content, the viscosity, and other properties of the hydrothermal treatment

35 product, the aperture size, the opening ratio, the screw pitch (the distance between the screw and an outlet), and so forth of the pressure-separation device 12 are carefully set. The dewatering system illustrated in FIG. 13 of JP 6734496 B has an aperture size which can be changed depending on a change in the

property of the hydrothermal treatment product, and therefore, is suitable for the pressure-separation device 12. In response to a change in property of the hydrothermal treatment product, the pressure-separation device 12 may have, for example, an adjustable internal pressure by adjusting the outlet size.

5 Furthermore, different from the illustration shown in FIG. 2, the pressure-separation device 12 may be configured as a single unit consisting of the screw press only.

[0023]

10 Regarding the pressure-separation device 12 shown in FIG. 2, the hydrothermal treatment product transported from the adjustment tank 11 in the first facility 2 using the first transport device 21 is firstly fed to the rotary drum screen 12A. Then, in the rotary drum screen 12A, some of the hydrothermal treatment liquid is separated from the hydrothermal treatment product. Next, the remaining hydrothermal treatment product discharged from the rotary drum
15 screen 12A is fed to the screw press 12B.

Therefore, unlike in a case where the rotary drum screen 12A is not installed in the preceding stage (a case when the pressure-separation device 12 is a single unit consisting of the screw press only), in the present case, the amount of the hydrothermal treatment product which is to be pressed and separated into
20 the hydrothermal treatment liquid and the residue by the screw press 12B in the following stage is in a reduced amount instead of the total amount of the hydrothermal treatment product transported using the first transport device 21. Thus, regarding the pressure-separation device 12 shown in FIG. 2, the power consumption of the screw press 12B can be reduced (power saving).

25 The hydrothermal treatment liquid separated by the rotary drum screen 12A and the hydrothermal treatment liquid separated by the screw press 12B are collected and stored in the solubilization tank 13 in the second facility 3.

[0024]

30 The solubilization tank 13 in the second facility 3 is a device which stores, heats up, and solubilizes the hydrothermal treatment liquid separated by the pressure-separation device 12. The heating temperature can be, for example, about 40°C to 60°C.

By solubilizing the hydrothermal treatment liquid in the solubilization tank 13, suspended solids (hereinafter referred to as "SS") suspended in the
35 hydrothermal treatment liquid turn into dissolved solids (hereinafter referred to as "DS") dissolved in the hydrothermal treatment liquid. Thus, the amount of SS in the total amount of solids (Total Solids, hereinafter referred to as "TS"; $TS = SS + DS$) contained in the hydrothermal treatment liquid stored in the

solubilization tank 13 decreases. Therefore, it can be said that the solubilization tank 13 is a device which reduces the amount of SS, increases the amount of DS, and promotes acid fermentation of the hydrothermal treatment liquid.

Generally, in terms of the gas production using microorganisms or bacteria, it is preferable to have a large amount of organic DS in the TS. TS, SS, or DS of the hydrothermal treatment liquid stored in the solubilization tank 13 can be measured by a dedicated measuring device (not illustrated).

Similar to the adjustment tank 11, an agitation device may be installed in the solubilization tank 13 to agitate the hydrothermal treatment liquid stored in the solubilization tank 13 and to promote the solubilization of the hydrothermal treatment liquid.

[0025]

The second transport device 22 is a device that: when the concentration of the organic matter contained in the hydrothermal treatment liquid stored in the solubilization tank 13 in the second facility 3 is less than a predetermined concentration (for example: TS is about 10% and DS is about 6%), transports the hydrothermal treatment liquid from the solubilization tank 13 back to the adjustment tank 11 in the first facility 2, and when the predetermined concentration is achieved (including a case where the concentration is approximately equal to or more than the predetermined concentration; the predetermined concentration may be a range of concentration, for example, TS of about 10% to 12%, and DS of about 6% to 8%), transports the hydrothermal treatment liquid from the solubilization tank 13 to the methane fermentation device 14 in the third facility 4.

Based on a result of the measurement by the measuring device described above, the second transport device 22 may be configured to automatically select one destination, either the adjustment tank 11 or the methane fermentation device 14, and transport the hydrothermal treatment liquid stored in the solubilization tank 13 to the selected destination.

The predetermined concentration is the concentration of organic matter suitable for methane fermentation in the fermentation device 14, or in other words, it is set to a concentration of organic matter which is suitable for methane gas generation using microorganisms or bacteria. At the predetermined concentration, the hydrothermal treatment liquid stored in the solubilization tank 13 is acidic with the pH value being less than 7, preferably equal to or less than 5.

[0026]

Similar to the first transport device 21, when the first facility 2 and the second facility 3 are installed close to each other, the second transport device 22 is preferably a pipeline. This pipeline connects the adjustment tank 11 in the first facility 2 and the solubilization tank 13 in the second facility 3, and is equipped with a pump for pressure-feeding the hydrothermal treatment liquid from the solubilization tank 13 to the adjustment tank 11.

On the other hand, when the first facility 2 and the second facility 3 are installed far from each other, the second transport device 22 is preferably an automobile equipped with a storage tank and so forth (for example: a vacuum car and so forth). In this case, the hydrothermal treatment liquid is conveyed from the solubilization tank 13 to the adjustment tank 11 using the automobile.

In any case, the hydrothermal treatment liquid is circulated between the first facility 2 and the second facility 3 using the second transport device 22.

[0027]

When the second facility 3 and the third facility 4 are installed close to each other, the second transport device 22 is preferably a pipeline. This pipeline connects the solubilization tank 13 in the second facility 3 and the methane fermentation device 14 in the third facility 4, and is equipped with a pump for pressure-feeding the hydrothermal treatment liquid in the solubilization tank 13 to an inlet of the methane fermentation device 14.

[0028]

When the first facility 2, the second facility 3, and the third facility 4 are installed close to each other, the second transport device 22, for example, may be equipped with a switching device installed in the middle of a pipeline connecting the solubilization tank 13 in the second facility 3 and the adjustment tank 11 in the first facility 2; and the switching device is also connected with another pipeline which branches to the inlet of the methane fermentation device 14 in the third facility 4.

Based on the concentration of the organic matter contained in the hydrothermal treatment liquid stored in the solubilization tank 13 in the second facility 3 as described above, by using the switching device, the second transport device 12 can alternatively select the destination and the conveying pipeline which is any one of the following pipelines: the pipeline connecting the solubilization tank 13 in the second facility 3 and the adjustment tank 11 in the first facility 2; or the other pipeline described above.

[0029]

On the other hand, when the second facility 3 and the third facility 4 are installed far from each other, the second transport device 22 is preferably an

automobile equipped with a storage tank and so forth (for example: a vacuum car and so forth). In this case, by using the automobile, the hydrothermal treatment liquid is conveyed from the solubilization tank 13 to the methane fermentation device 14 and fed to the inlet of the methane fermentation device 14.

When the first facility 2 and the second facility 3 are installed close to each other, and the second facility 3 and the third facility 4 are installed far from each other, the second transport device 22 may be: a pipeline for transporting the hydrothermal treatment liquid between the first facility 2 and the second facility 3, and an automobile for transporting the hydrothermal treatment liquid between the second facility 3 and the third facility 4. In other words, the second transport device 22 may include two types of transport devices which are a pipeline and an automobile.

Similarly, when the first facility 2 and the second facility 3 are installed far from each other, and the second facility 3 and the third facility 4 are installed close to each other, the second transport device 22 may be: an automobile for transporting the hydrothermal treatment liquid between the first facility 2 and the second facility 3, and a pipeline for transporting the hydrothermal treatment liquid between the second facility 3 and the third facility 4.

[0030]

The second transport device 22 transports the hydrothermal treatment liquid stored in the solubilization tank 13 in the second facility 3 back to the adjustment tank 11 in the first facility 2 until the concentration of the organic matter contained in the hydrothermal treatment liquid reaches the predetermined concentration described above.

Thus, the hydrothermal treatment product stored in the adjustment tank 11 in the first facility 2 can be wetted, so that the hydrothermal treatment product can be easily transported by the first transport device 21 and the power consumption of the pressure-separation device 12 in the second facility 3 can be reduced.

[0031]

In addition, because the hydrothermal treatment liquid transported back from the solubilization tank 13 in the second facility 3 to the adjustment tank 11 in the first facility 2 is heated up in the solubilization tank 13, the hydrothermal treatment liquid can be injected into the adjustment tank 11 at one of the following temperature conditions: it is maintained at the heated temperature, or it is maintained at a temperature which is slightly lower than that of hydrothermal treatment liquid temperature due to natural heat dissipation and so forth but higher than room temperature.

In this case, the hydrothermal treatment liquid transported back can contribute to the adjustment of the properties of the hydrothermal treatment product by, for example, promoting the solubilization of at least some part of the hydrothermal treatment product stored in the adjustment tank 11.

5 [0032]

Furthermore, in the hydrothermal treatment system 1, the hydrothermal treatment is performed multiple times sequentially, and even if the ratio among the organic contents in the waste containing organic matter to be hydrothermally treated by the hydrothermal treatment device 10 in the first facility 2 varies for
10 each time which leads to a great variation in the concentration of the organic matter contained in the hydrothermal treatment liquid obtained from each hydrothermal treatment batch, due to the transporting back as described above, the concentration of the organic matter contained in the hydrothermal treatment liquid stored in the solubilization tank 13 can be stabilized by circulating the
15 hydrothermal treatment liquid between the first facility 2 and the second facility 3.

When the concentration of the organic matter contained in the hydrothermal treatment liquid stored in the solubilization tank 13 reaches the predetermined concentration, the hydrothermal treatment liquid which reaches
20 the predetermined concentration is transported to the methane fermentation device 14 by the second transport device 22. Therefore, the concentration of the organic matter contained in the hydrothermal treatment liquid fed to the methane fermentation device 14 is always almost constant and has less variation, and the hydrothermal treatment liquid contains a large amount of the organic matter
25 contributing to the methane gas production. Thus, the methane fermentation device 14 can stably generate the methane gas.

[0033]

In a methane fermentation device in which methane gas is generated by microorganisms or bacteria by utilizing organic matter as a feedstock, generally,
30 inside the device these two steps need to be performed: solubilization of the organic matter and acid fermentation.

However, in the hydrothermal treatment system 1, when the concentration of the organic matter contained in the hydrothermal treatment liquid stored in the solubilization tank 13 reaches the predetermined concentration, the above-
35 mentioned two steps have already been executed and completed in the solubilization tank 13. Therefore, in the methane fermentation device 14, the solubilization step and the acid fermentation step can be omitted, thus, the methane gas can be rapidly generated.

[0034]

The methane fermentation device 14 in the third facility 4 is a device which generates methane gas and digestate by utilizing the hydrothermal treatment liquid stored in the solubilization tank 13 in the second facility 3. The methane fermentation device 14 heats up the hydrothermal treatment liquid (to about 37°C or about 55°C) and generates methane gas by means of methane fermentation. After the generation of methane gas, the remaining liquid fertilizer (also referred to as fermentation residue or digested sludge) is the digestate.

When the hydrothermal treatment liquid stored in the solubilization tank 13 in the second facility 3, for example, contains a large amount of fiber from paper and so forth, the fiber is not completely decomposed in the methane fermentation device 14 and some of fiber still remains, thus, the discharged digestate contains the remaining fiber. Therefore, when the digestate contains a sufficient amount of fiber, a defibrated liquid supply device 17 to be described later or an excreta receiving tank 18 to be described later for the purpose of improving the dewatering efficiency of the dehydrator 15 described below, is not required.

[0035]

The dehydrator 15 is a device (for example: a screw press) which separates the digestate discharged from the methane fermentation device 14 into dewatered sludge and separated liquid. The dewatered sludge is then transported to a waste incineration facility 20 to be described later and can be incinerated in the waste incineration facility 20. On the other hand, the separated liquid is then transported to the waste liquid treatment device 16.

[0036]

The waste liquid treatment device 16 is a device which performs at least nitrification and denitrification treatment, i.e., biological treatment, to purify the separated liquid obtained from the dehydrator 15 and generate recycled water. Examples of the waste liquid treatment device 16 are: a biological treatment device which performs the nitrification and denitrification treatment; and an excreta treatment facility.

The recycled water generated in the waste liquid treatment device 16 can be supplied to the adjustment tank 11 in the first facility 2 through a supply path 25 (for example: a pipeline).

Immediately after starting up the operation of the hydrothermal treatment system 1, the hydrothermal treatment system 1 cannot transport the hydrothermal treatment liquid back to the adjustment tank 11 and cannot wet the hydrothermal treatment product stored in the adjustment tank 11 using the hydrothermal

treatment liquid because the hydrothermal treatment liquid in the solubilization tank 13 in the second facility 3 is not yet stored. Therefore, in this case, the hydrothermal treatment system 1 can wet the hydrothermal treatment product stored in the adjustment tank 11 by supplying the recycled water from the waste liquid treatment device 16 to the adjustment tank 11, so that the conveyance of the hydrothermal treatment product by the first transport device 21 and the operation of the pressure-separation device 12 in the second facility 3 can be smoothly performed immediately after the starting up the operation of the hydrothermal treatment system 1.

When the above-mentioned transporting back cannot be performed, in the hydrothermal treatment system 1, the hydrothermal treatment product can be wetted by injecting tap water into the adjustment tank 11. However, it is desirable to use the recycled water instead of tap water in order to lower the cost and improve the performance efficiency of the hydrothermal system 1.

[0037]

The configuration described above is at least included in the hydrothermal treatment system 1. As illustrated in FIG. 1, the hydrothermal treatment system 1 may further include the following devices and facilities.

[0038]

The defibrated liquid supply device 17 is a device which defibrates paper (for example: used paper such as old newspaper) and supplies the defibrated liquid to the digestate discharged from the methane fermentation device 14.

Since the defibrated liquid supply device 17 supplies the defibrated liquid into the digestate, the dehydrator 15 dehydrates the mixed liquid of the digestate and defibrated liquid. Because the defibrated liquid contains a large amount of fiber, the fiber contained in the mixed liquid, which functions as a substitute of dewatering, aids and absorbs the water content of the mixed liquid. Therefore, the dehydration efficiency of the mixed liquid in the dehydrator 15 can be improved. Since the dewatered sludge discharged from the dehydrator 15 contains some of this fiber, the volume of the dewatered sludge increases, as compared with a case when the defibrated liquid is not mixed with the digestate.

Furthermore, since the fiber contained in the defibrated liquid does not contain a nitrogen component and when the fiber absorbs the moisture, it also absorbs the nitrogen component contained in the mixed liquid, thus, the nitrogen concentration in the separated liquid separated by the dehydrator 15 is reduced. Therefore, the load of the biological treatment in the waste liquid treatment device 16 can be reduced. The defibrated liquid supply device 17 may be configured by, for example, a paper supplying device, a defibrating device, a

defibration used paper storage tank, and a defibration used paper supplying pump described in JP 5905364 B granted to Mitsubishi Heavy Industries Environmental & Chemical Engineering Co., Ltd.

[0039]

5 The excreta receiving tank 18 is a tank which stores excreta. The hydrothermal treatment system 1 can take advantage of the following properties: the property that the "C/N ratio" of the excreta (the ratio between the amount of nitrogen contained in the liquid and the amount of carbon used as a nutrient source by microorganisms during denitrification in the biological treatment) is
10 about 3 to 5, and the property that the excreta contains fiber.

 Specifically, in the hydrothermal treatment system 1, the excreta stored in the excreta receiving tank 18 is supplied to the methane fermentation device 14, the digestate discharged from the methane fermentation device 14, or the waste liquid treatment device 16. It should be noted that the excreta may be supplied
15 to two or all of these three destinations, instead of one destination.

[0040]

 To achieve an efficient methane fermentation in the methane fermentation device 14, the amount of nitrogen contained in the hydrothermal treatment liquid needs to be about 1000 mg/L or more and about 3000 mg/L or less. However,
20 there may be a case where the amount of nitrogen contained in the hydrothermal treatment liquid transported from the solubilization tank 13 to the methane fermentation device 14 is insufficient.

 In this case, the excreta in the excreta receiving tank 18 is supplied to the methane fermentation device 14 to be mixed with the hydrothermal treatment
25 liquid, hence, the shortage of the amount of nitrogen contained in the hydrothermal treatment liquid transported to the methane fermentation device 14 can be compensated by the nitrogen contained in the excreta. In other words, the excreta is supplied to adjust the balance of the amount of nitrogen for the methane fermentation.

30 An increase in the amount of carbon contained in the hydrothermal treatment liquid stored in the methane fermentation device 14 due to supplying the excreta to the methane fermentation device 14, does not negatively affect the hydrothermal treatment system 1 because most of the carbon turns into methane gas in the methane fermentation device 14.

35 In addition, the excreta in the excreta receiving tank 18 may be not directly supplied to the methane fermentation device 14 but it may be supplied to the upstream of the methane fermentation device 14 which is, for example, the adjustment tank 11 in the first facility 2 or the solubilization tank 13 in the second

facility 3. In this case, the excreta is indirectly supplied to the methane fermentation device 14.

[0041]

When the excreta in the excreta receiving tank 18 is supplied to the digestate discharged from the methane fermentation device 14 to form the mixed liquid, the fiber contained in the excreta functions as a substitute of dewatering aids as in the case of the fiber contained in the defibrated liquid described above, therefore, the dehydration efficiency of the mixed liquid in the dehydrator 15 can be improved.

In the hydrothermal treatment system 1 equipped with both the defibrated liquid supply device 17 and the excreta receiving tank 18, when the fiber content in the digestate is in a small amount, supplying additional fiber is necessary to improve the dehydration efficiency, and by utilizing fiber from defibrated liquid or the excreta, the shortage of fiber can be compensated. The hydrothermal treatment system 1 may be equipped with either the defibrated liquid supply device 17 or the excreta receiving tank 18, or may be equipped with both of them.

[0042]

In general, denitrification of liquid in biological treatment can be efficiently performed when the C/N ratio of the liquid is about 2 to 3. Therefore, when biological treatment of the separated liquid is performed in the waste liquid treatment device 16, if the C/N ratio of the separated liquid is less than 2, it is preferable to increase the value of the C/N ratio by supplying the excreta from the excreta receiving tank 18 and mixing them.

When the separated liquid and the excreta are mixed to form the mixed liquid, the amount of carbon and the amount of nitrogen both increase. However, since the C/N ratio of the excreta is about 3 to 5 as described above, the increase in the amount of carbon is larger than the increase in the amount of nitrogen. Therefore, even if the C/N ratio of the separated liquid is less than 2, the C/N ratio of the mixed liquid can be easily adjusted to about 2 to 3 by mixing the excreta. In other words, here, the excreta is supplied to adjust the balance of the C/N ratio of the separated liquid which will be subjected to the biological treatment.

[0043]

A third transport device 23 is a device which transports the methane gas generated by the methane fermentation device 14 in the third facility 4 to a gas utilization facility 19 described below.

When the methane fermentation device 14 and the gas utilization facility 19 are installed close to each other, the third transport device 23 is preferably a

pipeline. This pipeline connects the methane fermentation device 14 and the gas utilization facility 19, and transports the methane gas generated in the methane fermentation device 14 to the gas utilization facility 19.

On the other hand, when the methane fermentation device 14 and the gas utilization facility 19 are installed far from each other, the third transport device 23 is preferably an automobile (truck) equipped with a loading platform for loading a gas cylinder or an automobile having a gas tank mounted thereon. In this case, the gas cylinder or the gas tank, loaded or mounted on the automobile, is filled with the methane gas generated by the methane fermentation device 14, and the methane gas can be transported to the gas utilization facility 19.

[0044]

The gas utilization facility 19 is a facility which utilizes the methane gas generated by the methane fermentation device 14 in the third facility 4. The gas utilization facility 19 is, for example, a power plant which generates steam using heat generated by burning the methane gas or mixed gas obtained by mixing the methane gas with another gas in a boiler and rotates a steam turbine with the steam to generate electric power. In recent years, regarding the thermal power plant, in order to reduce the amount of carbon dioxide emission during combustion, thermal power plants using liquefied natural gas (LNG) containing methane as a main fuel component have become mainstream; and the gas utilization facility 19 can also be a power plant corresponding to the thermal power plants.

The gas utilization facility 19 may be a power plant equipped with a gas turbine, a gas engine, or a fuel cell, or a facility which reforms the methane gas to produce city gas.

When the gas utilization facility 19 is a power plant equipped with a gas engine, the gas utilization facility 19 is generally equipped with a heat recovery device for exhaust gas generated by the gas engine. The heat recovery device can generate hot water by utilizing the exhaust gas.

[0045]

When the gas utilization facility 19 is a power plant which generates electric power by using a steam turbine, and at least one of the following facilities: the first facility 2, the second facility 3, or the third facility 4 is installed close to the gas utilization facility 19, waste steam, which is high-temperature steam that has been used for electric power generation in the steam turbine in the gas utilization facility 19, can be used in any of the following facilities which is close to the gas utilization facility 19: the first facility 2, the second facility 3, or the third facility 4.

For example, when the gas utilization facility 19 equipped with a steam turbine is installed close to the first facility 2, the gas utilization facility 19 and the first facility 2 may be connected to each other by a pipeline, and the waste steam may be transported to the hydrothermal treatment device 10 in the first facility 2 through the pipeline. The high-temperature and high-pressure steam to be used in the hydrothermal treatment device 10 can be all from this waste steam or only some of it.

In addition, when the gas utilization facility 19 equipped with a steam turbine is installed close to the second facility 3, the gas utilization facility 19 and the second facility 3 may be connected to each other by a pipeline, and the waste steam may be transported to the solubilization tank 13 in the second facility 3 through the pipeline. The waste steam is used for heating up the hydrothermal treatment liquid stored in the solubilization tank 13.

Furthermore, when the gas utilization facility 19 equipped with a steam turbine is installed close to the third facility 4, the gas utilization facility 19 and the third facility 4 may be connected to each other by a pipeline, and the waste steam may be transported to the methane fermentation device 14 in the third facility 4 through the pipeline. The waste steam is used for heating up the hydrothermal treatment liquid stored in the methane fermentation device 14.

[0046]

In addition, when the gas utilization facility 19 equipped with a gas engine is installed close to the second facility 3, the gas utilization facility 19 and the second facility 3 may be connected to each other by a pipeline, and the hot water generated by the heat recovery device described above may be transported to the solubilization tank 13 in the second facility 3 through the pipeline. The hot water is used for heating up the hydrothermal treatment liquid stored in the solubilization tank 13.

Similarly, when the gas utilization facility 19 equipped with a gas engine is installed close to the third facility 4, the gas utilization facility 19 and the third facility 4 may be connected to each other by a pipeline, and the hot water may be transported to the methane fermentation device 14 in the third facility 4 through the pipeline. The hot water is used for heating up the hydrothermal treatment liquid stored in the methane fermentation device 14.

As described above, the temperature for heating up the solubilization tank 13 is about 40°C to 60°C, and the temperature for heating up the methane fermentation device 14 is about 37°C or about 55°C. Thus, in order to heat up the solubilization tank 13 and the methane fermentation device 14, hot water is easier to handle than waste steam.

[0047]

As described above, when the gas utilization facility 19 is equipped with a steam turbine, the waste steam discharged from the steam turbine can be used as a heat source in the hydrothermal treatment system 1, and when the gas utilization facility 19 is equipped with a gas engine, the hot water generated by the heat recovery device can be used as a heat source in the hydrothermal treatment system 1, therefore, it can lower the cost and improve the performance efficiency of the hydrothermal treatment system 1.

[0048]

A fourth transport device 24 is a device which transports the residue which is separated by the pressure-separation device 12 in the second facility 3 to the waste incineration facility 20 described below.

When the second facility 3 and the waste incineration facility 20 are installed close to each other, the fourth transport device 24 is preferably a conveyor which connects a residue discharge port of the pressure-separation device 12 and a waste pit of the waste incineration facility 20, and transports the residue discharged from the pressure-separation device 12 to the waste pit.

On the other hand, when the second facility 3 and the waste incineration facility 20 are installed far from each other, the fourth transport device 24 is preferably an automobile, such as a truck or a garbage truck. In this case, the residue discharged from the pressure-separation device 12 can be loaded on or stored in a truck bed or a garbage truck and transported to the waste incineration facility 20.

[0049]

The waste incineration facility 20 is a facility for incinerating waste using an incinerator, and it can also incinerate the residue discharged from the pressure-separation device 12 in the second facility 3 and the dewatered sludge separated by the dehydrator 15. In the waste incineration facility 20, heat generated from the incinerator is used to produce high-temperature and high-pressure steam in a boiler and this high-temperature and high-pressure steam is used to move the steam turbine so that the electric power can be generated.

When at least one of the following facilities: the first facility 2, the second facility 3, or the third facility 4 is installed close to the waste incineration facility 20, waste steam, which is high-temperature steam that has been used for electric power generation in the steam turbine of the waste incineration facility 20, can be used in the first facility 2, the second facility 3, or the third facility 4 which is close to the waste incineration facility 20.

For example, when the waste incineration facility 20 is installed close to the first facility 2, the waste incineration facility 20 and the first facility 2 may be connected to each other by a pipeline, and the waste steam may be transported to the hydrothermal treatment device 10 in the first facility 2 through the pipeline. The high-temperature and high-pressure steam to be used in the hydrothermal treatment device 10 can be all from this waste steam or only some of it.

In addition, when the waste incineration facility 20 is installed close to the second facility 3, the waste incineration facility 20 and the second facility 3 may be connected to each other by a pipeline, and the waste steam may be transported to the solubilization tank 13 in the second facility 3 through the pipeline. The waste steam is used for heating up the hydrothermal treatment liquid stored in the solubilization tank 13.

Furthermore, when the waste incineration facility 20 is installed close to the third facility 4, the waste incineration facility 20 and the third facility 4 may be connected to each other by a pipeline, and the waste steam may be transported to the methane fermentation device 14 in the third facility 4 through the pipeline. The waste steam is used for heating up the hydrothermal treatment liquid stored in the methane fermentation device 14.

As described above, since the waste steam of the waste incineration facility 20 can be effectively used as a heat source in the hydrothermal treatment system 1, it can lower the cost and improve the performance efficiency of the hydrothermal treatment system 1.

[0050]

The hydrothermal treatment system 1 may be a system including none, one, two, three, or four out of these four devices/facilities: (1) the defibrated liquid supply device 17, (2) the excreta receiving tank 18, (3) the third transport device 23 and the gas utilization facility 19, or (4) the fourth transport device 24 and the waste incineration facility 20.

Reference Signs List

[0051]

1 Hydrothermal treatment system

2 First facility

3 Second facility

4 Third facility

10 Hydrothermal treatment device

11 Adjustment tank

- 12 Pressure-separation device
- 12A Rotary drum screen
- 12B Screw press
- 13 Solubilization tank
- 5 14 Methane fermentation device
- 15 Dehydrator
- 16 Waste liquid treatment device (excreta treatment facility)
- 17 Defibrated liquid supply device
- 18 Excreta receiving tank
- 10 19 Gas utilization facility
- 20 Waste incineration facility
- 21 First transport device
- 22 Second transport device
- 23 Third transport device
- 15 24 Fourth transport device
- 25 Supply path

Claims

[Claim 1]

A hydrothermal treatment system comprising:

5 a hydrothermal treatment device configured to perform a hydrothermal reaction of waste containing organic matter;

 an adjustment tank configured to wet a hydrothermal treatment product obtained from the hydrothermal reaction;

10 a first transport device configured to transport the hydrothermal treatment product wetted in the adjustment tank;

 a pressure-separation device configured to apply pressure to the hydrothermal treatment product transported by the first transport device to separate the hydrothermal treatment product into hydrothermal treatment liquid and residue;

15 a solubilization tank configured to store and heat up the hydrothermal treatment liquid separated by the pressure-separation device;

 a second transport device configured to transport the hydrothermal treatment liquid which is heated up and solubilized in the solubilization tank back to the adjustment tank;

20 a methane fermentation device configured to generate methane gas and digestate by utilizing the hydrothermal treatment liquid stored in the solubilization tank;

 a dehydrator configured to separate the digestate into dewatered sludge and separated liquid; and

25 a waste liquid treatment device configured to perform at least nitrification and denitrification of the separated liquid to generate recycled water, wherein

 the second transport device transports the hydrothermal treatment liquid back to the adjustment tank when a concentration of organic matter contained in the hydrothermal treatment liquid stored in the solubilization tank is less than a
30 predetermined concentration which is a concentration of the organic matter suitable for methane gas generation using microorganisms or bacteria, and transports the hydrothermal treatment liquid to the methane fermentation device when the concentration of the organic matter is equal to or more than the predetermined concentration.

35

[Claim 2]

The hydrothermal treatment system according to claim 1, further comprising a defibrated liquid supply device configured to supply defibrated liquid obtained by defibrating paper, to the digestate.

5

[Claim 3]

The hydrothermal treatment system according to claim 1 or 2, further comprising an excreta receiving tank configured to store excreta, wherein

the excreta in the excreta receiving tank is supplied to the methane
10 fermentation device to be mixed with the hydrothermal treatment liquid,
the excreta in the excreta receiving tank is mixed with the digestate, or
the excreta in the excreta receiving tank is mixed with the separated liquid.

[Claim 4]

15 The hydrothermal treatment system according to claim 3, wherein
the pressure-separation device is equipped with a rotary drum screen in a
preceding stage and a screw press in a following stage, and
the solubilization tank stores the hydrothermal treatment liquid separated
by the rotary drum screen and the hydrothermal treatment liquid separated by the
20 screw press.

[Claim 5]

The hydrothermal treatment system according to claim 4, wherein
the waste liquid treatment device is an excreta treatment facility and the
25 recycled water is supplied to the adjustment tank,

the hydrothermal treatment system further comprises:

a third transport device configured to transport the methane gas
generated by the methane fermentation device and a gas utilization facility which
utilizes the methane gas transported by the third transport device, or

30 a fourth transport device configured to transport the residue
separated by the pressure-separation device and a waste incineration facility
configured to incinerate the residue transported by the fourth transport device,

when the hydrothermal treatment device and the adjustment tank are
installed close to the pressure-separation device and the solubilization tank, the
35 first transport device is a pipeline equipped with a crushing pump and the second
transport device is a pipeline equipped with a pump,

when the hydrothermal treatment device and the adjustment tank are installed far from the pressure-separation device and the solubilization tank, the first transport device and the second transport device are both an automobile,

5 when the methane fermentation device and the gas utilization facility are installed close to each other, the third transport device is a pipeline,

when the methane fermentation device and the gas utilization facility are installed far from each other, the third transport device is an automobile,

10 when the waste incineration facility is installed close to the pressure-separation device and the solubilization tank, the fourth transport device is a conveyor,

when the waste incineration facility is installed far from the pressure-separation device and the solubilization tank, the fourth transport device is an automobile,

15 the gas utilization facility is equipped with a steam turbine or a gas engine, and steam which has been used for electric power generation in the steam turbine is supplied to the hydrothermal treatment device, the solubilization tank, or the methane fermentation device, or hot water generated from the gas engine's exhaust gas is supplied to solubilization tank or the methane fermentation device, and

20 the waste incineration facility is equipped with a steam turbine, and steam which has been used for electric power generation in the steam turbine is supplied to the hydrothermal treatment device, the solubilization tank, or the methane fermentation device.