

SPECIFICATION

[Title of Document] Specification

[Title of the Invention] **METHOD FOR METHANE FERMENTATION OF ORGANIC WASTES**

[Technical Field]

[0001] This invention relates to a method of treating organic wastes by the methane fermentation with membrane separation.

[Background Art]

[0002] Among municipal wastes, organic wastes, such as garbage discarded from homes or restaurants, garbage discarded from factories manufacturing ready-prepared foods or dishes or from processing plants of agricultural products or aquatic products, and sewage sludge, are treated by methane fermentation. During methane fermentation, fermentation sludge increases, and it is drawn from the fermenter. By doing so, methane bacterium is also drawn. Then, the fermentation with membrane separation has been developed where fermentation broth is sent to a membrane separation tank where membrane separation is carried out, and separated sludge is returned to the fermenter (e.g. Patent Document 1).

[0003] An outline of the fermentation with membrane separation is shown in Figure 4. The organic wastes to be charged in the fermenter are pressurized and extruded from a separator (1) having a mesh size of 0.3–0.7 mm to separate and remove the residues, and then, they are charged in the fermenter where methane fermentation is carried out. The employed fermentation temperature is high, i.e. 50–57 °C, in order to lower viscosity of the liquid permeating the membrane. The fermentation sludge is taken out from the fermenter to circulate between the membrane separation tank, and another separator (2) is provided in the circulating line. Excess sludge is drawn from the bottom of the fermenter, and is dehydrated by a dehydrator, and taken out as

dehydrated cake.

[Prior Art Document]

[Patent Documents]

[0004] [Patent Document 1] JP 2000-24661 A

[Summary of the Invention]

[Problem to be Solved by the Invention]

[0005] The methane fermentation with membrane separation is necessary to avoid inclusion of the contaminant into the membrane separator tank for stable operation of membrane separation. In Document 1, garbage or the like is compressed and pulverized to remove the contaminant by pressurizing to extrude it from a screen having a mesh size of 0.3–0.7 mm, and further, a screen which is a separator is also provided in the supply line from the fermenter to the membrane separator tank.

[0006] However, the inventors investigated this method, and found that when the mesh size of screen being slits, which is a separator, is 0.3–0.7 mm, the residue not passing the separator increase to raise their treating cost, and moreover, because the residue contain a significant amount of biodegradable organic substance, essentially utilizable materials for methane fermentation are also discarded to raise the treating cost.

[0007] The object of the invention is to provide a means capable of removing efficiently contaminant which interferes with stable operation of membrane, and decreasing organic substance accompanied with the contaminant to reduce treating cost of discharged residue.

[Means for Solving the Problem]

[0008] In order to solve the above problems, the present invention provides an apparatus for methane fermentation of organic wastes with membrane separation, which is provided with a first separator separating the organic waste to be charged in a fermenter, and a second separator separating the fermentation broth which is discharged from the fermenter and sent to the membrane

separation tank, wherein the mesh size of the first separator is 1.0 mm or more and 10 mm or less, and the mesh size of the second separator is 0.5 mm or more and 3.0 mm or less, and the mesh size of the first separator is larger than the mesh size of the second separator, and at least a part of the residue separated by the second separator is returned to the fermenter; and

a method for methane fermentation of organic wastes with membrane separation, which comprises separating the organic wastes to be charged in a fermenter by a first separator having a mesh size of 1.0 mm or more and 10 mm or less, separating the fermentation broth, which is discharged from the fermenter and sent to the membrane separation tank, by a second separator having a mesh size of 0.5 mm or more and 3.0 mm or less and less than the first separator, and returning at least a part of the residue separated by the second separator to the fermenter.

[0009] Namely, the inventors investigated eagerly, and as a result, they found that when the mesh size of the first separator located before charging in the fermenter is made 1.0 mm or more, the amount of the separated residue is not so decreased, but inclusion of organic materials can be decreased sharply. And, they further found that by rendering the mesh size of the second separator 0.5 – 3.0 mm which separates the fermentation broth delivered from the fermenter to the membrane separation tank, the contaminant escaped from the first separator can be removed efficiently to operate the membrane separation tank smoothly for a long time, and there is no problem of clogging in the second separator.

[Effects of the Invention]

[0010] According to the invention, contaminant, which is an inclusion of organic wastes and damage the membrane, can be removed efficiently to render that membrane fermentation can be operated stably for a long time, and most of the organic substance are fermented to decrease the generation of discharged residue, and thereby, treating cost of discharged wastes can be reduced.

[Brief Description of the Drawings]

[0011] [FIG. 1] A block diagram illustrating an embodiment of the invention.

[FIG. 2] A block diagram illustrating another embodiment of the invention.

[FIG. 3] A block diagram illustrating still another embodiment of the invention.

[FIG. 4] A block diagram illustrating a conventional conducting method.

[Mode for Carrying Out the Invention]

[0012] The organic wastes charging in the apparatus for methane fermentation of the invention are subjected to methane fermentation, are include garbage discarded from homes or restaurants, garbage discarded from factories manufacturing ready-prepared foods or dishes or from processing plants of agricultural products or aquatic products, sludge discarded from sewage treatment plants, and the like.

[0013] The garbage discharged from homes or restaurants is generally put in a plastic bag, and many garbage discharged from factories manufacturing ready-prepared foods or dishes are put in a corrugated box, and therefore, received organic wastes are crushed by a crusher or the like to take out the contents therefrom.

[0014] The organic waste thus received is first subjected to separation, in order to remove crushed pieces of the plastic bag, stones included in the organic waste and so on. In the invention, the mesh size of the first separator located before charging in the fermenter is made 1.0 mm or more. While, when the mesh size is more than 10 mm, clogging of the pump transferring the organic waste to the fermenter tends to occur, the mesh size is preferably 10 mm or less. Therefore, favorable mesh size of the first separator in the invention is 1.0 mm or more and 10 mm or less, preferably 2.0 mm or more and 8.0 mm or less, more preferably 3.0 mm or more and 7.0 mm or less. As the type of the separator, there are rotary blade type bag-rupture selector, hammer blade type crusher selector, and the like. The substances separated by the first

separator are not fermentable substances by methane fermentation or to inhibit operation of apparatus, such as pieces of plastic bag, pieces of corrugated board, stone, paper and cloth.

[0015] The organic waste, from which the substances unsuitable for fermentation have been removed as residue, is charged in the fermenter. Whereas, the residue is disposed by incineration or the like.

[0016] The fermenter has a closed structure, and are provided with an exhaust port of gas at the upper part and a drawing port of sludge at the bottom. The fermenter is further provided with an outlet of fermentation broth and an inlet of sludge returned from the membrane separation tank to form a circulating line, and in general, a stirrer for stirring the fermentation broth is also attached. In addition, measuring instruments necessary for the management of fermentation are also attached, such as a level gauge and a thermometer.

[0017] The drawing port of sludge is connected to a dehydrator, where the sludge is dehydrated, and the sludge is discharged as dehydrated cake. A part of the dehydrated cake is utilized as compost or fuel, but most of it is disposed by incineration.

[0018] As the stirrer, mixing blade type stirrer, such as paddle stirrer is used. In order to reduce the burden of the second separator, it is preferable to enable the number of revolutions of the stirrer to be controlled by an inverter so as to agitate the fermentation broth moderately. Thereby, precipitation of residue is facilitated by the moderate stirring, and the amount of residue to be charged into the second separator can be decreased.

[0019] Moreover, when the outlet of the fermentation broth is located at low position of the fermenter in the circulating line between the fermenter and the membrane separation tank, precipitable residue is sent in quantity to the second separator. Therefore, in order to reduce the burden of the second separator, it is preferable that the outlet is located at high position, i.e. 1/4 or more, preferably about 1/2–3/4, of the depth of liquid in the fermenter. Whereas, the position of the inlet of sludge returned from the membrane separation tank may be either high or low.

[0020] When the fermentation broth sent from the fermenter to the membrane separation tank includes big contaminant, they are nipped by membranes to degrade washing ability of the blower for membrane surface or stick on the membrane surface to reduce effective membrane area. As a result, transmembrane pressure difference is raised, and washing frequency is increased. Then, the second separator is provided to the line delivering the fermentation broth from the fermenter to the membrane separation tank, and contaminant, which interferes with stable operation, is removed. When the mesh size of the second separator is too small, clogging of the mesh tends to occur, and stable supply of the fermentation broth to the membrane separation tank cannot be made. Furthermore, in order to render the sludge concentration in the membrane separation tank not too high, the flow rate of the fermentation broth drawn from the fermenter becomes great, and employed suction pump is big. Therefore, it is unfavorable in view of equipment cost. Whereas, when the mesh size is too large, relatively large contaminant leaks out to interfere with stable operation of membrane separation.

[0021] Therefore, a suitable mesh size of the second separator is 0.5 mm or more and 3.0 mm or less. Furthermore, the mesh size of the second separator is rendered smaller than the first separator. Since residue separated by the second separator contains a considerable quantity of organic substances it is returned to the fermenter. The return may be joined to the circulating line or the sending back side to the fermenter, or may be direct to the fermenter.

[0022] The second separator may be constituted by plural steps, i.e. by joining plural separators in series. Namely, the residue caught on the side having a large mesh size are heavy because of containing rice which is liable to supply water or the like in quantity, and the return is carried out by a pump. Alternatively, since the content of organic substance is small, they may be discharge out of the system. On the other hand, since the residue caught on the side having a small mesh size is light because of containing small vegetable garbage or the like in quantity, it can be returned without

using a pump. Since the rate of organic substance is high, it is returned to the fermenter. When the second separator is constituted by plural separators, residue accumulated on the surface of screen reduce, and maintenance of the separator is rendered easy. The mesh size is, for example, 2.0 mm or more and 3.0 mm or less at the front part, and 0.5 mm or more and 2.0 mm or less at the rear part.

[0023] As the type of the separator, bar screen type, drum screen type or the like can be used.

[0024] The fermentation broth, from which contaminant has been removed by the second separator, is charged in the membrane separation tank, and membrane separation is carried out. In the membrane separation tank, plural membrane modules are provided, and a diffuser for washing membrane is mounted under there. The pore size of the membrane is preferably about 0.05–0.4 μm as the average pore size which does not pass methane bacterium. Due to the methane fermentation being anaerobic, as the gas to be supplied to the diffusers, air is unfavorable, and biogas containing methane and carbon dioxide as principal components exhausted from the fermenter or the like is used.

[0025] In the method of methane fermentation using such an apparatus, from organic waste, substances unsuitable for fermentation are removed as residue by the first separator, and then, the organic waste is put in a fermenter. Methane bacterium (methanogen) is inoculated, and methane fermentation is conducted. On that occasion, concentration of the organic waste is adjusted by adding water, and therefor, a mixing tank may be provided between the first separator and the fermenter. The concentration is made in common 4–10 % by weight of TS (Total Solids). The methane fermentation may be conducted by conventional manner, and although high temperature fermentation may conducted by using thermophile, it may be conducted conventionally at about 35–40 °C. During fermentation, it is necessary to keep the concentration of methane bacterium so that the fermentation proceeds smoothly, and the concentration is maintained about 2–5 vol. % as the concentration of fermentation

sludge. For that purpose, the fermentation broth is circulated between the fermenter and the membrane separation tank, while water separated by membrane is drawn, and the sludge is sent back to the fermenter. The excess sludge precipitated in the fermenter is taken out from the drawing port of the sludge.

[0026] The fermentation broth in the fermenter is stirred by a stirrer. When the stirring is too strong, the sludge precipitated in the fermenter whirls up to increase the burden of the second separator. Then, the frequency is controlled by an inverter so that the number of revolutions makes mill stirring. Since the residue separated by the second separator contains organic substance in quantity, it is fundamentally returned to the fermenter. However, the residue containing substances unsuitable for fermentation in quantity is taken out of the system.

[0027] The fermentation may be carried out by continuous operation or batchwise operation.

[0028] A construction of an embodiment of the invention is shown in Figure 1. The organic waste is introduced into the first separator having a mesh size of 1.0–10 mm from the left side of the figure to remove substances unsuitable for fermentation, and then, charged in the fermenter. In the fermenter, the fermentation broth is stirred by a stirrer controlled by an inverter, and is circulated between the fermenter and the membrane separation tank by a pump (not illustrated). A sludge densitometer is mounted in the fermenter and the line delivering to the membrane separation tank to measure each sludge concentration, and the data are inputted in a criterion apparatus. Its instruction is delivered to the inverter, and the stirring rate of the stirrer is controlled. Then, contaminant in the fermentation broth is removed by the second separator having a mesh size of 0.5–3.0 mm. The residue, which is the removed contaminant, is joined to the return line to the fermenter. The fermentation broth, from which contaminant has been removed, enters into the membrane separation tank, and water permeated the membrane is drawn and discharged to out of the system. Whereas, the fermentation sludge is concentrated and returned to the fermenter. In the membrane separation tank, a part of

methane gas exhausted from the fermenter is discharged by a blower from the underside of membrane modules to wash membrane surfaces. The sludge precipitated in the fermenter is drawn from the bottom of the fermenter, and is dehydrated by the dehydrator, and taken out as dehydrated cake.

[0029] A construction of another embodiment of the invention is shown in Figure 2. In this embodiment, the second separator is composed by two separators joined in series. The front separator has a mesh size of 2.0–3.0 mm, and the rear separator has a mesh size of 0.5–2.0 mm, and the residue separated by the front separator is joined to the return line through a pump. The other construction is the same as the embodiment shown in Figure 1.

[0030] A construction of still another embodiment of the invention is shown in Figure 3. In this embodiment, the residue separated by the front separator is discharged to out of the system. The other construction is the same as the embodiment shown in Figure 2.

[Examples]

[0031] The apparatus shown in Figure 1 was used. The organic waste was garbage put in a bag, and discarded from homes. Gathered garbage was put in a hopper, and bag was broken by a crusher, and then, the garbage was introduced in the first separator. The first separator employed was a blade type bag rupture separator, and changing mesh size from 0.5 mm to 10 mm, the garbage introduced was separated. The obtained results are shown in Table 1.

[0032] [Table 1]

Mesh Size (mm)	0.5	1.0	5.0	10
*1 Proportion of Separated Residue (wt. %)	40	30	25	20
*2 Organic Substance in Residue (wt. %)	20	10	3	3

*1 Proportion of residue to introduced amount into separator

*2 Weight % of methane fermentable component (garbage)

(The other components are paper • cloths, plastic • synthetic resin • rubber • leathers, wood • bamboo • straws, and incombustibles.)

[0033] From the above results, it was found that, favorable mesh size is 1.0 mm or more and 10 mm or less. Because, when the mesh size is less than 1.0 mm, the proportion of separated residue is great, and the proportion of organic substance is also great. Whereas, when the mesh size is more than 10 mm, clogging of transfer pump to the fermenter occurs.

[0034] Then, the mesh size of the first separator was set 10 mm, and separated organic waste was put in the fermenter, and methane fermentation was carried out. The fermenter was a closed type cylinder having a volume of 10 m³, and the form of the bottom was funnel. On the inside of the fermenter, a stirrer of paddle type stirring blade was mounted with an inverter control mechanism for rotational speed. During fermentation operation, the fermentation broth was circulated at 1 m³ / h between the fermenter and the membrane separation tank. The organic waste was charged continuously, and sludge accumulated at the bottom was drawn to keep the TS concentration of the fermentation broth at 2–5 wt. % (e.g. 3 wt. %). The volume of gas supplied from the fermenter to the diffuser in the membrane separation tank was controlled constant at a speed of 4 NL / min / m² • effective membrane area.

[0035] Thus, changing the mesh size of the second separator from 0.1 mm to 4.0 mm, and the number of days to reach 15 kPa of the transmembrane pressure difference from washing of membrane surface was examined. The results are shown in Table 2.

[0036] [Table 2]

Mesh Size (mm)	0.1	0.5	1.0	3.0	4.0	None
Number of Days	*1 -	20	17	15	5	3

*1 Stable operation cannot be conducted by clogging of screen.

[0037] From the above results, it was confirmed that favorable mesh size was 0.5 mm or more and 3 mm or less.

[0038] When the SS (Suspended Solid) concentration of the sludge drawn from the fermenter exceeds the SS concentration in the fermenter, the amount of the residue generated in the second

separator is raised to increase the load of the second separator. Therefore, in the case that the SS concentration of the sludge drawn from the fermenter exceeded the SS concentration in the fermenter, the rotational speed of the stirrer was lowered from 30 rpm to 20 rpm by the control of the inverter. Thereby, precipitation was facilitated in the fermenter, and the SS concentration of the sludge drawn from the fermenter was lowered.

[0039] Besides, in the case of the drawing position of the fermentation broth at the height of 1/4 or 1/5 of the liquid level in the fermenter, the SS concentration of the drawn sludge and the SS concentration in the fermenter were measured, and the results are shown in Table 3. The rotational speed of the stirrer in both cases was 30 rpm.

[0040] From the above results, it was confirmed that the drawing position of the fermentation broth is desired to be 1/4 of the liquid level in the fermenter or higher than that.

[0041] [Table 3]

Drawing Position of Fermentation Broth	1/4	1/5
SS Concentration of Drawn Sludge (mg / L)	30,000	35,000
SS Concentration in Fermenter (mg / L)	30,000	30,000

[0042] Subsequently, as to the apparatuses in Figures 1–3, the mesh size of every first separator was 10 mm, and the mesh size of the second separator was 0.5 mm in Figure 1, and 2.5 mm at the front part and 0.5 mm at the rear part in Figure 2 and 3. Then, methane fermentation was conducted, and decomposition rate of organic substance in the organic waste was measured. The results are shown in Table 4.

[0043] [Table 4]

System	Conventional Method (Fig. 4)	All Residue Return (Fig. 1, 2)	Part of Residue Return (Fig. 3)
Decomposition Rate of Organic Substance (%)	90	95	94

[0044] Additionally, organic substance was determined by COD-Cr.

[0045] From the above results, it turned out that the residue separated by the second separator contains a certain degree of organic substance, and the decomposition rate of organic substance is improved by returning it to the fermenter to increase the generation volume of methane gas.

[Industrial Applicability]

[0046] According to the invention, since methane gas can be produced by the methane fermentation of organic waste efficiently, it can be utilized widely for methane fermentation of organic waste.

CLAIMS

[Title of Document] Claims

[Claim 1] A method for methane fermentation of organic wastes with membrane separation, which comprises separating the organic wastes to be charged in a fermenter by a first separator having a mesh size of 1.0 mm or more and 10 mm or less, separating the fermentation broth, which is discharged from the fermenter and sent to the membrane separation tank, by a second separator of which the mesh size is 0.5 mm or more and 3.0 mm or less and less than the first separator, returning at least a part of the residue separated by the second separator to the fermenter, and operating fermentation with keeping the TS concentration of the fermentation broth in the fermenter at 2—5 wt. %, and mounting an inverter control mechanism to control stirring of the stirrer, which stirs the fermentation broth in the fermenter, to the stirrer, and controlling the number of revolutions of the stirrer so that the SS concentration of the sludge in the fermentation broth sending from the fermenter to the second separator does not exceed the SS concentration in the fermenter.

[Claim 2] The method for methane fermentation as set forth in claim 1, wherein the second separator comprises plural separators joined in series.

[Claim 3] The method for methane fermentation as set forth in claim 2, wherein the front part separator has a mesh size of 2.0 mm or more and 3.0 mm or less and the rear part separator has a mesh size of 0.5 mm or more and less than 2.0 mm among the plural separators joined in series.

[Claim 4] The method for methane fermentation as set forth in any one of claims 1 — 3, wherein the drawing position of the fermentation broth delivered from the fermenter to the second separator is at a height of 1/4 or more of the liquid level in the fermenter.