

SYSTEM FOR DECONTAMINATING LIQUID WASTE CONTAINING  
MICROORGANISM AND/OR VIRUS

TECHNICAL FIELD

[0001]

The present invention relates to a system for decontaminating liquid waste containing a microorganism and/or a virus, which refers to at least one selected from bacterium, filamentous fungus, yeast, alga, protozoa, virus, phage, prion, and the like (the same applies hereinafter). Specifically, the present invention relates to a decontamination system for inactivating liquid waste from a pharmaceutical facility or a factory, a laboratory, a hospital, or the like, which is concerned about the presence of microorganisms and/or viruses.

BACKGROUND ART

[0002]

Conventional treatment of liquid waste containing microorganisms and/or viruses includes inactivation treatment (which means disinfection treatment (the same applies thereafter)) with a chemical liquid. Such inactivation treatment with a chemical liquid includes first subjecting liquid waste to pH adjustment and coagulation sedimentation; and then subjecting the sludge fraction to dewatering and then incineration (burning) and subjecting the liquid phase fraction to treatment with a disinfectant such as sodium

hypochlorite, which is followed by neutralization of the excessive chemical and then discharging out of the system. Unfortunately, such inactivation treatment with a chemical liquid has the problem of high running cost since it requires a large amount of the chemical liquid and a large amount of energy for incineration.

[0003]

Alternative treatment of liquid waste containing microorganisms and/or viruses includes inactivation treatment by heating. Proposed examples of such inactivation treatment by heating include inactivation treatment using a batch heat treatment apparatus using steam or electrical resistance (see, for example, Patent Documents 1 and 2). Such inactivation treatment by heating can solve the problem with the inactivation treatment with a chemical liquid.

[0004]

Patent Document 1: Japanese Unexamined Patent Application, Publication No. 2000-263037

Patent Document 2: U.S. Published Patent Application Publication, No. 2016/0145121, Specification

## DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

[0005]

In recent years, however, mainstream bio-pharmaceutical production has shifted from conventional mass production to small-volume continuous production using disposable single-use

devices to facilitate the production of a wide variety of products using different types of microorganisms and/or viruses. In the inactivation treatment using a batch heat treatment apparatus, therefore, liquid waste is allowed to stand undecontaminated until a certain amount of liquid waste has accumulated. If a central decontamination facility is used for such treatment, the untreated microorganism and/or virus may cause back contamination through piping.

[0006]

A laboratory or hospital uses a relatively small amount of water and produces a relatively small amount of liquid waste. Such a situation requires on-site, instant, continuous inactivation treatment in each suite (each manufacturing area) rather than a central decontamination facility suitable for inactivation treatment of a large volume of liquid waste. Unfortunately, no decontamination system capable of continuously inactivating, by heating, a small volume of liquid waste containing microorganisms and/or viruses has been found yet.

[0007]

The present invention has been made in light of the above, and an object of the present invention is to provide a decontamination system capable of continuously inactivating, by heating, a small volume of liquid waste containing a microorganism and/or a virus.

Means for Solving the Problems

[0008]

To achieve the object, the present invention is directed to the following aspects.

(1) A decontamination system for continuously inactivating liquid waste containing a microorganism and/or a virus, the decontamination system including: a liquid waste receiving vessel that receives the liquid waste from a liquid waste discharging facility; a steam generator that produces steam; a heat exchanger that heats the liquid waste supplied from the liquid waste receiving vessel by exchanging heat with the steam produced by the steam generator; a liquid waste supply means that supplies the liquid waste from the liquid waste receiving vessel to the heat exchanger; and a controller that controls the liquid waste receiving vessel, the steam generator, the heat exchanger, and the liquid waste supply means to continuously inactivate the liquid waste, the heat exchanger including: a heater that has a coiled tube heat exchanger and heats the liquid waste to a predetermined first temperature or more by exchanging heat with the steam produced by the steam generator; and a retention unit that has a coiled tube heat exchanger and maintains the liquid waste at the first temperature or more for a predetermined period of time while exchanging heat with the steam produced by the steam generator after the liquid waste is heated to the first temperature or more by the heater.

[0009]

(2) The decontamination system according to aspect (1) may further include a flow rate detection means that is

provided in a flow path between the liquid waste receiving vessel and the heater to detect a flow rate of the liquid waste passing through the flow path; a first temperature detection means that is provided in a flow path between the heater and the retention unit to detect a temperature of the liquid waste passing through the flow path; and a second temperature detection means that is provided in a flow path downstream of the retention unit to detect a temperature of the liquid waste passing through the flow path, in which the controller may control the liquid waste receiving vessel, the liquid waste supply means, the steam generator, and the heat exchanger based on the flow rate detected by the flow rate detection means, the temperature detected by the first temperature detection means, and the temperature detected by the second temperature detection means.

[0010]

(3) The decontamination system according to aspect (2) may further include a liquid waste circulation means that circulates, to the liquid waste receiving vessel, the liquid waste discharged from the heat exchanger, in which the controller may control the liquid waste circulation means to circulate, to the liquid waste receiving vessel, the liquid waste discharged from the heat exchanger when the temperature detected by the second temperature detection means is less than the first temperature.

[0011]

(4) In the decontamination system according to any one of

aspects (1) to (3), the heat exchanger may further include a preheater that is provided in a flow path between the liquid waste receiving vessel and the heater to preheat the liquid waste supplied from the liquid waste receiving vessel to the heater, and drain water discharged from the heater may be supplied to the preheater.

[0012]

(5) The decontamination system according to aspect (4) may further include a drain circulation means that circulates, to the steam generator, drain water discharged from the preheater.

[0013]

(6) In the decontamination system according to any one of aspects (1) to (5), the heat exchanger may further include a cooler that has a coiled tube heat exchanger and cools the liquid waste to a predetermined second temperature or less by exchanging heat with cooling water after the liquid waste is maintained at the first temperature or more for the predetermined period of time by the retention unit.

[0014]

(7) In the decontamination system according to aspect (6), the heat exchanger may further include a precooler that is provided in a flow path between the retention unit and the cooler and precools the liquid waste to be supplied to the cooler after the liquid waste is maintained at the first temperature or more for the predetermined period of time by the retention unit, and drain water discharged from the cooler

may be supplied to the precooler.

[0015]

(8) The decontamination system according to aspect (6) or (7) may further include a pressure detection means that is provided in a flow path downstream of the cooler to detect a pressure in the flow path; and a regulating valve that is provided in a flow path downstream of the pressure detection means to adjust a pressure in the flow path, in which the controller may control opening and closing of the regulating valve based on the pressure detected by the pressure detection means.

[0016]

(9) The decontamination system according to any one of aspects (1) to (8) may further include a chemical liquid reservoir that stores a chemical liquid; and a chemical liquid circulation means that supplies, to the heat exchanger, the chemical liquid stored in the chemical liquid reservoir and circulates, to the chemical liquid reservoir, the chemical liquid supplied to the heat exchanger.

[0017]

(10) The decontamination system according to any one of aspects (1) to (9) may further include a strainer that is provided in a liquid waste introduction path for introducing the liquid waste from the liquid waste discharging facility into the liquid waste receiving vessel and filters the liquid waste; and a strainer cleaning means that thermally cleans the strainer by supplying, to the strainer, the steam produced by

the steam generator.

Effects of the Invention

[0018]

The present invention makes it possible to provide a decontamination system capable of continuously inactivating, by heating, a small volume of liquid waste containing a microorganism and/or a virus.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

FIG. 1 is a diagram showing a configuration of a decontamination system according to an embodiment of the present invention;

FIG. 2 is a diagram showing a chemical liquid circulation process in the decontamination system according to an embodiment of the present invention;

FIG. 3 is a diagram showing an inactivation process in the decontamination system according to an embodiment of the present invention;

FIG. 4 is a diagram showing an inactivation abnormality management process in the decontamination system according to an embodiment of the present invention; and

FIG. 5 is a diagram showing a strainer maintenance process in the decontamination system according to an embodiment of the present invention.

#### PREFERRED MODE FOR CARRYING OUT THE INVENTION

[0020]

Hereinafter, an embodiment of the present invention will be described in detail with reference to the drawings.

[0021]

FIG. 1 is a diagram showing a configuration of a decontamination system 100 according to an embodiment of the present invention. The decontamination system 100 according to this embodiment decontaminates a small volume of liquid waste (e.g., 300 L/day) discharged from a facility (not shown), such as a laboratory or a hospital, for example, by performing an inactivation process for 20 hours. The inactivation process includes, for example, maintaining liquid waste at 135°C for 90 seconds, which enables continuous inactivation of liquid waste, for example, at 250 mL/min. The decontamination system 100 according to this embodiment can be manufactured, for example, with a height of 1,000 mm or less, and can be installed in a compact space beside a sink or the like.

[0022]

As shown in FIG. 1, the decontamination system 100 according to this embodiment includes, as main components, a liquid waste receiving vessel 1, a liquid waste supply means (including a liquid waste supply system on-off valve 5 and a pump 6), a heat exchanger 10 (including a preheater 8, a heater 11, a retention unit 13, a precooler 16, and a cooler 17), a boiler 20, a chemical liquid reservoir 25, and a controller 90. The decontamination system 100 further includes a strainer 3, a flowmeter 7, a first thermometer 12, a second

thermometer 15, a regulating valve 19, a plurality of various on-off valves for switching between the flow path systems, and various drains for the preheater 8, the heater 11, the retention unit 13, the precooler 16, and the cooler 17.

[0023]

The liquid waste receiving vessel 1 is a vessel for receiving liquid waste containing microorganisms and/or viruses (hereinafter also simply referred to as "liquid waste") discharged from a facility (not shown), such as a laboratory or a hospital. A liquid waste introduction path is provided to introduce liquid waste into the liquid waste receiving vessel 1. The liquid waste introduction path is provided with liquid waste introduction system on-off valves 2a and 2b and a strainer 3. The controller 90 controls the introduction of the liquid waste into the liquid waste receiving vessel 1 by controlling the opening and closing of the liquid waste introduction system on-off valves 2a and 2b. In this embodiment, the various on-off valves and regulating valves include solenoid valves or the like.

[0024]

The liquid waste receiving vessel 1 has a volume of, for example, 20 L, which is small in volume. The liquid waste receiving vessel 1 is provided with a liquid level gauge 4, which allows continuous inactivation to start when it is confirmed that a stored volume of 5 L is reached. It will be understood that the setting (the stored volume level) for starting the continuous inactivation may be made in any

desired way.

[0025]

The liquid waste supply system on-off valve 5 and the pump 6 of the liquid waste supply means are provided in a flow path between the liquid waste receiving vessel 1 and the heater 11. The liquid waste supply system on-off valve 5 and the pump 6 are controlled by the controller 90 to supply the liquid waste from the liquid waste receiving vessel 1 to the heat exchanger 10 including the heater 11 and other components.

[0026]

The flowmeter 7 is provided downstream of the pump 6. The flow meter 7 detects the flow rate of the liquid waste supplied to the preheater 8 and the heater 11. The flowmeter 7 sends a detection signal to the controller 90.

[0027]

The preheater 8 is provided in a flow path between the liquid waste receiving vessel 1 and the heater 11. The preheater 8 preheats the liquid waste supplied from the liquid waste receiving vessel 1 to the heater 11. As a result, the liquid waste preheated by the preheater 8 is supplied to the heater 11. Drain water discharged from the heater 11 is supplied to the preheater 8, and heat is exchanged between the drain water and the liquid waste. Further, the preheater 8 has a preheater drain 9 as a drain circulation means. The drain water passing through the preheater drain 9 is circulated to and reused in the boiler 20.

[0028]

The heater 11 is provided downstream of the preheater 8 to heat the preheated liquid waste by heat exchange with steam produced by the boiler 20. Specifically, the heater 11 heats the preheated liquid waste to a predetermined first temperature or more. In this embodiment, for example, the first temperature is set to 135°C. Specifically, after being preheated to, for example, 25°C, the liquid waste is heated to 135°C or more by the heater 11.

[0029]

The heater 11 includes a coiled tube heat exchanger similar to the retention unit 13 and the cooler 17 described later. In contrast, a conventional continuous inactivation treatment apparatus uses a spiral heat exchanger. Such a spiral heat exchanger is formed by spiraling two flat plates with a spacer inserted between them to ensure a flow path. Such a spiral heat exchanger is suitable for heat exchange of a large volume of liquid waste since its high thermal transfer capacity is provided by a single flow path structure through which high-temperature fluid and low-temperature fluid flow countercurrently. In fact, there is now no conventional spiral heat exchanger with a low flow rate and a small heat transfer area. For example, while the coiled tube heat exchanger used in this embodiment may have only a heat transfer area of 0.2 m<sup>2</sup> or less, there is no conventional spiral heat exchanger with a heat transfer area of 0.2 m<sup>2</sup> or less.

[0030]

The heat exchanger used in this embodiment also needs to have an airtight pressure vessel. In this regard, if a build of a compact, small-volume spiral heat exchanger is attempted, any clamp structure cannot be used and welding must be used to form an airtight pressure vessel. However, welding makes it impossible to conduct disassembly, inspection, and maintenance of internal parts, and thus cannot be used for the heat exchanger according to this embodiment. In this embodiment, therefore, a coiled tube heat exchanger is used to make it possible to inactivate a small volume of liquid waste.

[0031]

The heater 11 has heater drains 11a and 11b and a heater drain system on-off valve 11c. The controller 90 controls the opening and closing of the heater drain system on-off valve 11c to supply heater drain water to the preheater 8 through the heater drain 11a or to allow heater drain water to be circulated to the boiler 20 through the heater drain 11b and to be reused in the boiler 20. Alternatively, a drain system on-off valve 14 is opened so that the heater drain water is discharged out of the system through the heater drain 11b.

[0032]

The first thermometer 12 as the first temperature detection means is provided in a flow path between the heater 11 and the retention unit 13. The first thermometer 12 detects the temperature of the liquid waste, which has been heated to the first temperature or more by the heater 11. The first thermometer 12 sends a detection signal to the controller 90.

[0033]

The retention unit 13 is provided downstream of the heater 11. The retention unit 13 maintains the liquid waste, which has been heated by the heater 11 to the first temperature or more, at the first temperature or more for a predetermined period of time while exchanging heat with steam produced by the boiler 20. For example, the retention unit 13 maintains the liquid waste at 135°C or more for 90 seconds. The inventor has confirmed that maintaining at 135°C for 90 seconds means successfully killing all of a six-digit number of organisms and viruses including all bacteria, human immunodeficiency virus (HIV), hepatitis viruses such as hepatitis B virus (HBV) and hepatitis C virus (HCV), and other viruses, which are potentially contained in the liquid waste.

[0034]

As used herein, the term "SAL" refers to a sterility assurance level indicated using " $10^{-n}$ ", which is the probability that a single microorganism will survive after sterilization. For example, "SAL  $10^{-6}$ " is required for terminal sterilization performed after a pharmaceutical product is filled and sealed in a final container. In general, overkill sterilization conditions may be employed to ensure "SAL  $10^{-6}$ ", and as an index for that,  $F_0 \geq 12$  is required (ISO/TS 17665-2). The  $F_0$  value is a sterilization index used as a reference for high-pressure steam sterilization. The  $F_0$  value is equivalent to the time (minutes) needed to kill at 121.1°C (250°F) microorganisms of which the  $z$  value is 10°C

(the degree of temperature change needed to change the D value (the time (minutes) needed to kill and reduce living microbes to 1/10 at a given temperature) by 10 times).

[0035]

The decontamination system 100 according to this embodiment can process the liquid waste at 300 L/day when continuously operated at 250 mL/minute for 20 hours. The pump 6 used as the liquid waste supply means in this embodiment may include an inverter, for example, which makes the flow rate variable from 240 mL/minute to 540 mL/minute, so that the liquid waste can be processed at 600 L/day, for example, when the liquid waste is continuously processed at 500 mL/minute for 20 hours. This is because this embodiment is based on the  $F_0$  value used to ensure sterilization (inactivation). In this case, the controller 90 may cause the retention unit 13 to maintain the temperature at 138°C or more so that  $F_0 > 30$  can be achieved. This means that the decontamination system can be provided such that it achieves  $F_0 \geq 12$  mentioned above and processes the liquid waste at 300 L/day to 600 L/day by itself. In contrast, the tank disclosed in the prior art documents, which is in the form of a reaction tank, has a constant capacity, which means that the total volume to be processed using the reaction tank cannot be changed.

[0036]

As mentioned above, the retention unit 13 includes a coiled tube heat exchanger similar to the heater 11 or the cooler 17. The retention unit 13 retains the liquid waste

while exchanging heat with the steam produced by the boiler 20. Therefore, the retention unit 13 can reliably maintain the liquid waste at the first temperature or more for a predetermined period of time.

[0037]

The retention unit 13 has a retention unit drain 13a and a retention unit drain system on-off valve 13b. The controller 90 controls the opening and closing of the retention unit drain system on-off valve 13b to allow retention unit drain water to be circulated to the boiler 20 through the retention unit drain 13a and to be reused in the boiler 20.

Alternatively, the drain system on-off valve 14 is opened to discharge the retention unit drain water out of the system through the retention unit drain 13a.

[0038]

The second thermometer 15 as the second temperature detection means is provided downstream of the retention unit 13. The second thermometer 15 detects the temperature of the liquid waste, which has been maintained at the first temperature or more for a predetermined period of time by the retention unit 13. The second thermometer 15 sends a detection signal to the controller 90.

[0039]

The precooler 16 is provided in a flow path between the retention unit 13 and the cooler 17. The pre-cooler 16 pre-cools the liquid waste which has been maintained at the first temperature or more for a predetermined period of time

by the retention unit 13. As a result, the liquid waste precooled by the precooler 16 is supplied to the cooler 17. Drain water discharged from the cooler 17 is supplied to the precooler 16, in which heat is exchanged between the drain water and the liquid waste.

[0040]

The cooler 17 is provided downstream of the precooler 16. After the retention unit 13 maintains the liquid waste at the first temperature or more for a predetermined period of time and the precooler 16 pre-cools the liquid waste, the cooler 17 cools the liquid waste to a predetermined second temperature or less by exchanging heat with cooling water supplied from the outside. For example, the cooler 17 cools the liquid waste to 50°C to 60°C or less. This makes it possible to discharge the liquid waste as sewage water, which must be at 40°C or less. As mentioned above, the cooler 17 includes a coiled tube heat exchanger similar to the heater 11 or the retention unit 13.

[0041]

The cooler 17 is connected to a cooling water supply path to which cooling water is supplied from the outside, and the cooling water supply path is provided with cooling system on-off valves 21a to 21c. The controller 90 controls the opening and closing of the cooling system on-off valves 21a to 21c to supply cooling water from the outside to the cooler 17 or the chemical liquid reservoir 25.

[0042]

The cooler 17 has a cooler drain 17a and a cooler drain system on-off valve 17b. The controller 90 controls the opening and closing of the cooler drain system on-off valve 17b to supply cooler drain water to the precooler 16 through the cooler drain 17a or to discharge cooler drain water out of the system.

[0043]

A pressure gauge 18 as the pressure detection means is provided downstream of the cooler 17. The pressure gauge 18 detects the pressure in the flow path through which the liquid waste flows after being cooled to the second temperature or less by the cooler 17. The pressure gauge 18 sends a detection signal to the controller 90.

[0044]

The regulating valve 19 is provided downstream of the pressure gauge 18 to adjust the pressure in the flow path by the opening and closing operation. The controller 90 controls the opening and closing of the regulating valve 19.

Specifically, the opening and closing of the regulating valve 19 is controlled based on the pressure value detected by the pressure gauge 18. As a result, the pressure in the flow path is kept constant so that the liquid waste is prevented from bumping when discharged through the discharge system on-off valve 23.

[0045]

The boiler 20 as the steam generator is an electric boiler to produce steam from water. It will be understood that

the steam generator is not limited to an electric boiler and may be any device capable of producing steam. The steam produced is supplied to the heater 11 and the retention unit 13 or the strainer 3. The controller 90 controls the opening and closing of steam system on-off valves 20a to 20f to supply steam to these parts. The steam system on-off valves 20e and 20f function as strainer cleaning means by supplying steam to the strainer 3.

[0046]

The chemical liquid reservoir 25 functions to store a chemical liquid and functions as a chemical liquid circulation vessel to circulate the chemical liquid, which is supplied to the heat exchanger 10 before the start of the inactivation process. The chemical liquid reservoir 25 has a chemical liquid supply system on-off valve 25a as a chemical liquid circulation means. The controller 90 controls the opening and closing of the chemical liquid supply system on-off valve 25a to supply the chemical liquid from the chemical liquid reservoir 25 to the heat exchanger 10 and to circulate the chemical liquid to the chemical liquid reservoir 25 after it is supplied to the heat exchanger 10.

[0047]

The chemical liquid reservoir 25 includes an alkali reservoir 26, an acid reservoir 27, an alkali supply system on-off valve 26a, and an acid supply system on-off valve 27a. The alkali reservoir 26 stores sodium hydroxide as an alkali, which is non-limiting and may be replaced by any other alkali,

such as potassium hydroxide. The acid reservoir 27 stores nitric acid as an acid, which is non-limiting and may be replaced by any other inorganic acid, such as phosphoric acid, or any other organic acid, such as sulfamic acid.

[0048]

When an alkali is supplied and circulated as the chemical liquid to and from the heat exchanger 10, substances solidified and denatured by heating in the flow path, such as proteins, are dissolved and removed. In particular, this is effective since the liquid waste containing a microorganism and/or a virus to be treated according to this embodiment is a bio-pharmaceutical product or the like, which contains a large amount of proteins. Further, when an acid is supplied and circulated as the chemical liquid to and from the heat exchanger 10, scale including silica, calcium, and the like precipitated by heating in the flow path are dissolved and removed. This makes it possible to prevent the flow path from being clogged.

[0049]

The chemical liquid reservoir 25 and other components described above function in the form of a cleaning-in-place (CIP) unit (which refers to a unit for automatic in-process cleaning without attachment of additional devices or disassembly of the production equipment) for a facility producing a pharmaceutical product, such as a blood product, a factory, a hospital, or the like.

[0050]

In the decontamination system 100 of this embodiment having the features described above, the controller 90 operates to execute chemical liquid circulation, inactivation, inactivation abnormality management, and strainer maintenance. Hereinafter, each of these processes will be described in detail with reference to FIGS. 2 to 5.

[0051]

FIG. 2 is a diagram showing a chemical liquid circulation process in the decontamination system 100 according to this embodiment. In Fig. 2, the thick broken line indicates how the chemical liquid flows, the thin broken line indicates how the steam flows, and the thin dash-dot-dash line indicates how the cooling water flows. The chemical liquid circulation is executed prior to the inactivation of the liquid waste. First, the chemical liquid supply system on-off valve 25a is opened while the liquid waste supply system on-off valve 5 is closed, and the pump 6 operates to supply the chemical liquid from the chemical liquid reservoir 25 to the heat exchanger 10. At the same time, the liquid waste circulation system on-off valve 22 and the discharge system on-off valve 23 are closed while the chemical liquid circulation system on-off valve 24 is opened, so that the chemical liquid is circulated to the chemical liquid reservoir 25. The circulation of the chemical liquid is continued until the temperature detected by the first thermometer 12 at the outlet of the heater 11 reaches, for example, 135°C. The chemical liquid circulation is executed by switching between the alkali and the acid as appropriate. The

switching between the alkali and the acid is executed by controlling the opening and closing of the alkali supply system on-off valve 26a and the acid supply system on-off valve 27a. This process removes proteins and scale from the inactivation treatment path and prevents the path from being clogged.

[0052]

FIG. 3 is a diagram showing an inactivation process in the decontamination system 100 according to this embodiment. In FIG. 3, the thick solid line indicates how the liquid waste flows, the thin broken line indicates how the steam flows, and the thin dash-dot-dash line indicates how the cooling water flows. The inactivation process is started by closing the chemical liquid supply system on-off valve 25a and opening the liquid waste supply system on-off valve 5 when the temperature detected by the first thermometer 12 reaches, for example, 135°C. When the process is started, the chemical liquid in the inactivation treatment path is forced to flow toward the chemical liquid reservoir 25 by the liquid waste. In this system, all of the path pipes have the same diameter. Therefore, the time point at which the chemical liquid in the inactivation treatment path is replaced by the liquid waste is calculated based on the flow rate detected by the flowmeter 7, and at that time point, the liquid waste circulation system on-off valve 22 is closed and the discharge system on-off valve 23 is opened.

[0053]

In this process, the liquid waste from the liquid waste receiving vessel 1 is preheated by the preheater 8, and then supplied, for example, at 25°C to the heater 11. Drain water is supplied from the heater 11 to the preheater 8, and drain water from the preheater 8 is circulated to the boiler 20 and reused in the boiler 20. When the liquid waste is supplied to the heater 11, the heater 11 heats the liquid waste to, for example, 135°C by exchanging heat with steam supplied from the boiler 20. The liquid waste heated to 135°C is supplied to the retention unit 13 and then maintained, for example, at 135°C or more for 90 seconds. The flow rate detected by the flowmeter 7 is controlled so that the retention unit 13 ensures the necessary holding time. After being maintained, for example, at 135°C or more for 90 seconds by the retention unit 13, the liquid waste is precooled by the precooler 16 and then supplied to the cooler 17. The liquid waste supplied to the cooler 17 is cooled to, for example, 50°C to 60°C or less by heat exchange with the cooling water, and then discharged out of the system. Drain water from the cooler 17 is supplied to the precooler 16, and drain water from the precooler 16 is discharged out of the system.

[0054]

In this process, for example, if the liquid waste is received at a temperature of 25°C, the inactivation is performed at 135°C for 90 seconds, and the liquid waste is preheated to 65°C by the preheater 8, the desired performance can be achieved by inputting, from the outside, steam energy

at 2.2 kg/hour and a pressure of 4 kgf/cm<sup>2</sup>. In contrast, if a conventional killing tank (an airtight reaction vessel into which steam is directed input) is used to inactivate the liquid waste under the same conditions at 300 L/day similarly to this embodiment, the required amount of steam will be 66 kg. In such a case, the liquid waste will remain untreated (not inactivated) for a long period of time in an area, which may raise a concern about contamination of the workspace. This shows the benefits of the decontamination system according to this embodiment.

[0055]

FIG. 4 is a diagram showing an inactivation abnormality management process in the decontamination system 100 according to this embodiment. In FIG. 4, the thick solid line indicates how the liquid waste circulates, the thin broken line indicates how the steam flows, and the thin dash-dot-dash line indicates how the cooling water flows. The inactivation abnormality management process is executed in case the retention unit 13 fails to maintain the liquid waste, for example, at 135°C or more for 90 seconds, which can be monitored by the second thermometer 15. In this process, the discharge system on-off valve 23 is closed and the liquid waste circulation system on-off valve 22 is opened so that the liquid waste is circulated to the liquid waste receiving vessel 1 without being discharged out of the system. This prevents the liquid waste from being discharged out of the system before the liquid waste is decontaminated.

[0056]

FIG. 5 is a diagram showing a strainer maintenance process in the decontamination system 100 according to this embodiment. This strainer maintenance process is executed for replacement of the strainer 3 and the like. In FIG. 5, the thin broken line indicates how the steam flows. In this process, the steam is supplied from the boiler 20 to the strainer 3 to thermally clean the strainer 3.

[0057]

The decontamination system 100 according to this embodiment has the following advantageous effects.

(1) The decontamination system 100 according to this embodiment can continuously inactivate a small volume of liquid waste containing microorganisms and/or viruses. Thus, bacteria and viruses that have been insufficiently disinfected with conventional chemical liquids can be reliably inactivated by heating to a predetermined temperature (lethal temperature).

(2) The inactivation using steam only is less likely to pollute the environment than the conventional disinfection with chemical liquid. The disinfection with chemical liquid is highly costly since it requires a large amount of chemical liquid. In contrast, the present system based on heating can perform the process with lower running cost.

(3) The process using a plurality of heat exchangers can effectively utilize the released heat and thus is energy-saving compared to the batch heat treatment in which steam is

input directly. The combination of multiple heat exchangers can reduce the input of steam and allows circulation and reuse of steam drain, which makes it possible to reduce the usage of water and electricity and to cool the final processed water to a predetermined temperature.

(4) The ability to perform a continuous process allows for a space-saving, compact apparatus to perform the process. Moreover, the untreated liquid can be instantly treated, which prevents back contamination of the atmosphere (indoor).

(5) The ability to clean the whole system including piping and heat exchangers with an alkali (such as sodium hydroxide) and an acid (such as nitric acid) makes it possible to prevent scale deposition and proteins in the piping and the devices and to dissolve them again, which makes the maintenance of the system easy. This makes it possible to prevent clogging inherent to heat exchangers, to passivate the piping and devices, and to prolong the life of the system.

(6) The set temperature can be changed as desired depending on the type of the target virus, which can address unknown bacteria and viruses in the future.

(7) The reuse of the supplied steam allows efficient use of the steam for thermal cleaning of the system. Furthermore, thermal cleaning is possible for replacement of the strainer 3.

(8) The untreated cooling water is used to cool the final processed water to a predetermined temperature by heat exchange, so that the usage of the cooling water can be

reduced.

[0058]

It will be understood that the embodiments described above are not intended to limit the present invention and may be altered or modified within the scope of the present invention to achieve the object.

#### EXPLANATION OF REFERENCE NUMERALS

[0059]

1 Liquid waste receiving vessel  
2a, 2b Liquid waste introduction system on-off valve  
3 Strainer  
4 Liquid level gauge  
5 Liquid waste supply system on-off valve (liquid waste supply means)  
6 Pump (liquid waste supply means)  
7 Flowmeter (flow rate detection means)  
8 Preheater  
8 Preheater drain (first drain circulation means)  
10 Heat exchanger  
11 Heater  
11a, 11b Heater drain  
11c Heater drain system on-off valve (drain circulation means)  
12 First thermometer (first temperature detection means)  
13 Retention unit  
13a Retention unit drain  
13b Retention unit drain system on-off valve

- 14 Drain system on-off valve
- 15 Second thermometer (second temperature detection means)
- 16 Precooler
- 16a Precooler drain (second drain circulation means)
- 17 Cooler
- 17a Cooler drain
- 17b Cooler drain system on-off valve
- 18 Pressure gauge
- 19 Regulating valve
- 20 Boiler (steam generator)
- 20a, 20b, 20c, 20d Steam system on-off valve
- 20e, 20f Steam system on-off valve (strainer cleaning means)
- 21a, 21b, 21c Cooling system on-off valve
- 22 Liquid waste circulation system on-off valve (liquid waste circulation means)
- 23 Discharge system on-off valve (liquid waste circulation means)
- 24 Chemical liquid circulation system on-off valve (chemical liquid circulation means)
- 25 Chemical liquid reservoir (chemical liquid circulation means)
- 25a Chemical liquid supply system on-off valve (chemical liquid circulation means)
- 26 Alkali reservoir
- 26a Alkali supply system on-off valve
- 27 Acid reservoir
- 27a Acid supply system on-off valve

90 Controller

100 Decontamination system

## CLAIMS

1. A decontamination system for continuously inactivating liquid waste containing a microorganism and/or a virus, the decontamination system comprising:

a liquid waste receiving vessel that receives the liquid waste from a liquid waste discharging facility;

a steam generator that produces steam;

a heat exchanger that heats the liquid waste supplied from the liquid waste receiving vessel by exchanging heat with the steam produced by the steam generator;

a liquid waste supply means that supplies the liquid waste from the liquid waste receiving vessel to the heat exchanger; and

a controller that controls the liquid waste receiving vessel, the steam generator, the heat exchanger, and the liquid waste supply means to continuously inactivate the liquid waste,

the heat exchanger including:

a heater that has a coiled tube heat exchanger and heats the liquid waste to a predetermined first temperature or more by exchanging heat with the steam produced by the steam generator; and

a retention unit that has a coiled tube heat exchanger and maintains the liquid waste at the first temperature or more for a predetermined period of time while exchanging heat with the steam produced by the steam generator after the

liquid waste is heated to the first temperature or more by the heater.

2. The decontamination system according to claim 1, further comprising:

a flow rate detection means that is provided in a flow path between the liquid waste receiving vessel and the heater to detect a flow rate of the liquid waste passing through the flow path;

a first temperature detection means that is provided in a flow path between the heater and the retention unit to detect a temperature of the liquid waste passing through the flow path; and

a second temperature detection means that is provided in a flow path downstream of the retention unit to detect a temperature of the liquid waste passing through the flow path, wherein

the controller controls the liquid waste receiving vessel, the liquid waste supply means, the steam generator, and the heat exchanger based on the flow rate detected by the flow rate detection means, the temperature detected by the first temperature detection means, and the temperature detected by the second temperature detection means.

3. The decontamination system according to claim 2, further comprising a liquid waste circulation means that circulates, to the liquid waste receiving vessel, the liquid waste

discharged from the heat exchanger, wherein

the controller controls the liquid waste circulation means to circulate, to the liquid waste receiving vessel, the liquid waste discharged from the heat exchanger when the temperature detected by the second temperature detection means is less than the first temperature.

4. The decontamination system according to any one of claims 1 to 3, wherein the heat exchanger further includes a preheater that is provided in a flow path between the liquid waste receiving vessel and the heater to preheat the liquid waste supplied from the liquid waste receiving vessel to the heater, and

drain water discharged from the heater is supplied to the preheater.

5. The decontamination system according to claim 4, further comprising a drain circulation means that circulates, to the steam generator, drain water discharged from the preheater.

6. The decontamination system according to any one of claims 1 to 5, wherein

the heat exchanger further includes a cooler that has a coiled tube heat exchanger and cools the liquid waste to a predetermined second temperature or less by exchanging heat with cooling water after the liquid waste is maintained at the first temperature or more for the predetermined period of time

by the retention unit.

7. The decontamination system according to claim 6, wherein the heat exchanger further includes a precooler that is provided in a flow path between the retention unit and the cooler and precools the liquid waste to be supplied to the cooler after the liquid waste is maintained at the first temperature or more for the predetermined period of time by the retention unit, and

drain water discharged from the cooler is supplied to the precooler.

8. The decontamination system according to claim 6 or 7, further comprising:

a pressure detection means that is provided in a flow path downstream of the cooler to detect a pressure in the flow path; and

a regulating valve that is provided in a flow path downstream of the pressure detection means to adjust a pressure in the flow path, wherein

the controller controls opening and closing of the regulating valve based on the pressure detected by the pressure detection means.

9. The decontamination system according to any one of claims 1 to 8, further comprising:

a chemical liquid reservoir that stores a chemical

liquid; and

a chemical liquid circulation means that supplies, to the heat exchanger, the chemical liquid stored in the chemical liquid reservoir and circulates, to the chemical liquid reservoir, the chemical liquid supplied to the heat exchanger.

10. The decontamination system according to any one of claims 1 to 9, further comprising:

a strainer that is provided in a liquid waste introduction path for introducing the liquid waste from the liquid waste discharging facility into the liquid waste receiving vessel and filters the liquid waste; and

a strainer cleaning means that thermally cleans the strainer by supplying, to the strainer, the steam produced by the steam generator.