

**BALLAST WATER TREATMENT METHOD AND
BALLAST WATER TREATMENT SYSTEM**

BACKGROUND

5 **(a) Field of the Invention**

 The present invention relates to a clarification
treatment of ballast water in a ship for example. In
particular, the present invention relates to ballast water
treatment method and system for clarifying a coagulated
10 flocs separated from ballast water.

(b) Description of the Related Art

 According to International Convention for the control
and management of Ships' Ballast Water and Sediments
15 adopted in 2004 by International Maritime Organization
(IMO), ships are required to include therein treatment
systems to kill planktons for example in ballast water for
the purpose of avoiding the disturbance of an ecological
system and health hazards due to the migration and
20 diffusion of microorganisms via ballast water. Currently,
there have been developed ballast water treatment
techniques using combinations of various water treatment
techniques such as ozonation, ultraviolet irradiation,
heating treatment, and magnetic separation.
25 For example, a ballast water treatment technique using

ozone is disclosed in Japanese Unexamined Patent Application Publication No. 2008-100157. The ballast water treatment technique disclosed in Japanese Unexamined Patent Application Publication No. 2008-100157 mixes ozone

5 generated by an ozone generating system in the ballast water transferred to a ballast tank to thereby kill microorganisms and bacteria or the like in the ballast water by the strong oxidizing action by ozone.

A ballast water treatment technique using ultraviolet
10 irradiation is disclosed in Japanese Unexamined Patent Application Publication No. 2006-263664 for example. The ballast water treatment technique disclosed in Japanese Unexamined Patent Application Publication No. 2006-263664 adds hydrogen peroxide or hydrogen peroxide-generating
15 compound to ballast water to irradiate ultraviolet light in the wavelength range of 240 to 300 nm to ballast water prior to the discharge of ballast water. In this technique, adding hydrogen peroxide or a hydrogen peroxide-generating compound to ballast water is for the purpose of
20 killing microorganisms and bacteria or the like by the strong oxidizing action or the like as in the previously-described ozonation technique. The ultraviolet irradiation is for the purpose of avoiding the environment pollution by discharged ballast water by degrading hydrogen peroxide
25 remaining in the ballast water.

A ballast water treatment technique by a heating treatment is disclosed in Japanese Unexamined Patent Application Publication No. 2008-110276. The technique disclosed in Japanese Unexamined Patent Application
5 Publication No. 2008-110276 performs a heat exchange between pumped low-temperature ballast water and high-temperature ballast water subjected to a heating treatment in advance to thereby heat the low-temperature ballast water to a temperature at which microorganisms and bacteria
10 or the like are killed.

A magnetic separation technique is disclosed in Japanese Unexamined Patent Application Publication No. H9-117618. The technique disclosed in Japanese Unexamined Patent Application Publication No. H9-117618 adds magnetic
15 powders and coagulant to ballast water to agitate the mixture to thereby generate magnetic flocs including microorganisms and bacteria or the like in ballast water to separate the magnetic flocs by a magnetic separation system from ballast water and to collect the magnetic flocs
20 remaining in the ballast water by a drum-type filter. According to this technique, microorganisms and bacteria or the like in ballast water are physically removed. Thus, no impact is caused on the environment by discharged ballast water.

25 Under the background as described above, private

companies have developed ballast water management systems using various techniques as described above. IMO has provided requirements for an approval of a ballast water management system. Such an approval is done in Japan
5 through Ministry of Land, Infrastructure, Transport and Tourism as a responsible organization.

Requirements for an approval of a ballast water management system include a discharge standard regarding
10 microorganisms and bacteria or the like (Toxicogenic *Vibrio Cholerae*, *Escherichia coli*, enterococci) included in ballast water. Thus, an approval of a ballast water management system requires evidence that the system sufficiently satisfies these standards.

15 However, when the techniques disclosed in the above respective publications are used to perform a ballast water treatment in a large volume, it is difficult to find an evidence in the above respective publications that these techniques can kill microorganisms and bacteria or the like
20 in ballast water. Furthermore, in the case of the technique disclosed in Japanese Unexamined Patent Application Publication No. 2008-110276, although microorganisms and bacteria or the like included in ballast water can be removed as magnetic flocs, there has been
25 pointed out a risk of collecting and retaining flocs of

coagulated microorganisms and bacteria or the like for which an impact on the ecological system and health is worried.

In view of the above, it is an objective of the present invention to provide a method and system for a ballast water treatment that can kill microorganisms and bacteria or the like included in magnetic flocs so that no impact is caused on the environment and human bodies.

10 **SUMMARY**

A ballast water treatment method according to the present invention for achieving the above objective is characterized in including: a step of adding magnetic powders and coagulant to ballast water to thereby generate magnetic flocs including microorganisms and bacteria; a step of collecting the magnetic flocs from the ballast water; and a step of heating the collected magnetic flocs to a temperature at which the microorganisms and the bacteria are killed, the temperature being determined in advance.

In a ballast water treatment method having the above characteristic, the heating step may insert the magnetic flocs to a pipe path and heat the pipe path to which the magnetic flocs are inserted.

25 By the characteristics as described above, magnetic

flocs as a heating target can be heated securely. This eliminates such magnetic flocs that are treated while being unheated due to short pass for example.

In the ballast water treatment method having the above
5 characteristics, the heating of the magnetic flocs is desirably performed by double-boiling the pipe path.

By the characteristics as described above, scale is suppressed from adhering to the interior of the pipe path.

In the ballast water treatment method having the above
10 characteristics, an exit temperature of the pipe path may be measured to investigate a heating status of the magnetic flocs.

By the characteristics as described above, whether bacteria or the like included in the magnetic flocs are
15 killed or not securely can be confirmed empirically.

In the ballast water treatment method having the above characteristics, a pressure in the pipe path may be measured to investigate a status of the pipe path.

By the characteristics as described above, the damage
20 or clogging of the pipe path through which magnetic flocs are sent can be detected.

A ballast water treatment system of the present invention for achieving the above objective includes: a coagulation section for agitating magnetic powders and
25 coagulant added to ballast water to generate magnetic

flocs; a magnetic separation section for collecting the magnetic flocs generated by the coagulation section; a pipe path through which the magnetic flocs collected by the magnetic separation section is sent; and a heating section
5 for heating the pipe path.

In the ballast water treatment system having the above characteristics, the heating section may be a tank in which water is stored and the pipe path may be immersed in the tank.

10 By the configuration as described above, the pipe path can be heated by double-boiling, thus suppressing scale from adhering to the interior of the pipe path.

In the ballast water treatment system having the above characteristics, the tank includes a steam supply opening
15 through which steam from a ship machine for heating water in the tank is supplied.

By the configuration as described above, heating can be performed economically. Furthermore, the steam jetting can agitate water in the tank to thereby provide a uniform
20 temperature distribution in the tank.

In the ballast water treatment system having the above characteristics, an exit of the pipe path may have a temperature sensor.

By the configuration as described above, the heating
25 status of magnetic flocs can be known through the detection

of the temperature, thus confirming whether bacteria or the like included in the magnetic floc are securely killed.

In the ballast water treatment system having the above characteristics, the pipe path may have a pressure sensor.

5 By the configuration as described above, the status of the pipe path such as damage or clogging can be detected.

The ballast water treatment system having the above characteristics is characterized in that the pipe path is structured to have an inlet and an exit provided at an
10 upper part and to extend from the inlet to the lowest part and draw an oval helical shape from the lowest part thereof so as to extend to the exit.

By the configuration as described above, the machining is simplified and a necessary and sufficient length can be
15 secured. Even when a magnetic floc includes air, air can be naturally removed from the magnetic floc.

According to the ballast water treatment method having the characteristics as described above, microorganisms and bacteria or the like included in a magnetic floc can be
20 killed so as to eliminate an impact on the environment and human bodies.

According to the ballast water treatment system having the above characteristic, the ballast water treatment method having the above characteristics can be carried out
25 to kill microorganisms and bacteria or the like included in

a magnetic floc so as to eliminate an impact on the environment and human bodies.

BRIEF DESCRIPTION OF THE DRAWINGS

5 Fig. 1 illustrates the configuration showing a ballast water treatment system according to an embodiment.

 Fig. 2A illustrates the top configuration of a heat sterilization section according to an embodiment.

 Fig. 2B illustrates the front configuration of the heat
10 sterilization section according to an embodiment.

 Fig. 2C illustrates the side configuration of the heat sterilization section according to an embodiment.

 Fig. 3A illustrates the top configuration of an
insertion tube constituting the heat sterilization section
15 according to an embodiment.

 Fig. 3B illustrates the front configuration of the insertion tube constituting the heat sterilization section according to an embodiment.

 Fig. 3C illustrates the side configuration of the
20 insertion tube constituting the heat sterilization section according to an embodiment.

 Fig. 4 illustrates the relation between the retention time of magnetic flocs in an insertion tube and an achieving temperature according to an embodiment.

25 Fig. 5 illustrates the flow of a startup preparation

step in the heat sterilization section according to an embodiment.

Fig. 6 illustrates the flow of a magnetic floc heat sterilization step in the heat sterilization section according to an embodiment.

Fig. 7 illustrates the flow of a heat sterilization ending step in the heat sterilization section according to an embodiment.

Fig. 8A illustrates the top configuration of a heat sterilization section according to the first modification example.

Fig. 8B illustrates the front configuration of the heat sterilization section according to the first modification example.

Fig. 9A illustrates the top configuration of a heat sterilization section according to the second modification example.

Fig. 9B illustrates the front configuration of the heat sterilization section according to the second modification example.

Fig. 10A illustrates the top configuration of a heat sterilization section according to the third modification example.

Fig. 10B illustrates the front configuration of the heat sterilization section according to the third

modification example.

DETAILED DESCRIPTION OF EMBODIMENTS

The following section will describe in detail an
5 embodiment according to a ballast water treatment method
and a ballast water treatment system of the present
invention with reference to the drawings.

First, with reference to Fig. 1, the entire
configuration of a ballast water treatment system 10
10 according to an embodiment will be described. The ballast
water treatment system 10 has: a coagulation section 20, a
magnetic separation section 30, a filter separation section
40, and a heat sterilization section 50.

The coagulation section 20 has a flash mixer 22 and a
15 flocculator 24 and generates magnetic flocs F out of raw
water (ballast water) sent via a pump 12. To realize this,
a piping path for sending raw water to the flash mixer 22
includes a magnetic powders addition section 14 and a
coagulant addition section 16. Furthermore, a path through
20 which water is sent from the flash mixer 22 to the
flocculator 24 includes a organic flocculant addition
section 18. Magnetic powder may be preferably torrriron
tetraoxide for example. Coagulant may be preferably
aqueous inorganic coagulant such as polyaluminum chloride,
25 ferric chloride, and ferric sulfate. Organic flocculant

may be preferably anionic and nonionic ones.

The flash mixer 22 has mixing paddle 23 that rotates with a high speed to agitate raw water and magnetic powders and coagulant added to the raw water. The raw water to
5 which magnetic powders and coagulant are added is subjected to the high-speed agitation by the mixing paddle 23 to thereby generate minute magnetic flocs (magnetic micro flocs) having a size of about tens of μm . When magnetic micro flocs are generated, microorganisms and bacteria or
10 the like in raw water are absorbed to surround magnetic powder as a core and are taken into magnetic micro flocs because the microorganisms and bacteria or the like in raw water are electrically-charged.

The flocculator 24 is configured as a continuous multi-
15 stage flocculator having multiple stages (three stages in this embodiment). The flocculator tanks 24A to 24C at the respective stages have agitating paddles 25A to 25C, respectively. The flocculator 24 having the configuration as described above is set so that the agitation speed is
20 decreased in a stepwise manner from the upstream-side flocculator tank 24A to the downstream-side flocculator tank 24C. The flocculator 24 receives ballast water including magnetic micro flocs and organic flocculant added to this ballast water sent from the flash mixer 22. Thus,
25 the low-speed agitation is performed in a step-wise manner

from the flocculator tank 24A to the flocculator tank 24C to thereby grow magnetic micro flocs. Furthermore, since the agitation speed is decreased in a step-wise manner, there is a small risk where the grown magnetic flocs F are
5 broken by the collision with the agitating paddles 25A to 25C.

In this embodiment, as shown in Fig. 1, the flash mixer 22 and the flocculator 24 constituting the coagulation section 20 are provided in an integrated structure.

10 However, another structure also may be used in which the flash mixer 22 and the flocculator 24 are separated and are connected by a piping through which water is sent from the flash mixer 22 to the flocculator 24.

In the coagulation section 20 having the configuration
15 as described above, air is removed from the flash mixer 22, the flocculator 24, and the path connecting them so that the spaces thereof are completely filled with water. By doing this, even when a ship including the ballast water treatment system 10 swings, no wave is caused in the
20 ballast water (ballast water including magnetic micro flocs or the like) in the coagulation section 20, thus providing a smooth water delivery.

The magnetic separation section 30 collects, from the ballast water, the magnetic flocs F grown by the
25 coagulation section 20 to have a predetermined size. The

magnetic separation section 30 includes: a magnetic separator 32, magnetic discs 34, scrapers (not shown), and a conveyor 36. The magnetic separator 32 receives the ballast water including the magnetic flocs F sent from the coagulation section 20. The magnetic discs 34 are attached to rotating drums for example and at least a part thereof is immersed in the ballast water in the magnetic separator 32 to rotate the rotating drum. This consequently attracts and collects the magnetic flocs F floating in the magnetic separator 32. The magnetic flocs F absorbed and collected by the magnetic discs 34 are raised by the screw rotation from the magnetic separator 32 and are scraped by the scrapers from the magnetic discs 34. Then, the scraped magnetic flocs F are transferred by the conveyor 36 to the magnetic flocs storage tank 38.

The filter separation section 40 collects dusts and minute magnetic flocs for example that could not be collected by the magnetic separator 32. In the filter separation section 40, the water being treated is supplied via a water supply pipe 44 to the inner side of a filter drum 42. The water being treated supplied to the filter drum 42 is filtered by being flowed from the inner side of the filter drum 42 to the outer side. During this, collected matters such as magnetic flocs and dusts remaining in the water being treated adhere to the inner

side of the filter drum 42. This consequently removes the contamination substance such as magnetic flocs and dusts remaining in the water being treated. Thus, the water being treated is turned into purified treated water.

5 The contamination substance adhered to the inner side of the filter drum 42 is washed away by water jetted from a spray nozzle 46 provided above the filter drum 42. The contamination substance washed away by water jetted from the spray nozzle 46 to the filter drum 42 drops into a
10 hopper 48 (an inlet of the contamination substance discharge pipe) provided in the filter drum 42 and is discharged via the contamination substance discharge pipe 48a. It is noted that the treated water purified by the filter drum 42 may be partially used as water jetted
15 through the spray nozzle 46. In this case, as shown in Fig. 1, the treated water may be partially sent by the circulation pump 45 to the spray nozzle 46. The contamination substance and water jetted through the spray nozzle 46 are returned to the previous stage of the pump 12
20 via a pump 49 provided in the contamination substance discharge pipe 48a.

 The heat sterilization section 50 subjects the magnetic flocs F collected by the magnetic separation section 30 to a heating treatment to thereby kill microorganisms and
25 bacteria or the like included in the magnetic flocs F. The

magnetic flocs F collected by the magnetic separation section 30 are temporarily stored in a collected flocs receiver tank 52 and is sent via a pump 54 to the heat sterilization section 50. It is noted that the magnetic
5 flocs F are in the form of slurry and thus the pump 54 used for transfer may be a positive displacement pump such as a tube pump or a uniaxial screw-type pump.

The magnetic flocs F subjected to the heat sterilization by the heat sterilization section 50 is sent
10 to a collected flocs storage tank 56. The collected flocs storage tank 56 includes a circulation mechanism 58 (pump) and an agitation mechanism (not shown) for the purpose of preventing the precipitation and separation of the magnetic flocs F. The reason is that, if the magnetic flocs F are
15 separated from water and is precipitated, it is difficult to take out the magnetic flocs F by suction but the circulation and agitation as described above can prevent the separation and precipitation of the magnetic flocs F. The collected flocs storage tank 56 includes a sampling
20 system 59 of the magnetic flocs F. By confirming that the sampled magnetic flocs F includes no microorganisms or bacteria or the like, the safety of the magnetic flocs F in the collected flocs storage tank 56 can be confirmed.

The following section will describe a specific
25 configuration of the heat sterilization section 50

according to an embodiment in detail with reference to Fig. 2A, Fig. 2B, Fig. 2C, Fig. 3A, Fig. 3B, and Fig. 3C. The heat sterilization section 50 according to an embodiment includes a heat exchanger tube 60 and a tank 70.

5 The heat exchanger tube 60 is a pipe path for the pneumatic transportation of the magnetic flocs F sent from the collected flocs receiver tank 52 via the pump 54. The heat exchanger tube 60 is desirably configured by a hollow material having heat resistance and corrosion resistance.
10 A specific example may include a titanium piping for example.

 As shown in Fig. 3A, Fig. 3B, and Fig. 3C, the heat exchanger tube 60 includes, at the upper part thereof, an inlet 62 and an exit 64. The piping extends from the inlet
15 62 to the lowest part and is bent from the lowest part to have an oval shape (so-called track shape). The bent heat exchanger tube 60 upwardly extends to draw an oval and helical shape to reach the exit 64. The reason is that the configuration as described above can be machined more
20 easily than in the case of a hairpin curve shape having a bent section with a smaller radius for example and can secure a necessary and sufficient length. Furthermore, by the configuration in which the heat exchanger tube 60 having the inlet 62 at the upper part thereof is caused to
25 extend to the lower side and then is caused to extend to

the exit 64 provided at the upper part, even when the magnetic flocs F includes air, air can be removed naturally and no risk is caused where lifted air inhibits the pneumatic transportation of the magnetic flocs F. It is
5 noted that the heat exchanger tube 60 formed by bending is longitudinally bound and retained by a support 69, thereby preventing the deformation of the pipe path due to the deadweight.

The inlet 62-side of the heat exchanger tube 60 is
10 connected to the pump 54. The exit 64-side is connected to the collected flocs storage tank 56. The inlet 62-side of the heat exchanger tube 60 has a pressure gauge 66, thus providing a configuration where the pressure in the heat exchanger tube 60 can be measured. By the configuration as
15 described above, damage of the heat exchanger tube 60 and the clogging of the interior of the insertion tube can be known. When the heat exchanger tube 60 is broken for example, the magnetic flocs F subjected to pneumatic transportation is caused to leak, thus causing a decrease
20 of the pressure in the heat exchanger tube 60. The clogging of the interior of the heat exchanger tube 60 on the other hand causes an increase of the pressure in the heat exchanger tube 60. The exit 64 of the heat exchanger tube 60 has a thermometer 68. By the configuration as
25 described above, it is possible to know whether the heating

status of the magnetic flocs sent by pneumatic transportation into the heat exchanger tube 60 is appropriate or not.

The tank 70 is a tank to contain and heat the above-
5 described heat exchanger tube 60. The tank 70 stores therein water. Thus, the heat exchanger tube 60 is immersed in water stored in the tank 70. Water stored in the tank 70 may be soft water used in the ship. The reason
10 for example from adhering to the interior of the tank 70 or the heat exchanger tube 60, thus providing a longer maintenance cycle.

The tank 70 includes a steam supply opening 72 for supplying steam as a heat source for heating water and a
15 condensed water discharge opening 74 for discharging excessive water caused by the steam supply. The steam supply opening 72 and the condensed water discharge opening 74 may be provided in the following layout. Specifically, the steam supply opening 72 is provided at the lower part-
20 side of the tank 70 (or at least at the lower-half part) and the condensed water discharge opening 74 is provided at the upper part-side of the tank 70 and at least at a position higher than the upper part of the heat exchanger tube 60 immersed in water. By the layout as described
25 above, the high-temperature steam jetted through the steam

supply opening 72 moves upward while heating the water in the tank 70 to thereby cause an agitation action, thus providing a uniform temperature distribution in the tank 70. Furthermore, the condensed water discharge opening 74
5 provided at a position higher than the upper part of the heat exchanger tube 60 can maintain the water level at a position higher than the heat exchanger tube 60.

The tank 70 may include a thermometer 80 and a water-level gauge 82. The reason is that, by measuring by the
10 thermometer 80 the temperature of the water in the tank 70 and maintaining the temperature in the tank 70 at a set value, a favorable heating status of the heat exchanger tube 60 can be maintained. The existence of the water-level gauge 82 can prevent water level from being lower
15 than the upper part of the heat exchanger tube 60 immersed in water. The reason is that the heat exchanger tube 60 cannot maintain a favorable heating status, if the heat exchanger tube 60 is not completely immersed in water.

In the heat sterilization section 50 having the
20 configuration as described above, the heat exchanger tube 60 may have such a diameter that prevents the precipitation or clogging of the magnetic flocs F. Whether the precipitation of the magnetic flocs F is caused or not has a relation with the delivery speed of the magnetic flocs F
25 sent by pneumatic transportation into the heat exchanger

tube 60 and the precipitation speed of the magnetic flocs F. Whether the clogging is caused or not has a relation with the diameter of the heat exchanger tube 60 and the viscosity and property of the magnetic flocs F. The
5 delivery speed of the magnetic flocs F sent by pneumatic transportation has a relation with the discharge flow rate of the pump 54 connected to the inlet of the heat exchanger tube 60 and the diameter (area) of the heat exchanger tube 60.

10 The heat exchanger tube 60 may have any length so long as the temperature at which microorganisms and bacteria or the like included in the magnetic flocs F can be killed can be maintained for a predetermined time when the magnetic flocs F is delivered at a predetermined delivery speed. It
15 is noted that an example according to the invention uses a temperature of 75 degrees C and the time of 3 minutes required to kill microorganisms and bacteria or the like by heating.

The pump 54 has a variable discharge flow rate. The
20 heat exchanger tube 60 has a diameter of 34 mm, a thickness of 1.2 mm, and a length of 57.4 m. This means that, when the magnetic flocs F are delivered at a speed of 7.3 m/min, the magnetic flocs F are retained in the heat exchanger tube 60 for about 7 minutes and 50 seconds.

25 When the heat sterilization section 50 in the above

configuration has the tank 70 including therein water of a temperature of about 80 degrees C, the achieving temperature of the magnetic flocs F changing with the retention time shows the tendency as shown in Fig. 4. As shown in Fig. 4, the temperature of the magnetic flocs F increases to 75 degrees C after about 3 minutes and 40 seconds during the time for which the magnetic flocs F are retained in the heat exchanger tube 60. Then, the temperature of the magnetic flocs F requires about 4 minutes and 10 seconds while maintaining the temperature of 75 degrees C or more until a fixed temperature of about 80 degrees C is reached. As described above, in order to kill microorganisms and bacteria or the like in the magnetic flocs F, the time of 3 minutes and the temperature of 75 degrees C are required. According to an experiment, when the heat exchanger tube 60 in the above configuration is used to deliver the magnetic flocs F at the above delivery speed, the magnetic flocs F can be retained at the temperature of 75 degrees C or more for 3 minutes or more, thus securely killing microorganisms and bacteria or the like included in the magnetic flocs F. The diameter and length of the heat exchanger tube 60 are determined based on various parameters including a flow rate and thus cannot be set to a fixed value. However, the heat exchanger tube 60 may have any diameter and length, in consideration of

the time during which the temperature of the magnetic flocs F sent by pneumatic transportation into the pipe path increases, so long as the magnetic flocs F can be retained at a temperature of 75 degrees C or more for the time of 3
5 minutes or more. In order to prevent the precipitation of the magnetic flocs F, the pneumatic transportation speed (flow rate) of the magnetic flocs F is set to 1.2 m/min or more.

In the heat sterilization section 50 having the
10 configuration as described above, the heat sterilization of the magnetic flocs F is carried out through three steps of a startup preparation, a heat sterilization, and a heat sterilization ending.

First, in the startup preparation step, as shown in
15 Fig. 5, the water level in the tank 70 is measured by the water-level gauge 82 (Step S100). When it is determined by the measurement of the water level that the water level is lower than a predetermined water level (i.e., the water level is lower than the water level at which the heat
20 exchanger tube 60 can be completely immersed in water), water is filled into the tank 70 (Step S110). When it is determined by the measurement of the water level by the water-level gauge 82 that the water level is equal to or higher than the predetermined water level, the temperature
25 of water stored in the tank 70 is measured by the

thermometer 80 (Step S120). When it is determined that the measured value by the thermometer 80 is lower than a set temperature (e.g., 80 degrees C to 95 degrees C), steam is supplied from the steam supply opening 72 into the tank 70 (Step S130). When the steam supply causes the temperature measured by the thermometer 80 to reach the set temperature, the magnetic flocs F can be taken into to the heat exchanger tube 60, thus stopping the steam supply (Step S140). Then, the storage amount (water level) of the magnetic flocs F in the collected flocs receiver tank 52 is detected (Step S150). When the water level of the collected flocs receiver tank 52 does not reach a standard value, there is a possibility where, during the pneumatic transportation of the magnetic flocs F by the pump 54, the fluid sent by pneumatic transportation may include therein air for example. Thus, a stand-by status is maintained until the water level reaches the standard value (Step S160). Thereafter, when the water level of the collected flocs receiver tank 52 reaches the standard value, the heat sterilization of the magnetic flocs F is enabled, thus completing the startup preparation (Step S170).

Next, in the heat sterilization step, the pump 54 is started as shown in Fig. 6 to send the magnetic flocs F by pneumatic transportation to the heat exchanger tube 60 (Step S200). After the start of the pneumatic

transportation of the magnetic flocs to the heat exchanger tube 60, the counting of the time required for the magnetic flocs to be discharged from the heat exchanger tube 60 is started (Step S210). The pneumatic transportation and heating of the magnetic flocs F cause the heat exchange between the water in the tank 70 and the magnetic flocs F. Thus, the temperature of the water in the tank 70 is measured by the thermometer 80 (Step S220). When it is determined by the temperature measurement that the water temperature is lower than a set temperature, the feeding of steam is performed (Step S230). Then, the processing returns to Step S220 and the water temperature is measured again. When it is determined in the measurement of the water temperature in Step S220 that the water temperature is equal to or higher than the set temperature, it is determined whether the steam supply (feeding) is performed or not (Step S240). When no steam supply is performed, then the storage amount (water level) of the magnetic flocs in the collected flocs receiver tank 52 is measured (Step S260). When steam supply is performed, the steam supply is stopped (Step S250) and then the processing proceeds to Step S260.

When the water level in the collected flocs receiver tank 52 is lower than the standard value, then the driving of the pump 54 is stopped and the magnetic flocs F are

stored in the collected flocs receiver tank 52 (Step S270). During this, the pump 54 for sending the magnetic flocs by pneumatic transportation is stopped and thus the count for calculating the discharge of the magnetic flocs is also
5 stopped (Step S280). When the water level in the collected flocs receiver tank 52 is equal to or higher than the standard value on the other hand, the operation status of the pump 54 is determined (Step S290). When the pump is not stopped, the pressure gauge 66 provided at the inlet 62
10 of the heat exchanger tube 60 detects the pressure in the heat exchanger tube 60 (Step S300). When it is determined in Step S290 that the pump 54 is stopped, then the processing returns to Step S200 and the pump 54 is started. An abnormal value detected by the pressure gauge 66 shows
15 that the heat exchanger tube 60 has a trouble such as breakage or clogging. In this case, an emergency stop is carried out where the pump 54 for sending the magnetic flocs F by pneumatic transportation and steam supplied to the tank 70 for example are stopped (Step S320). When a
20 value obtained by the pressure gauge 66 is normal on the other hand, the temperature measurement by the thermometer 68 provided at the exit 64 of the heat exchanger tube 60 is performed (Step S310). When the measured value by the thermometer 68 is lower than the temperature determined in
25 advance at which microorganisms and bacteria or the like

are killed, it is determined to be abnormal and an emergency stop is carried out (Step S320). When the measured value by the thermometer 68 is equal to or higher than the temperature at which microorganisms and bacteria or the like are killed on the other hand, it is determined as normal and then whether the count is completed or not is confirmed (Step S330). When the count is completed, the magnetic floc heat sterilization step is completed (Step S340). When the count is not completed on the other hand, then the processing returns to S220 and the steps after the measurement of the temperature of water in the tank 70 are performed again.

After the completion of the magnetic floc heat sterilization step, the processing proceeds to the heat sterilization ending step as shown in Fig. 7 (Step S400). First, cleaning water is taken into to the heat exchanger tube 60 (Step S410). After the taking of cleaning water (or simultaneously with the of taking cleaning water), the count of the time required for the magnetic flocs F remaining in the heat exchanger tube 60 to be substituted with cleaning water is started (Step S420). Thereafter, the thermometer 80 measures the temperature of water in the tank 70 (Step S430). When the temperature measured by the thermometer 80 is lower than the set temperature, steam is supplied from the steam supply opening 72 (Step S440).

Then, the processing returns to Step S430 and the temperature measurement is performed again. When the measured temperature in Step S430 is equal to or higher than the set temperature on the other hand, then whether
5 steam supply is stopped or not is determined (Step S450). When steam supply is stopped, then whether the count is completed or not is determined (Step S470). When steam supply is not stopped in Step S450, steam supply is stopped (Step S460). Then, the processing proceeds to the
10 determination of the completion of the count in Step S470. When the count is completed in Step S470, then the pump is stopped (Step S480). As a result, the taking of cleaning water into the heat exchanger tube 60 is also stopped. Thus, the interior of the heat exchanger tube 60 is filled
15 with cleaning water. When the count is not completed in Step S470 on the other hand, the processing returns to Step S430 where the temperature measurement of water in the tank 70 and the introduction of steam are repeated.

By using the heat sterilization section 50 performing
20 the heat sterilization treatment as described above, the heat exchanger tube 60 is heated by an indirect heating (double-boiling) by hot water of 100 degrees C or less. Thus, scale can be prevented from adhering to the interior of the heat exchanger tube 60. Furthermore, by the
25 structure in which water in the tank 70 is heated by jetted

steam and excessive condensed water is discharged, there is no part where a high pressure is caused in the tank 70, thus providing high safety. Furthermore, water and steam stored in the tank 70 can be both obtained from those used
5 for the ship including the ballast water treatment system 10, which is economic. Furthermore, water stored in the tank 70 is prevented from having a contact with contamination substance such as the magnetic flocs F. Thus, discharged condensed water can be reused in a
10 machinery such as ship.

Furthermore, by using the ballast water treatment system 10 having the heat sterilization section 50 as described above, microorganisms and bacteria or the like can be physically collected from ballast water to purify
15 the ballast water and the magnetic flocs F obtained by coagulating microorganisms and bacteria or the like can be sterilized. This can consequently solve not only an impact on the environment by the discharge of ballast water to other sea areas but also an impact on the environment and
20 human bodies by the storage of collected magnetic flocs F for a long period.

In the above embodiment, a configuration has been described in which the collected flocs receiver tank 52 is provided in the previous stage of the heat sterilization
25 section 50 to temporarily store magnetic flocs. However,

another configuration also may be used where the magnetic flocs storage tank 38 constituting the magnetic separation section 30 is used as a temporary storage means, thus omitting the collected flocs receiver tank 52. The
5 configuration as described above can reduce the installation space and equipment cost.

Furthermore, although a cylindrical pipe was shown as a pipe path in the embodiment, the present invention is not limited to a cylindrical pipe. Any pipe path can be used
10 so long as a narrow slit-like flow path is provided and magnetic floc passing therethrough can be securely heated by double-boiling.

The following section will describe a modification example of the heat sterilization section 50 according to
15 an embodiment. First, with reference to Fig. 8A and Fig. 8B, the first modification example will be described. Fig. 8A is a block diagram illustrating a top configuration of a heat sterilization section. Fig. 8B is a block diagram illustrating a front configuration.

20 A heat sterilization section 50b according to this modification example is characterized in that the form of a heat exchanger tube 60a is different from that in the above embodiment. Specifically, as is clear from Fig. 8A, the planar shape is formed as a hairpin curve shape instead of
25 an oval shape and this shape is superposed in a multiple

stages. By forming the heat exchanger tube 60b in the manner as described above, the volume of the tank 70 can be effectively used, thus increasing the length of the heat exchanger tube 60. This can consequently increase the time during which the magnetic flocs F are retained in the heat exchanger tube 60, thus securely killing microorganisms and bacteria or the like included in the magnetic flocs F. The other configurations are the same as those in the heat sterilization section 50 according to the above-described embodiment.

Next, with reference to Fig. 9A and Fig. 9B, the second modification example for a heat sterilization section will be described. Fig. 9A is a block diagram illustrating the top configuration of a heat sterilization section. Fig. 9B is a block diagram illustrating the front configuration.

The heat sterilization section 50b according to this modification example is also characterized in the form of the heat exchanger tube 60b. Specifically, the heat sterilization section 50b according to this modification example is characterized in that the two insertion tubes 60b are provided in the tank 70. Each of the insertion tubes 60b is formed by forming an oval roll to have a helical shape. By the heat exchanger tube 60b having the form as described above, this is section can have a doubled capacity for heat sterilization of the magnetic flocs F

and, even when one of the insertion tubes 60 is damaged or clogged, the heat sterilization treatment of the magnetic flocs F can be continued. The other configurations are the same as those in the heat sterilization section 50

5 according to the above-described embodiment.

Next, with reference to Fig. 10A and Fig. 10B, the third modification example for a heat sterilization section will be described. Fig. 10A is a block diagram illustrating the top configuration of a heat sterilization
10 section. Fig. 10B is a block diagram illustrating the front configuration.

A heat sterilization section 50c according to this modification example is characterized in the relation between the heat exchanger tube 60 and the tank 70. Thus,
15 the heat exchanger tube 60 according to this modification example may have the same form as that of the insertion tube in the heat sterilization section 50 according to the above-described embodiment and the heat sterilization sections 50a and 50b according to the above first and
20 second modification examples. The heat sterilization section 50c according to this modification example is that a structure 76 is provided in the dead space in the tank 70 configured by the roll or turning of the heat exchanger tube 60. The configuration as described above can exclude
25 water in the dead space, thus reducing the time required

for to increase the water temperature by steam. The structure 76 provided in the dead space desirably has a thermal conductivity higher than that of water. The other configurations are the same as those in the heat sterilization section 50 according to the above-described embodiment.

The above embodiment has been mainly exemplarily described where the heat sterilization section 50 is structured so that magnetic flocs are sent by pump to the interior of the heat exchanger tube 60 immersed in the tank 70 and the heat exchanger tube 60 is heated by double-boiling. However, the technical scope of the ballast water treatment method of the present invention also includes a case where a drying machine is used as a heat sterilization section for killing microorganisms and bacteria or the like coagulated in magnetic flocs. Any form of drying machine may be used. Thus, a drying machine herein may be, although not shown, the one that uses the steam heat generated and used by machines used for a ship including the ballast water treatment system to evaporate water included in a magnetic flocs.

One example of a drying machine may be the one that pushes magnetic flocs to the surface of a rotary drum heated by the above heat to evaporate water to subsequently scrape the magnetic flocs (in the dry form) from the

surface of the rotary drum.

Even when the drying machine having the configuration as described above is used as a heat sterilization section, no risk is caused where magnetic flocs have a short path to reach the collected flocs storage tank 56. Furthermore, in this embodiment, the rotary drum is directly heated by steam. Thus, the surface temperature (heating temperature) can be increased than in the case of where the heat exchanger tube 60 is heated by double-boiling. Thus, bacteria or the like can be securely killed within a short time. Furthermore, when a drying machine is used as the heat sterilization section, water included in magnetic flocs can be evaporated, thus reducing the volume of substances (dried magnetic flocs) stored as contamination substances.

Claims

1. A ballast water treatment method, comprising the steps of:

5 adding magnetic powder and coagulant into ballast water to thereby generate magnetic flocs including microorganisms and bacteria;

collecting the magnetic flocs from the ballast water; and

10 heating the collected magnetic flocs to a temperature at which the microorganisms and the bacteria are killed, the temperature being determined in advance.

2. The ballast water treatment method according to claim 1, wherein: the step of heating comprises inserting the
15 magnetic flocs to a pipe path and heating the pipe path to which the magnetic flocs are inserted.

3. The ballast water treatment method according to claim 2, wherein: the heating of the magnetic flocs is performed by
20 double-boiling the pipe path.

4. The ballast water treatment method according to claim 2, further comprising the step of measuring an exit
temperature of the pipe path to investigate a heating
25 status of the magnetic flocs.

5. The ballast water treatment method according to claim 3,
further comprising the step of measuring an exit
temperature of the pipe path to investigate a heating
5 status of the magnetic flocs.

6. The ballast water treatment method according to claim 2,
further comprising the step of measuring a pressure in the
pipe path to investigate a status of the pipe path.

10

7. The ballast water treatment method according to claim 3,
further comprising the step of measuring a pressure in the
pipe path to investigate a status of the pipe path.

15 8. The ballast water treatment method according to claim 4,
further comprising the step of measuring a pressure in the
pipe path to investigate a status of the pipe path.

9. A ballast water treatment system, comprising:
20 a coagulation section for agitating magnetic powder and
coagulant added to ballast water to generate magnetic
flocs;

a magnetic separation section for collecting the
magnetic flocs generated by the coagulation section;

25 a pipe path through which the magnetic flocs collected

by the magnetic separation section is sent; and
a heating section for heating the pipe path.

10. The ballast water treatment system according to claim
5 9, wherein: the heating section is a tank in which water is
stored and the pipe path is immersed in the tank.

11. The ballast water treatment system according to claim
10, wherein: the tank includes a steam supply opening
10 through which steam from a ship machine for heating water
in the tank is supplied.

12. The ballast water treatment system according to claim
9, wherein: an exit of the pipe path has a temperature
15 sensor.

13. The ballast water treatment system according to claim
10, wherein: an exit of the pipe path has a temperature
sensor.

20

14. The ballast water treatment system according to claim
11, wherein: an exit of the pipe path has a temperature
sensor.

25 15. The ballast water treatment system according to claim

9, wherein: the pipe path has a pressure sensor.

16. The ballast water treatment system according to claim
10, wherein: the pipe path has a pressure sensor.

5

17. The ballast water treatment system according to claim
11, wherein: the pipe path has a pressure sensor.

18. The ballast water treatment system according to claim
10 12, wherein: the pipe path has a pressure sensor.

19. The ballast water treatment system according to claim
13, wherein: the pipe path has a pressure sensor.

15 20. The ballast water treatment system according to claim
9, wherein: the pipe path is structured to have an inlet
and an exit provided at an upper part and to extend from
the inlet to the lowest part so as to draw an oval helical
shape from the lowest part thereof to the exit.

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