

[Description]

[Title of the Invention] AMMONIA TREATMENT SYSTEM

[Technical Field]

[0001]

The present invention relates to an ammonia treatment system, and more particularly, to an ammonia treatment system that electrolyzes ammonia contained in blow off water serving as drainage from a boiler facility.

This application claims priority to and the benefit of Japanese Patent Application Nos. 2012-119933 filed on May 25, 2012, and 2013-010251 filed on January 23, 2013, the contents of which are incorporated herein by reference.

[Background Art]

[0002]

For instance, hydrazine used for removing oxygen serving as a cause of corrosion in a thermal power plant is considered to be “a chemical substance having Mutagenicity.” Therefore, adoption of water treatment using a more safe oxygen scavenger or without use of the oxygen scavenger has been proceeding recently.

As the oxygen scavenger not using hydrazine, ammonia having a high hydrogen ionic index (pH) (for example, pH 7 to pH 9) is known in the art. However, it is presumed that using ammonia as the oxygen scavenger may increase the concentration of ammonia in the drainage from a plant in the future (for example, see Non-Patent Document 1). Meanwhile, a decrease of nitrogen is also required according to the regulation of emissions and a quick response will be required.

[0003]

Patent Document 1 discloses an ammonia treatment system that electrolyzes the drainage from a power plant so as to decompose ammonia, wherein an end point of electrolysis is determined from the concentration of residual chlorine.

An ammonia treatment system using chemicals such as sodium hyperchlorite to decompose ammonia through chlorine treatment is also known in the related art.

[Prior Art Document]

[Patent Document]

[0004]

[Patent Document 1] Japanese Patent No. 4518826

[Non-Patent Document]

[0005]

[Non-Patent Document 1] “Aspects on Non-Toxic Oxygen Scavenger in Power Plant Cycle Chemistry” [online], Mitsubishi Heavy Industries, Ltd., technical report Vol. 46, No. 2 (2009), [searched on March 30, 2012], Internet address <URL: <http://www.mhi.co.jp/technology/review/pdf/462/462055.pdf>>

[Summary of the Invention]

[Problems to be Solved by the Invention]

[0006]

However, for instance, when the drainage from a boiler facility is treated, the amount of the drainage or the concentration of ammonia is greatly varied. In a starting of an operation in which an amount of blow off water is large, for instance, there is a problem that the electrolysis cannot be completed.

Further, a case of decomposition of ammonia using chemicals such as sodium hyperchlorite needs a space for installing a tank containing sodium hyperchlorite as a strong alkaline oxidant, and it is difficult to incorporate the tank in existing facilities.

[0007]

The present invention provides an ammonia treatment system provided in a boiler facility, wherein electrolysis of ammonia may be suitably performed even when the boiler shows great variation in drainage.

[Means for Solving the Problems]

[0008]

According to a first aspect of the present invention, an ammonia treatment system includes a boiler facility configured to recover heat; an ammonia inflow device configured to flow ammonia into a feed-water system in the boiler facility; an ammonia concentration measuring unit configured to measure the concentration of ammonia contained in blow off

water from the feed-water system or the boiler facility; a flow rate measuring unit configured to measure the amount of the blow off water; a reception tank configured to receive the blow off water; a chloride ion feeding unit configured to introduce an aqueous sodium chloride solution as a source of chloride ions into the reception tank; an electrolysis tank configured to electrolyze treated water including the blow off water and the aqueous sodium chloride solution; and a controller configured to control a current and processing time during the electrolysis. The controller calculates a required amount of chlorine based on the concentration of ammonia and the amount of the blow off water, and controls the current level during electrolysis.

[0009]

According to the above configuration, electrolysis is controlled based on the concentration of ammonia contained in blow off water or the feed-water system in the boiler facility and the amount of the blow off water. For this reason, a drainage quality standard of the concentration of ammonia can be satisfied even when the boiler shows great variation in drainage.

[0010]

In the above ammonia treatment system, the system may include a residual chlorine measuring unit configured to measure a concentration of residual chlorine contained in the treated water during electrolysis, and the controller may determine the end point of electrolysis using the concentration of residual chlorine.

[0011]

According to the above configuration, it is possible to more precisely control the drainage quality standard of the concentration of the discharged ammonia by using the concentration of residual chlorine serving as an indicator for the end of electrolysis.

[0012]

In the above ammonia treatment system, the system may include a chloride ion concentration measuring unit configured to measure the concentration of chloride ions contained in the treated water, and the controller may control an introduction amount of the aqueous sodium chloride solution so that the concentration of chloride ions becomes a

predetermined level or more.

According to the above configuration, chloride ions required for electrolysis can be stably secured.

[0013]

In the above ammonia treatment system, a concentration device may be installed between the reception tank and the electrolysis tank to concentrate ammonia contained in at least a part of the treated water.

[0014]

According to the above configuration, since ammonia introduced into the electrolysis tank is concentrated by the concentration device and a required amount of chlorine is reduced, the feed amount of chloride ions serving as a raw material can be decreased.

[0015]

According to a second aspect of the present invention, an ammonia treatment system of the present invention includes a boiler facility configured to recover heat; an ammonia inflow device configured to flow ammonia into a feed-water system in the boiler facility; an ammonia concentration measuring unit configured to measure a concentration of ammonia contained in blow off water from the feed-water system or the boiler facility; a flow rate measuring unit configured to measure an amount of the blow off water; a chloride ion feeding unit configured to introduce an aqueous sodium chloride solution as a source of chloride ions; an electrolysis tank configured to electrolyze the aqueous sodium chloride solution; a mixing tank configured to receive the blow off water, and receive the treated water from the electrolysis tank; and a controller configured to control a current and processing time during the electrolysis. The controller calculates a required amount of chlorine based on the concentration of ammonia and the amount of the blow off water, and controls the current level during electrolysis.

[0016]

According to the above configuration, the electrolysis is controlled based on the concentration of ammonia of the feed-water system in the boiler facility or the blow off

water and the amount of the blow off water. For this reason, a drainage quality standard of the concentration of ammonia can be satisfied even when the boiler shows great variation in drainage.

Also, since the aqueous sodium chloride solution at a high concentration of chloride ions is introduced into the electrolysis tank, the current density can be increased.

[0017]

In the above ammonia treatment system, the system may include a residual chlorine measuring unit configured to measure the concentration of residual chlorine contained in the treated water during electrolysis, and the controller may determine the end point of electrolysis using the concentration of residual chlorine.

[0018]

In the above ammonia treatment system, the system may include a chloride ion concentration measuring unit configured to measure the concentration of chloride ions contained in the treated water, and the controller may control an introduction amount of the aqueous sodium chloride solution so that the concentration of chloride ions becomes a predetermined level or more.

[0019]

In the above ammonia treatment system, the system may include a desalination device installed at a downstream side of the mixing tank, and a concentrated water recycling pipeline configured to feed a part of the concentrated water concentrated by the desalination device, as a source of chloride ions, into the electrolysis tank.

[0020]

According to the above configuration, since chloride ions to be supplied to the electrolysis tank are recovered from the desalination device and then fed into the tank, a feeding cost of chloride ions may be reduced.

[Effect of the Invention]

[0021]

According to the ammonia treatment system described above, the electrolysis is controlled based on the concentration of ammonia contained in blow off water or the

feed-water system in the boiler facility and the amount of the blow off water. For this reason, a drainage quality standard of the concentration of ammonia can be satisfied even when the boiler shows great variation in drainage.

[Brief Description of the Drawings]

[0022]

FIG. 1 is an overall system diagram of a combined cycle power plant having an ammonia treatment system according to a first embodiment of the present invention.

FIG. 2 is a detailed system diagram of the ammonia treatment system according to the first embodiment of the present invention.

FIG. 3 is a detailed system diagram of an ammonia treatment system according to a second embodiment of the present invention.

FIG. 4 is a detailed system diagram of an ammonia treatment system according to a third embodiment of the present invention.

FIG. 5 is a detailed system diagram of an ammonia treatment system according to a fourth embodiment of the present invention.

FIG. 6 is a detailed system diagram of an ammonia treatment system according to a fifth embodiment of the present invention.

FIG. 7 is a detailed system diagram of an ammonia treatment system according to a sixth embodiment of the present invention.

FIG. 8 is a detailed system diagram of an ammonia treatment system according to a seventh embodiment of the present invention.

FIG. 9 is a detailed system diagram of an ammonia treatment system according to an eighth embodiment of the present invention.

FIG. 10 is a detailed system diagram of an ammonia treatment system according to a ninth embodiment of the present invention.

FIG. 11 is a detailed system diagram of an ammonia treatment system according to a tenth embodiment of the present invention.

[Modes for Carrying out the Invention]

[0023]

(First embodiment)

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

As illustrated in FIG. 1, an ammonia treatment system 1 of the present embodiment is provided in a combined cycle power plant 2 having an exhaust heat recovery boiler 3. The combined cycle power plant 2 includes a gas turbine 4, an exhaust heat recovery boiler 3 for receiving an emission gas from the gas turbine 4, a steam turbine 5, a power generator (not shown) driven by rotational driving force of the gas turbine 4 and steam turbine 5 to generate electric power, and the ammonia treatment system 1 for treating the blow off water discharged from the exhaust heat recovery boiler 3.

[0024]

The exhaust heat recovery boiler 3 is provided with a high pressure heating unit 6, a medium pressure heating unit 7, and a low pressure heating unit 8. The exhaust heat recovery boiler 3 generates steam through the high pressure heating unit 6, the medium pressure heating unit 7 and the low pressure heating unit 8, and the generated steam is delivered to the steam turbine 5 in order to work by the steam in the steam turbine 5. Emission gas of the steam turbine 5 is condensed to form a condensate by a condenser 9 and then introduced into the exhaust heat recovery boiler 3 by a condensate pump 10. The condensate concentrated by the condenser 9 is delivered to the exhaust heat recovery boiler 3 through a feed-water line 11.

[0025]

The high pressure heating unit 6 is provided with a high pressure super-heater 13, a high pressure drum 14, a high pressure evaporator 15 and a high pressure economizer 16. Water contained in the high pressure drum 14 is overheated and circulated by the high pressure evaporator 15 disposed in the exhaust heat recovery boiler 3, and generates high pressure steam in the high pressure drum 14. The high pressure steam generated in the high pressure drum 14 is overheated by the high pressure super-heater 13 disposed in the exhaust heat recovery boiler 3 and then introduced into the steam turbine 5.

[0026]

The medium pressure heating unit 7 is provided with a medium pressure super-heater 17, a medium pressure drum 18, a medium pressure evaporator 19 and a medium pressure economizer 20. Water contained in the medium pressure drum 18 is overheated and circulated by the medium pressure evaporator 19 disposed in the exhaust heat recovery boiler 3, and generates medium pressure steam in the medium pressure drum 18. The medium pressure steam generated in the medium pressure drum 18 is introduced into a re-heater 21 through the medium pressure super-heater 17, reheated in the re-heater 21, and then introduced into the steam turbine 5. Steam from the medium pressure super-heater 17 is introduced into the gas turbine 4 side to cool a hot part (a combustor, a vane, or the like) of the gas turbine 4.

[0027]

The low pressure heating unit 8 is provided with a low pressure super-heater 23, a low pressure drum 24, a low pressure evaporator 25 and a low pressure economizer 26. Water contained in the low pressure drum 24 is overheated and circulated by the low pressure evaporator 25 disposed in the exhaust heat recovery boiler 3, and generates a low pressure steam in the low pressure drum 24. The low pressure steam generated in the low pressure drum 24 is introduced into the steam turbine 5 through the low pressure super-heater 23.

[0028]

The condensate 27 obtained from the condenser 9 is fed into the low pressure drum 24 through a deaerator 28 and the low pressure economizer 26. A feed-water line 29 connected to the high pressure drum 14 and the medium pressure drum 18 is arranged at an outlet of the low pressure economizer 26. Feed water of the feed-water line 29 is fed into the high pressure drum 14 through a high pressure feed-water pump 30, and fed into the medium pressure drum 18 through a medium pressure feed-water pump 31. That is, the feed water is simultaneously fed to the low pressure drum 24, the medium pressure drum 18, and the high pressure drum 14. The low pressure drum 24 is a drum serving as a unit at the low pressure side. The medium pressure drum 18 and the high pressure

drum 14 are drums serving as a unit at the high pressure side.

Meanwhile, a circulation pump 32 for circulating the feed water from the low pressure economizer 26 is installed on a line between the feed-water line 11 and the feed-water line 29.

[0029]

A part of the condensate 27 is returned to the condenser 9 at an inlet side of the deaerator 28 and branched from the feed-water line 11, so as to return a part of water to the deaerator 28 side. Arrangement of individual devices in the exhaust heat recovery boiler 3 is only an example, and the number or alignment of economizers or super-heaters may be appropriately modified in consideration of performance of the gas turbine 4 or the like.

[0030]

An ammonia inflow device 34 to inflow ammonia, as a pH regulator, is installed on the feed-water line 11 serving as a feed-water system. For pH regulation, a predetermined amount of ammonia flows from the ammonia inflow device 34 into the feed water, whereby the feed water in the low pressure drum 24 has a pH of 9.0 or more and the concentration of ammonia becomes 0.5 ppm or more.

[0031]

In general, when the pH of the feed water is less than 9.0, erosion and/or corrosion may occur due to the flow. For this reason, the feed water in the low pressure drum 24 is set so as to be pH 9.0 or more. A pressure of the feed water in the low pressure drum 24 is lower than those of feed water in the high pressure drum 14 and the medium pressure drum 18. In addition, ammonia is easy to vaporize and is easily mixed in a gas phase as the pressure is decreased (it is rarely mixed in a liquid phase). That is, the ratio of distribution between the gas phase and the liquid phase is high. Therefore, by causing the feed water in the low pressure drum 24 to have a pH of 9.0 or more, it becomes possible to cause the feed water in the high pressure drum 14 and the medium pressure drum 18 to have a higher pH value than 9.0.

[0032]

Meanwhile, a plurality of the ammonia concentration measuring devices 47, 48 and 49 to measure a concentration of ammonia in the feed water are installed on the feed-water line 11 at an outlet side of the condenser 9. More specifically, the ammonia concentration measuring device 47 is disposed between the condensate pump 10 and the ammonia inflow device 34 on the feed-water line 11. The ammonia concentration measuring device 48 is installed between the ammonia inflow device 34 and the deaerator 28. Also, the ammonia concentration measuring device 49 is installed between the deaerator 28 and the low pressure economizer 26.

[0033]

A blow line 35 is branched between the condenser 9 and the condensate pump 10 on the feed-water line 11. The blow line 35 is a line for discharging the blow off water serving as waste water containing ammonia generated in the combined cycle power plant 2 having the exhaust heat recovery boiler 3.

[0034]

Further, a flow rate measuring device 53 to measure an amount of the blow off water is installed on the blow line 35. The amount of the blow off water measured by the flow rate measuring device 53 is transmitted to the controller 41.

[0035]

The ammonia treatment system 1 is connected to the blow line 35. The ammonia treatment system 1 is further provided with a reception tank 36 in which the blow off water is stored and sea water is introduced, an electrolytic treatment device 37 and a controller 41.

The electrolytic treatment device 37 includes a circulation regulating tank 38 in which treated water including the blow off water flowed out from the reception tank 36 as well as sea water is introduced, an electrolysis tank 39 in which a control solution from the circulation regulating tank 38 is introduced, and a circulation pump 40 for circulating an electrolytic treatment solution. Herein, the electrolytic treatment solution treated in the electrolysis tank 39 is circulated into the circulation regulating tank 38.

[0036]

As illustrated in FIG. 2, a sea water introduction line 42 (a chloride ion feeding unit) for introducing sea water as a source of chloride ions (a concentration of chloride ions: about 18,000 mg/liter), is connected to the reception tank 36. The sea water introduction line 42 is provided with a sea water pump 46. The sea water pump 46 is configured to be capable of being controlled by the controller 41.

[0037]

Further, a liquid introduced through the sea water introduction line 42 is not particularly limited to the sea water, but may be liquid containing chloride ions. For instance, a configuration of introducing an aqueous sodium chloride solution from the sea water introduction line 42 may be adopted. As such, the system of the present invention may be applicable to facilities in which it is difficult to supply sea water by introducing an aqueous sodium chloride solution.

[0038]

Further, a pH measuring device 43 for measuring the pH of the treated water, a temperature measuring device 51 for measuring a temperature of the treated water, and a chloride ion concentration measuring device 44 for measuring a concentration of chloride ions of the treated water, are installed in the circulation regulating tank 38.

[0039]

The electrolysis tank 39 includes at least a pair of electrodes immersed in the treated solution in the electrolysis tank 39, and a direct current (DC) power supply 45 connected to the electrodes. When DC voltage is applied between these electrodes by the DC power supply 45, the treated solution in the tank is electrolyzed.

Further, a residual chlorine measuring device 52 for measuring a concentration of residual chlorine contained in the electrolysis tank 39 is installed in the electrolysis tank 39. The residual chlorine measuring device 52 is connected to the controller 41.

[0040]

Next, operation of the ammonia treatment system 1 according to the present embodiment will be described.

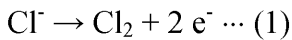
First, the blow off water containing ammonia is introduced into the reception tank

36, and sea water containing sodium chloride is introduced through the sea water introduction line 42 into the stored blow off water.

[0041]

Following this, the treated water including the blow off water and sea water and containing chloride ions is fed into the electrolytic treatment device 37 at a predetermined rate.

In this regard, the treated water is supplied to the circulation regulating tank 38 of the electrolytic treatment device 37, and then fed into the electrolysis tank 39. In the electrolysis tank 39, a predetermined voltage is applied between the electrodes and current is supplied so that a predetermined current density is formed inside the electrolysis tank 39, and then chlorine (Cl₂) is generated at an anode by an electrode reaction according to Equation (1) below:



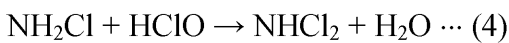
[0042]

Further, hyperchlorous acid (HClO) is generated by Cl₂ generated in the treated solution in the tank by a solution reaction according to Equation (2) below:



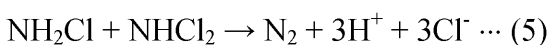
[0043]

If ammonia is present in the treated water, it reacts with hyperchlorous acid by the solution reaction to thus generate chloroamine (NH₂Cl, NHCl₂) according to Equation (3) and Equation (4) below:



[0044]

Further, chloroamine generated according to Equation (3) and Equation (4) is finally decomposed to nitrogen gas (N₂) by a solution reaction according to Equation (5) below:



[0045]

The controller 41 controls the DC power supply 45 based on the concentration of ammonia measured by the ammonia concentration measuring devices 47, 48 and 49, and the amount of blow off water measured by the flow rate measuring device 53, thereby controlling the current level of the electrolytic treatment device 37 and the processing time. That is, since the controller 41 controls the current of the power supply so that a hyperchlorous acid concentration is adaptable to the amount of blow off water and the concentration of ammonia, ammonia can be treated with a high precision in the ammonia treatment system 1.

Meanwhile, the ammonia concentration measuring device may be configured to be installed at only one place. In this case, an installation position of the ammonia concentration measuring device 47 close to the condenser 9 has high priority.

[0046]

The processing time of the electrolysis performed by the electrolytic treatment device 37 is controlled by the controller 41, based on a concentration of residual chlorine measured by the residual chlorine measuring device 52 as well as the concentration of ammonia, and, after terminating the above process, the treated water is suitably collected and drained.

More specifically, the controller 41 determines whether or not the concentration of residual chlorine reaches at least a predetermined value or more. Further, the controller sets a concentration of residual chlorine in which a concentration of ammonia may be decided to become a predetermined value or less, based on a pre-test. When the concentration of residual chlorine reaches the set value, electrolysis is stopped. The treated water is drained through a residual chlorine treating device (not shown).

In other words, with regard to the processing time of electrolysis set by the concentration of ammonia, even if the concentration of ammonia is not suitably reduced, the processing time is extended until the concentration of ammonia is decreased to a predetermined value or less.

[0047]

Further, an amount of sea water is controlled according to a value measured by

the pH measuring device 43. That is, the controller 41 controls the sea water pump 46 so that the pH of the treated water in the circulation regulating tank 38 reaches a range of pH 7 to pH 9, based on input from the pH measuring device 43, thus regulating the amount of sea water.

Similarly, the amount of sea water is controlled according to a value measured by the temperature measuring device 51. That is, the controller 41 controls the sea water pump 46 so that a temperature of the treated water reaches a range of 20 °C to 50 °C, thus regulating the amount of sea water.

Similarly, the amount of sea water may be controlled according to a value measured by the chloride ion concentration measuring device 44.

That is, the controller 41 controls the sea water pump 46 to allow a concentration of chloride ions of the treated water to be at least 2,000 mg/liter, thus regulating the amount of sea water.

[0048]

According to the above embodiment, electrolysis is controlled based on a concentration of ammonia contained in blow off water or a feed-water system in an exhaust heat recovery boiler 3 and an amount of the blow off water. Accordingly, a drainage quality standard of the concentration of ammonia can be satisfied even when a boiler shows great variation in drainage.

[0049]

Further, it is possible to more precisely control the concentration of discharged ammonia by using the concentration of residual chlorine serving as an indicator for the end of electrolysis.

In addition, since an introduction amount of sea water is regulated to allow a concentration of chloride ions contained in the treated water to be at least 2,000 mg/liter, chloride ions required for electrolysis can be stably secured.

[0050]

Further, since the introduction amount of sea water is suitably regulated so that the pH of the treated water in the electrolytic treatment device 37 is in the range of pH 7 to

pH 9, generation of chlorine gas and/or trichloroamine can be inhibited while efficiently performing the decomposition of ammonia.

[0051]

Further, when a temperature of the treated water is high, the generated chlorine easily becomes volatile. However, since an introduction amount of sea water is regulated so that the temperature of the treated water reaches a range of 20 °C to 50 °C, it is possible to prevent an ability of ammonia removal by chlorine volatilization from deteriorating.

Moreover, since no space for installing a sodium hyperchlorite tank is needed, it is easily incorporated in an existing facility instead.

[0052]

(Second embodiment)

Hereinafter, a second embodiment of the present invention will be described in detail with reference to the accompanying drawing.

FIG. 3 is a detailed system diagram of the ammonia treatment system according to the present embodiment. Meanwhile, the present embodiment is substantially described with a focus on differences from the first embodiment described above while a detailed description of the same parts is omitted here.

[0053]

As illustrated in FIG. 3, an ammonia treatment system 1B according to the present embodiment includes an electrolytic treatment device 37B, a reception tank 36 which is connected to a blow line 35, and stores the blow off water therein, a mixing tank 55 into which the treated water flowed out from the reception tank 36 and the treated water from the electrolytic treatment device 37B are introduced, and a controller 41.

A sea water introduction line 70 for introducing the sea water as a source of chloride ions is connected to the reception tank 36. A sea water pump 71 is installed on the sea water introduction line 70. The sea water pump is configured to be capable of being controlled by the controller 41. Further, a temperature measuring device 72 for measuring the temperature of the blow off water is installed in the reception tank 36.

[0054]

The electrolytic treatment device 37B includes a circulation regulating tank 38B in which the sea water is introduced, an electrolysis tank 39 in which a control solution from the circulation regulating tank 38B is introduced, and a circulation pump 40 for circulating the electrolytic treatment solution. The electrolytic treatment device 37B is configured such that the electrolytic treatment solution treated in the electrolysis tank 39 is circulated to the circulation regulating tank 38B.

[0055]

A sea water introduction line 42B for introducing the sea water as a source of chloride ions is connected to the circulation regulating tank 38B. A sea water pump 46 is installed on the sea water introduction line 42B, and the sea water pump 46 is configured to be capable of being controlled by the controller 41.

[0056]

A pH measuring device 43 for measuring the pH of the treated water, a temperature measuring device 51 for measuring a temperature of the treated water, and a chloride ion concentration measuring device 44 for measuring a concentration of chloride ions of the treated water are installed in the circulation regulating tank 38B.

[0057]

Next, operation of the ammonia treatment system 1B according to the present embodiment will be described.

Sea water containing sodium chloride is directly introduced into the circulation regulating tank 38B of the electrolytic treatment device 37B to generate hyperchlorous acid (HClO). The treated water containing the hyperchlorous acid is introduced into the mixing tank 55 in which the blow off water is stored, and ammonia contained in the blow off water reacts with the hyperchlorous acid by a solution reaction and finally decomposed to nitrogen gas (N₂).

Further, an amount of sea water introduced into the reception tank 36 is controlled according to a value measured by the temperature measuring device 72. The controller 41 controls the sea water pump 71 so that the temperature of the treated water in the reception tank 36 becomes 50 °C or less, thus regulating the amount of the sea water.

[0058]

According to the above embodiment, in addition to effects of the first embodiment, a current density can be increased since sea water having a high concentration of chloride ions is introduced into an electrolysis tank, and the electrolytic treatment device 37B can be compactified.

[0059]

(Third embodiment)

Hereinafter, a third embodiment of the present invention will be described in detail with reference to the accompanying drawing.

FIG. 4 is a detailed system diagram of the ammonia treatment system according to the present embodiment. Meanwhile, the present embodiment is substantially described with a focus on differences from the first embodiment described above while a detailed description of the same parts is omitted here.

[0060]

As illustrated in FIG. 4, in an ammonia treatment system 1C of the present embodiment, a concentration device 60 for concentrating ammonia contained in a part of or overall treated water is installed between a reception tank 36 and an electrolytic treatment device 37. That is, ammonia contained in the treated water discharged from the reception tank 36 is concentrated by the concentration device 60 and then introduced into the electrolytic treatment device 37. The concentration device 60 may include a device using a reverse osmotic membrane, electrodialysis, capacitor desalination, ion-exchange resin, water softener, or the like.

[0061]

According to the above embodiment, since ammonia introduced into the electrolytic treatment device 37 is concentrated by the concentration device 60, a required amount of chlorine (see Equation (2)) is reduced, and it is possible to decrease the feeding amount of chloride ions serving as a raw material. That is, chloride ions can be efficiently used in an electrolysis tank 39, thereby decreasing an externally feeding amount of the same.

[0062]

(Fourth embodiment)

Hereinafter, a fourth embodiment of the present invention will be described in detail with reference to the accompanying drawing.

FIG. 5 is a detailed system diagram of the ammonia treatment system according to the present embodiment. Meanwhile, the present embodiment is substantially described with a focus on differences from the third embodiment described above while a detailed description of the same parts is omitted here.

[0063]

As illustrated in FIG. 5, in an ammonia treatment system 1D of the present embodiment, a drainage having a low ammonia concentration generated during the concentration of ammonia in a concentration device 60 is mixed with the treated water discharged from an electrolytic treatment device 37. That is, the concentration device 60 of the present embodiment is provided with a drain pipe 61 configured to discharge the drainage having a low ammonia concentration. The drainage discharged from the drain pipe 61 is mixed with the treated water discharged from the electrolytic treatment device 37.

[0064]

According to the above embodiment, by mixing the drainage having a low ammonia concentration generated by the concentration device 60 with the treated water discharged from the electrolytic treatment device 37, the concentration of ammonia of the treated water discharged from the electrolytic treatment device can be maintained to a predetermined level or less.

[0065]

(Fifth embodiment)

Hereinafter, a fifth embodiment of the present invention will be described in detail with reference to the accompanying drawing.

FIG. 6 is a detailed system diagram of the ammonia treatment system according to the present embodiment. Meanwhile, the present embodiment is substantially

described with a focus on differences from the third embodiment described above while a detailed description of the same parts is omitted here.

[0066]

As illustrated in FIG. 6, in an ammonia treatment system 1E of the present embodiment, treated water from an electrolytic treatment device 37 is circulated between a reception tank 36 and a concentration device 60. That is, the ammonia treatment system 1E of the present embodiment returns the treated water obtained after electrolysis and ammonia treatment thereof, through a treated water circulation pipeline 62, to the front of the concentration device 60, so as to recycle and use sodium chloride.

[0067]

According to the above embodiment, recycling of chloride ions can be possible, and external supply of chloride ions is not needed.

[0068]

(Sixth embodiment)

Hereinafter, a sixth embodiment of the present invention will be described in detail with reference to the accompanying drawing.

FIG. 7 is a detailed system diagram of the ammonia treatment system according to the present embodiment. Meanwhile, the present embodiment is substantially described with a focus on differences from the second embodiment described above while a detailed description of the same parts is omitted here.

[0069]

As illustrated in FIG. 7, in an ammonia treatment system 1F of the present embodiment, a desalination device 63 for concentrating salts is installed at the downstream side of a mixing tank 55 and a part of the concentrated water concentrated by the desalination device 63 is fed into an electrolytic treatment device 37B as a source of chloride ions. The desalination device 63 and the electrolytic treatment device 37B are connected by a concentrated water recycling pipeline 64.

Further, the treated water discharged from the desalination device 63 may be emitted as effluent water, or otherwise, reused as boiler feed-water, industrial water and/or

general service water for various uses.

The desalination device 63 may include a device using a reverse osmotic membrane, electrodialysis, capacitor desalination, ion-exchange resin, water softener, or the like.

[0070]

According to the above embodiment, owing to a configuration of recovering chloride ions supplied to the electrolytic treatment device 37B from the desalination device 63 and then feeding the same, a feeding cost of chloride ions can be reduced.

[0071]

(Seventh embodiment)

Hereinafter, a seventh embodiment of the present invention will be described in detail with reference to the accompanying drawing.

FIG. 8 is a detailed system diagram of the ammonia treatment system according to the present embodiment. Meanwhile, the present embodiment is substantially described with a focus on differences from the sixth embodiment described above while a detailed description of the same parts is omitted here.

[0072]

As illustrated in FIG. 8, in an ammonia treatment system 1G of the present embodiment, a suspended solids (SS) separating device 65 for removing suspended solids from treated water is installed at the upstream side of a mixing tank 55 on a blow line 35. That is, the ammonia treatment system 1G of the present invention is configured to remove SS from the treated water containing ammonia introduced through the blow line 35, and then feed the treated water into the mixing tank 55.

[0073]

The SS separating device 65 may include a device using a strainer, micro-filtration film (MF) module, ultra-filtration (UF) module, sand filtration, settling basin, liquid cyclone, or the like.

[0074]

According to the above embodiment, because of SS removal, inflow of SS to the

electrolytic treatment device 37B and the desalination device 63 can be decreased, thereby a risk of damage to the electrolytic treatment device 37B or the desalination device 63 can be reduced.

[0075]

(Eighth embodiment)

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

FIG. 9 is a detailed system diagram of the ammonia treatment system according to the present embodiment. Meanwhile, the present embodiment is substantially described with a focus on differences from the sixth embodiment described above while a detailed description of the same parts is omitted here.

[0076]

As illustrated in FIG. 9, in an ammonia treatment system 1H of the present embodiment, a cooler 66 for cooling the treated water is installed at the upstream side of a mixing tank 55 on a blow line 35.

[0077]

According to the above embodiment, since hot treated water (for example, at a temperature of 80 °C) is cooled (for example, to 50 °C) by the cooler 66, a risk of damage to the electrolytic treatment device 37B or the desalination device 63 can be reduced.

[0078]

(Ninth embodiment)

Hereinafter, a ninth embodiment of the present invention will be described in detail with reference to the accompanying drawing.

FIG. 10 is a detailed system diagram of the ammonia treatment system according to the present embodiment. Meanwhile, the present embodiment is substantially described with a focus on differences from the sixth embodiment described above while a detailed description of the same parts is omitted here.

[0079]

As illustrated in FIG. 10, in an ammonia treatment system 1J of the present

embodiment, a Cl removing device 67 to remove residual chlorine (Cl_2 , ClO^-) is installed between a mixing tank 55 and a desalination device 63.

The Cl removing device 67 may include a device using activated carbon, aeration, a reducing agent, or the like. Such a reducing agent may include, for example, sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$), sodium hydrosulfite (NaHSO_3), sodium sulfite (Na_2SO_3), or the like.

[0080]

According to the above embodiment, the residual chlorine is reduced by the Cl removing device 67 and decomposes into chloride ions, whereby the residual chlorine contained in the treated water inflowing to the desalination device 63 can be blocked, and damage to the desalination device 63 can be prevented.

[0081]

(Tenth embodiment)

Hereinafter, a tenth embodiment of the present invention will be described in detail with reference to the accompanying drawing.

FIG. 11 is a detailed system diagram of the ammonia treatment system according to the present embodiment. Meanwhile, the present embodiment is substantially described with a focus on differences from the ninth embodiment described above while a detailed description of the same parts is omitted here.

[0082]

As illustrated in FIG. 11, in an ammonia treatment system 1K of the present embodiment, a residual chlorine measuring device 68 is installed at the downstream side of the Cl removing device 67 in the ammonia treatment system 1J according to the ninth embodiment (the upstream side of the desalination device 63), and the Cl removing device 67 is controlled depending upon a residual chlorine concentration measured by the residual chlorine measuring device 68.

Further, a bypass pipeline 69 for bypassing treated water discharged from the Cl removing device 67 to a concentrated water recycling pipeline 64 at the downstream side of the desalination device 63 is installed at the downstream side of the Cl removing device

67 (the upstream side of the desalination device 63). The treated water discharged from the Cl removing device 67 is introduced into either the desalination device 63 or the bypass pipeline 69 according to a command of the controller 41. Such a bypass process may be switched by a valve (not shown).

[0083]

A particular controlling method of the ammonia treatment system 1J according to the present embodiment will be described in detail. The controller 41 monitors a residual chlorine concentration of the treated water discharged from the mixing tank 55 by the residual chlorine measuring device 68 and operates the Cl removing device 67 so that the residual chlorine concentration is not detected. More specifically, the controller controls the additive amounts of the reducing agent and activated carbon, and the aeration quantity.

When the residual chlorine concentration is detected, a flow path toward the desalination device 63 is blocked using a valve, and the treated water is introduced into a bypass pipeline 69 then bypassed to the concentrated water recycling pipeline 64.

[0084]

According to the above embodiment, a removal rate of residual chlorine by the Cl removing device 67 can be improved.

[0085]

Meanwhile, technical configurations of the present invention are not limited to the above embodiments, and may include various modifications without departing from the scope of the present invention. For instance, although the embodiments described above have a configuration wherein a concentration of ammonia is measured by an ammonia concentration measuring device installed on a feed-water line 11, an alternative configuration for measuring a concentration of ammonia in blow off water on a blow line 35 may also be adopted.

[0086]

Further, means for measuring the concentration of ammonia is not particularly limited to use of an ammonia concentration measuring device, but may include a configuration for determining the concentration of ammonia from an inflow amount of

ammonia through an ammonia inflow device and an amount of blow off water in a feed-water system.

[Industrial Applicability]

[0087]

According to the ammonia treatment system described above, the electrolysis is controlled based on the concentration of ammonia contained in blow off water or the feed-water system in the boiler facility and the amount of the blow off water. For this reason, a drainage quality standard of the concentration of ammonia can be satisfied even when the boiler shows great variation in drainage.

[Description of Reference Numerals]

[0088]

- 1: ammonia treatment system
- 2: combined cycle power plant
- 3: exhaust heat recovery boiler (boiler facility)
- 11: feed-water line (feed-water system)
- 34: ammonia inflow device
- 35: blow line
- 36: reception tank
- 37: electrolytic treatment device
- 38: circulation regulating tank
- 39: electrolysis tank
- 41: controller
- 42, 42B: sea water introduction line (chloride ion feeding unit)
- 44: chloride ion concentration measuring device (chloride ion concentration measuring unit)
- 45: direct current power supply
- 46: sea water pump
- 47: ammonia concentration measuring device (ammonia concentration measuring unit)

48: ammonia concentration measuring device (ammonia concentration measuring unit)

49: ammonia concentration measuring device (ammonia concentration measuring unit)

52: residual chlorine measuring device (residual chlorine measuring unit)

53: flow rate measuring device (flow rate measuring unit)

55: mixing tank

60: concentration device

63: desalination device

64: concentrated water recycling pipeline

[Claims]

[Claim 1]

An ammonia treatment system comprising:

- a boiler facility configured to recover heat;
- an ammonia inflow device configured to flow ammonia into a feed-water system in the boiler facility;
- an ammonia concentration measuring unit configured to measure a concentration of ammonia contained in blow off water from the feed-water system or the boiler facility;
- a flow rate measuring unit configured to measure an amount of the blow off water;
- a reception tank configured to receive the blow off water;
- a chloride ion feeding unit configured to introduce an aqueous sodium chloride solution as a source of chloride ions into the reception tank;
- an electrolysis tank configured to electrolyze treated water including the blow off water and the aqueous sodium chloride solution; and
- a controller configured to control a current and processing time during the electrolysis,

wherein the controller calculates a required amount of chlorine based on the concentration of ammonia and the amount of the blow off water, and controls a current level during electrolysis.

[Claim 2]

The ammonia treatment system according to claim 1, further comprising a residual chlorine measuring unit configured to measure a concentration of residual chlorine contained in the treated water during electrolysis,

wherein the controller determines an end point of electrolysis based on the concentration of residual chlorine.

[Claim 3]

The ammonia treatment system according to claim 1 or 2, further comprising a chloride ion concentration measuring unit configured to measure a concentration of chloride ions contained in the treated water,

wherein the controller controls an introduction amount of the aqueous sodium chloride solution so that the concentration of chloride ions becomes a predetermined level or more.

[Claim 4]

The ammonia treatment system according to any one of claims 1 to 3, wherein a concentration device is installed between the reception tank and the electrolysis tank to concentrate ammonia contained in at least a part of the treated water.

[Claim 5]

An ammonia treatment system comprising:

a boiler facility configured to recover heat;

an ammonia inflow device configured to flow ammonia into a feed-water system in the boiler facility;

an ammonia concentration measuring unit configured to measure a concentration of ammonia contained in blow off water from the feed-water system or the boiler facility;

a flow rate measuring unit configured to measure an amount of the blow off water;

an electrolysis tank being provided with a chloride ion feeding unit configured to introduce an aqueous sodium chloride solution as a source of chloride ions, the electrolysis tank configured to electrolyze the aqueous sodium chloride solution;

a mixing tank configured to receive the blow off water, and receive the treated water from the electrolysis tank; and

a controller configured to control a current and processing time during the electrolysis,

wherein the controller calculates a required amount of chlorine based on the concentration of ammonia and the amount of the blow off water, and controls a current level during electrolysis.

[Claim 6]

The ammonia treatment system according to claim 5, further comprising a residual chlorine measuring unit configured to measure a concentration of residual chlorine contained in the treated water during electrolysis,

wherein the controller determines the end point of electrolysis based on the concentration of residual chlorine.

[Claim 7]

The ammonia treatment system according to claim 5 or 6, further comprising a chloride ion concentration measuring unit configured to measure a concentration of chloride ions contained in the treated water,

wherein the controller controls an introduction amount of the aqueous sodium chloride solution so that the concentration of chloride ions becomes a predetermined level or more.

[Claim 8]

The ammonia treatment system according to any one of claims 5 to 7, further comprising:

a desalination device installed at a downstream side of the mixing tank, and

a concentrated water recycling pipeline configured to feed a part of the concentrated water concentrated by the desalination device, as a source of chloride ions, into the electrolysis tank.

[Abstract]

An ammonia treatment system includes a boiler facility for recovering heat, an ammonia inflow device for flowing ammonia into a feed-water system in the boiler facility, an ammonia concentration measuring unit for measuring a concentration of ammonia contained in blow off water from the feed-water system or the boiler facility, a flow rate measuring unit for measuring the amount of the blow off water, a reception tank for receiving the blow off water, a chloride ion feeding unit for introducing an aqueous sodium chloride solution as a source of chloride ions into the reception tank, an electrolysis tank for electrolyzing treated water including the blow off water and the aqueous sodium chloride solution, and a controller for controlling a current and processing time during the electrolysis. The controller calculates a required amount of chlorine based on the concentration of ammonia and the amount of the blow off water, and controls a current level during electrolysis.