

Description

Title of Invention

AMMONIA AND HYDROGEN PRODUCTION SYSTEM

5 Technical Field

[0001]

The present invention relates to a system for producing ammonia and hydrogen using wastewater of a combustion furnace plant including a combustion
10 furnace and a boiler.

Background Art

[0002]

In recent years, a trend of using decarbonization as a countermeasure against global warming has gained
15 traction worldwide, and a technique using hydrogen (H_2) or ammonia (NH_3) as a fuel instead of a fossil fuel such as coal or petroleum has attracted attention as a technique for reducing emissions of carbon dioxide (CO_2). In Japan, for example, a technique has
20 been developed in which ammonia is produced using hydrogen produced by a water electrolysis device installed at a waste incinerator and the ammonia is used as a fuel for a gas engine or the like (see
25 Patent Document 1).

[0003]

On the other hand, it is known that, in a plant including a combustion furnace and a boiler that generates steam by heat of the combustion furnace,
30 such as a waste incinerator plant, a thermal power plant, or a chemical plant (hereinafter referred to as "combustion furnace plant"), chemicals containing ammonia are supplied to an exhaust gas to reduce nitrogen oxides (NO_x) and sulfur oxides (SO_x)
35 contained in the exhaust gas, or chemicals containing ammonia are used to adjust the pH value of water stored in the boiler, and thus a large amount of wastewater (hereinafter referred to as "ammonia-

containing wastewater") containing ammonia and ammonia nitrogen is produced.

Examples of a device for removing ammonia from ammonia-containing wastewater include an ammonia stripping device and a cation exchanger (ion exchange resin) (see Patent Documents 2 and 3).

Citation List

Patent Literature

10 [0004]

Patent Document 1: JP 2019-216501 A

Patent Document 2: JP 2004-097901 A

Patent Document 3: JP 2019-098206 A

15 Summary of Invention

Technical Problem

[0005]

In the technique of Patent Document 1, ammonia is synthesized from hydrogen generated by a water electrolysis device and nitrogen in the air. However, it is inefficient to produce ammonia using hydrogen produced by the water electrolysis device without utilizing a large amount of ammonia-containing wastewater present in a combustion furnace plant.

25 In the technique described in Patent Document 1, to reduce the temperature of an exhaust gas, a temperature reducing tower commonly known as a scrubber is installed upstream of a dust collector, and wastewater generated in the temperature reducing tower is supplied to the water electrolysis device. However, the water electrolysis device is a device that produces hydrogen using pure water as a feedstock, and the wastewater generated in the temperature reducing tower contains fly ash and heavy metals in the exhaust gas and chemicals used to treat the exhaust gas, and thus the wastewater cannot be directly supplied to the water electrolysis device.

[0006]

Accordingly, in a combustion furnace plant, to generate ammonia (NH_4OH) from ammonia-containing wastewater such as wastewater from exhaust gas treatment which is wastewater generated in a
5 denitrification device or a desulfurization device for the exhaust gas, or boiler blowdown water which is pH-adjusted wastewater from a boiler, the techniques of Patent Document 2 and Patent Document 3 may be applied.

10 However, generally speaking, the flow rate of the boiler blowdown water is much smaller than the flow rate of the wastewater from exhaust gas treatment. Thus, the pH value (hydrogen ion exponent) of the mixed liquid of the both becomes lower than the pH
15 value of the boiler blowdown water.

When ammonia is obtained by diffusing ammonia from the mixed liquid having a relatively low pH value using the technique of Patent Document 2, that is, by using an ammonia stripping device, the amount of
20 diffused ammonia is small as compared with a case where the pH value is high. Therefore, it is necessary to increase the pH value of the mixed liquid by adding a large amount of alkaline chemicals (e.g., strong alkaline sodium hydroxide).

25 On the other hand, the ion exchange resin of Patent Document 3 is more expensive than the ammonia stripping device of Patent Document 2, and is not suitable for treating a large amount of the mixed liquid from the viewpoint of high operating cost.

30 In other words, when ammonia is produced from ammonia-containing wastewater in a combustion furnace plant by using the techniques of Patent Document 2 and Patent Document 3, it is likely that the operating cost of the combustion furnace plant is high in either
35 case.

[0007]

The present invention has been made to solve the above-described problems, and an object of the present

invention is to provide an ammonia and hydrogen production system that can efficiently and inexpensively produce ammonia and hydrogen using ammonia-containing wastewater.

5

Solution to Problem

[0008]

An ammonia and hydrogen production system according to the present invention is applied to a combustion furnace plant and includes: a boiler that generates steam by heat of a combustion furnace; an exhaust gas treatment device that treats an exhaust gas of the combustion furnace and discharges wastewater from exhaust gas treatment; a separation device that separates boiler blowdown water of the boiler into ammonia-containing water and treated water; a water electrolysis device that produces hydrogen by performing electrolysis using the treated water; a hydrogen storage tank that stores the hydrogen; a first ammonia stripping device that diffuses ammonia from the wastewater from exhaust gas treatment; and an ammonia solution storage tank that stores ammonia solution containing the diffused ammonia. The exhaust gas and the boiler are supplied with chemicals containing ammonia or ammonia nitrogen. The ammonia-containing water separated by the separation device is injected at a first position of the first ammonia stripping device. The wastewater from exhaust gas treatment discharged from the exhaust gas treatment device is injected at a second position of the first ammonia stripping device different from the first position when viewed in a flow direction of the diffused ammonia.

35

Advantageous Effects of Invention

[0009]

According to the ammonia and hydrogen production system of the present invention, boiler blowdown water

which is ammonia-containing wastewater is separated into ammonia-containing water and treated water, and the treated water is electrolyzed by the water electrolysis device to produce hydrogen, and ammonia is separately diffused from the ammonia-containing water and wastewater from exhaust gas treatment which is ammonia-containing wastewater by injecting the ammonia-containing water and the wastewater from exhaust gas treatment at different positions of the ammonia stripping device when viewed in a flow direction of the diffused ammonia. Thus, the ammonia and hydrogen production system can efficiently produce ammonia solution as compared with a case where the ammonia-containing water and the wastewater from exhaust gas treatment are mixed and diffused.

In addition, the supply amount of chemicals for increasing the pH value can be reduced because injection is performed at the different positions, and the separation device can be configured at low cost because the separation device treats a small amount of boiler blowdown water instead of the wastewater from exhaust gas treatment.

Therefore, the ammonia and hydrogen production system of the present invention can produce ammonia and hydrogen efficiently and inexpensively by using ammonia-containing wastewater.

Brief Description of Drawings

[0010]

FIG. 1 is a diagram illustrating an embodiment of an ammonia and hydrogen production system according to the present invention.

FIG. 2 is a diagram illustrating a modification example of the ammonia and hydrogen production system according to the present invention.

Description of Embodiments

[0011]

An ammonia and hydrogen production system of the present invention will be described below with reference to FIGS. 1 and 2.

In the drawings, a reference sign consisting of only numeric character(s) represents a physical element such as a device, a part, and a portion related to the present system in the embodiment and modification example of the present invention. A reference sign consisting of a combination of the letter F and numeric character(s) represents a fluid such as a liquid or a gas generated in the present system, and a reference sign consisting of a combination of the letter P and numeric character(s) represents a position.

Note that the embodiment and the modification example described below are merely illustrative, and there is no intention to exclude various modifications and applications of techniques that are not explicitly described. Each configuration described below can be variously modified and implemented without deviating from the gist thereof. In addition, each configuration described below can be selected as appropriate except for a configuration essential to the present invention or can be combined with a known configuration.

[0012]

1. Embodiments

FIG. 1 is a block diagram illustrating an ammonia and hydrogen production system 1 according to an embodiment.

The ammonia and hydrogen production system 1 includes at least: a boiler 20 that generates steam by the heat of a combustion furnace 11; an exhaust gas treatment device 13 that treats an exhaust gas F10 of the combustion furnace 11 and discharges a wastewater F1 from exhaust gas treatment; a separation device 10 that separates a boiler blowdown water F2 of the boiler 20 into an ammonia-containing water (high-concentration ammonia-containing water) F5 and a

treated water F6; a water electrolysis device 32 that electrolyzes the treated water F6 to produce a hydrogen F7; a hydrogen storage tank 33 that stores the hydrogen F7; an ammonia stripping device 44 (first ammonia stripping device) that diffuses ammonia from the wastewater F1 from exhaust gas treatment; and an ammonia solution storage tank 51 that stores an ammonia solution F8 containing the ammonia in a diffused state.

10 [0013]

The ammonia and hydrogen production system 1 can be applied to a plant including a combustion furnace and a boiler that generates steam by the heat of the combustion furnace, that is, a combustion furnace plant, and can be applied to various plants such as a waste incineration plant, a thermal power plant, and a chemical plant. However, the combustion furnace plant to which the ammonia and hydrogen production system 1 is applied needs to include at least the components essential to the present invention (the components described in the claims), but does not need to include all the components described in FIG. 1.

Further, in the ammonia and hydrogen production system 1, all the components in FIG. 1 do not need to be arranged in the same site, and a plurality of components in FIG. 1 may be arranged in sites different from each other. In that case, the ammonia and hydrogen production system 1 may be configured by connecting the plurality of components via a pipeline or a transportation route for an automobile or the like.

[0014]

Each component in FIG. 1 and the effects thereof will be described.

35 The combustion furnace 11 is a furnace for obtaining heat by burning a fuel. For example, when a combustion furnace plant to which the present invention is applied is a waste incineration plant,

the fuel is typically a waste (municipal waste or industrial waste), and when the combustion furnace plant is a thermal power plant or a chemical plant, the fuel is typically coal, petroleum, natural gas, woody biomass, green fuel such as biogas produced by fermentation, or the like. However, as the fuel for the combustion furnace 11, ammonia or hydrogen, for example, ammonia or hydrogen produced by the ammonia and hydrogen production system 1 may be used.

The exhaust gas F10 generated in the combustion furnace 11 sequentially flows through a flue gas duct as follows and is discharged to the atmosphere from a stack 15. That is, the exhaust gas F10 flows in the order of a temperature reducing tower (not illustrated) that reduces the temperature of the exhaust gas F10, a dust collecting device 12 (e.g., bag filter or electrostatic dust collecting device) that removes dusts from the exhaust gas whose temperature has been reduced in the temperature reducing tower, an exhaust gas treatment device 13 of a wet type that removes harmful components such as nitrogen oxides (NO_x) and sulfur oxides (SO_x) from the exhaust gas from which the dusts have been removed by the dust collecting device 12, a carbon dioxide separation device 14 that separates and recovers carbon dioxides from the exhaust gas from which the harmful components have been removed by the exhaust gas treatment device 13, and the stack 15 that discharges the exhaust gas from which the carbon dioxides have been removed by the carbon dioxide separation device 14 to the atmosphere.

[0015]

Here, since the combustion furnace 11 or the flue gas duct is supplied with chemicals containing ammonia or ammonia nitrogen so as to reduce nitrogen oxides (NO_x) and sulfur oxides (SO_x), a large amount of the wastewater F1 from exhaust gas treatment, which is ammonia-containing wastewater, is discharged from the

exhaust gas treatment device 13 including a denitrification device or a desulfurization device of a wet type.

5 The wastewater F1 from exhaust gas treatment flows through a third pipe having one end connected to the exhaust gas treatment device 13, that is, the third pipe which is a third flow path 43 to be described in detail below.

10 In addition, the carbon dioxide separation device 14 can utilize a known technique in which a polymer separation membrane (carbon dioxide separation membrane) or an amine solution is used. Carbon dioxide separated by the carbon dioxide separation device 14 is stored in a carbon dioxide storage tank 37.

15 [0016]

The boiler 20 is a device that generates steam by using the heat of the combustion furnace 11.

20 The boiler 20 includes: a water purification device 27 that produces pure water from tap water or industrial water; a chemical supply device 28 that adds chemicals such as an acidity regulator to the pure water produced by the water purification device; a steam drum 21 that stores the pure water to which the chemicals are added; a waste heat recovery device 25 22 such as a heat transfer tube or a superheater tube that converts the water stored in the steam drum 21 into steam by using the heat of an exhaust gas; a steam turbine 23 that rotates an impeller by the steam produced by the waste heat recovery device 22 and 30 supplied to the steam drum 21; a generator 24 that generates power by a rotational force of the impeller of the steam turbine 23; a condenser 25 that returns the steam (waste steam F4) having rotated the impeller of the steam turbine 23 to water; and a deaerator 26 35 that removes a dissolved gas (oxygen, carbon dioxide, or the like) from condensate produced by the condenser 25 and supplies the condensate to the steam drum 21.

The boiler blowdown water F2 is discharged as needed from a blowdown piping 29 disposed below the steam drum 21.

[0017]

5 In consideration of corrosion resistance, the chemical supply device 28 supplies chemicals such as an acidity regulator containing ammonia or ammonia nitrogen so as to adjust the pH value of the water stored in the steam drum 21 to about 9 to 10 (e.g., a
10 pH value of about 10.3). Thus, the boiler blowdown water F2 is ammonia-containing wastewater having a pH value of about 9 to 10.

 Note that the water stored in the steam drum 21 is obtained by adding a small amount of chemicals to
15 pure water and does not contain impurities such as ashes, and thus is substantially equivalent to pure water. In addition, since the pH value of the wastewater F1 from exhaust gas treatment is typically about 6 to 9, the pH value of the boiler blowdown
20 water F2 is equal to the pH value of the wastewater F1 from exhaust gas treatment or greater than the pH value of the wastewater F1 from exhaust gas treatment.

 The amount of the boiler blowdown water F2 is smaller than the amount of the wastewater F1 from
25 exhaust gas treatment generated in the exhaust gas treatment device 13. For example, the amount of the boiler blowdown water F2 may be about one hundredth (1/100) to about one tenth (1/10) of the amount of the wastewater F1 from exhaust gas treatment.

30 [0018]

 The power generated by the generator 24 is used to operate various electric products (the water electrolysis device 32, the methanation device 35, the ammonia stripping device 44, the urea production
35 device 52, and the like) in the ammonia and hydrogen production system 1, and the surplus power may be sold to a power company. With an appropriate design in which the power is not sold to a power company or only

a small amount of the power is sold and all or most of the power is supplied to the various electric products installed in a combustion furnace plant to which the ammonia and hydrogen production system 1 is applied, a substantially power self-sufficient combustion furnace plant can be constructed.

[0019]

The separation device 10 is a device that is supplied with at least part of the boiler blowdown water F2 discharged as needed from the steam drum 21 and separates the at least part of the boiler blowdown water F2 into the ammonia-containing water F5 (high-concentration ammonia-containing water) and the treated water F6. Of course, the entire amount of the boiler blowdown water F2 may be supplied to the separation device 10 as illustrated in FIG. 1, if possible in terms of design. Although not illustrated, when there is a remaining boiler blowdown water that is not supplied to the separation device 10, the remaining boiler blowdown water is subjected to a water treatment in a general wastewater treatment facility 58, particularly in an inorganic treatment device 60 to be described below.

In the embodiment of FIG. 1, the separation device 10 is an ion removal device 30 (first ion removal device).

[0020]

For example, an RO membrane (reverse osmotic membrane) or an ion exchange resin is built in the ion removal device 30. The RO membrane is a membrane that allows hydrogen ions (H^+) and hydroxide ions (OH^-) in water to pass therethrough and prevents other unnecessary ions (e.g., Ca^{2+} , Mg^{2+} , and Na^+) from passing therethrough. The ion exchange resin is gel-like synthetic resin beads that substitute unnecessary ions in water with hydrogen ions or hydroxide ions.

Thus, the ion removal device 30, which is the separation device 10, is a device that is supplied

with the at least part of the boiler blowdown water and separates the at least the part of the boiler blowdown water into the ammonia-containing water F5 containing not only ammonia and ammonia nitrogen but
5 also other unnecessary ions and the treated water F6.
[0021]

Here, the pH value of the ammonia-containing water F5 generated by the ion removal device 30 is higher than the pH value of the boiler blowdown water
10 F2 and also higher than the pH value of the wastewater F1 from exhaust gas treatment. For example, when the boiler blowdown water F2 has a pH value of about 9 to 10 and the wastewater F1 from exhaust gas treatment has a pH value of about 6 to 9, the ammonia-containing
15 water F5 may have a pH value of greater than 10.5, specifically about 11.0 to about 13.0. Thus, the ammonia-containing water F5 is a high-concentration ammonia-containing water containing a high concentration of ammonia or ammonia nitrogen.

20 It is generally said that, in an ammonia stripping device, the amount of diffused ammonia decreases when the pH value of ammonia-containing water is 10.5 or less. Therefore, as will be described below, when the wastewater F1 from exhaust gas
25 treatment is supplied to the ammonia stripping device 44, it is desirable that an alkaline chemical supply device 55 appropriately supplies alkaline chemicals to the wastewater F1 from exhaust gas treatment to adjust the pH value of the wastewater F1 from exhaust gas
30 treatment to 10.5 or more.
[0022]

The water electrolysis device 32 is a device that electrolyzes the treated water F6 produced by the separation device 10 to produce hydrogen F7. In
35 general, water containing no impurities or very little impurities, that is, pure water or water substantially equivalent to pure water is supplied to a water electrolysis device to be electrolyzed. Thus, the

treated water F6 is pure water or water substantially equivalent to pure water. The hydrogen F7 produced by the water electrolysis device 32 is stored in the hydrogen storage tank 33.

5 Oxygen produced simultaneously with the hydrogen F7 during the electrolysis of the treated water F6 may be discharged into the atmosphere, supplied into the combustion furnace 11 as a combustion accelerator, or stored in an oxygen storage tank (not illustrated).

10 In general, a water electrolysis device includes a heating device for heating pure water or the like having a room temperature to efficiently perform electrolysis. However, the water electrolysis device 32 does not need to include a heating device. This is
15 because the boiler blowdown water F2, which is a feedstock for the water electrolysis device 32, has a high temperature, and thus the treated water F6 to be separated by the ion removal device 30 can be adjusted to a temperature (about 70°C to about 90°C) higher
20 than a room temperature. Accordingly, the water electrolysis device 32 can efficiently produce hydrogen with no heating device, and thus is excellent in cost effectiveness. Of course, when it is necessary to further heat the treated water F6 having a
25 temperature higher than a room temperature, the heating device may be added to the water electrolysis device 32.

[0023]

30 A distributing device 39 is a device that basically causes the ammonia-containing water F5 produced by the separation device 10 to flow only to a first flow path 41 and exceptionally distributes the ammonia-containing water F5 to both the first flow path 41 and a second flow path 42 when the flow rate
35 of the ammonia-containing water F5 is equal to or higher than a predetermined flow rate.

 The distributing device 39 of FIG. 1 includes a storage tank (no reference sign assigned) that stores

the ammonia-containing water F5 and a funnel 40. The funnel 40 is installed at a position of a reference water level in the storage tank. One end of a pipe (hereinafter referred to as "first pipe") serving as
5 the first flow path 41 is connected to the bottom surface of the storage tank. In addition, one end of a pipe (hereinafter referred to as a "second pipe") serving as the second flow path 42 is connected to the funnel 40, and the second pipe is disposed so as to
10 penetrate the bottom surface of the storage tank. A gap between the second pipe and the bottom surface is sealed with resin or the like so as to prevent water leakage.

In the distributing device 39 of FIG. 1, the ammonia-containing water F5 is supplied from above the
15 storage tank so as to avoid the funnel 40. The ammonia-containing water F5 flows out from the first pipe which is the first flow path 41, but when the flow rate of the ammonia-containing water F5 is higher
20 than the predetermined flow rate, the ammonia-containing water F5 is gradually accumulated in the storage tank. At this time, since the first pipe has a predetermined inside diameter, the flow rate of the ammonia-containing water F5 continuously flowing out
25 from the first pipe is constant in principle.

When the water level of the ammonia-containing water F5 stored in the storage tank reaches the reference water level, the stored ammonia-containing water F5 overflows into the funnel 40 and flows out
30 from the second pipe which is the second flow path 42.
[0024]

In the distributing device 39, the ammonia-containing water F5 continues to flow out from the first pipe even while flowing out from the second
35 pipe. The other end of the second pipe is connected to the third pipe described above, that is, a route of the third flow path 43. Thus, the ammonia-containing water F5 flowing out from the second pipe is mixed

with the wastewater F1 from exhaust gas treatment. However, to prevent the wastewater F1 from exhaust gas treatment from flowing from the third pipe to the second pipe, for example, a device such as a check
5 valve is installed to limit the flow direction to one direction.

[0025]

The distributing device 39 is not limited to a configuration including the funnel 40, but may have
10 any configuration as far as the distributing device 39 basically causes the ammonia-containing water F5 produced by the separation device 10 to flow only to the first flow path 41 and exceptionally distributes the ammonia-containing water F5 to both the first flow
15 path 41 and the second flow path 42 when the flow rate of the ammonia-containing water F5 is equal to or higher than a predetermined flow rate.

For example, the distributing device 39 may include: the storage tank having the bottom surface
20 connected with the first pipe and the second pipe at separate positions; a flow meter that measures the flow rate of the boiler blowdown water F2; a first solenoid valve installed at the first pipe; a second solenoid valve installed at the second pipe; and a
25 control device that receives information about the flow rate measured by the flow meter, opens the first solenoid valve and closes the second solenoid valve when the flow rate of the boiler blowdown water F2 is equal to or lower than a predetermined flow rate of
30 the first flow path 41, and opens both the first solenoid valve and the second solenoid valve when the flow rate of the boiler blowdown water F2 is higher than the predetermined flow rate of the first flow path 41.

35 [0026]

The ammonia stripping device 44 (first ammonia stripping device) is a device that sprays ammonia-containing water (the wastewater F1 from exhaust gas

treatment, the ammonia-containing water F5) containing ammonia and ammonia nitrogen toward steam so as to diffuse ammonia from the sprayed water by the heat of the steam. The steam used in the ammonia stripping device 44 may be the waste steam F4 described above. Steam having a higher temperature than the waste steam F4, for example, steam before rotating the impeller of the steam turbine 23 may be used, but it is advantageous in terms of cost effectiveness to use waste steam which does not affect the power generation amount of the generator 24.

The ammonia stripping device 44 includes one stripping tower elongated in the vertical direction or a plurality of stripping towers continuously connected in series. The stripping tower is a hollow tubular container standing in the vertical direction. Steam (waste steam F4) is supplied from a lower portion of the container, and the wastewater F1 from exhaust gas treatment or the ammonia-containing water F5 is sprayed from an upper portion of the container. Then, ammonium ions react with hydroxide ions in the stripping tower to produce the ammonia solution F8 in a gaseous state containing ammonia and steam.

[0027]

Note that, to improve the yield of ammonia, the stripping tower is generally configured as a multistage type in which a plurality of filler material and a plurality of trays are dispersedly arranged in the vertical direction.

In the ammonia stripping device 44 of FIG. 1, one stripping tower is used as an example, and the stripping tower is partitioned into three stages in the vertical direction by two trays 47 as an example. One stripping tower may be partitioned into four or more stages by three or more trays 47 or the like.

The ammonia-containing water sprayed in the ammonia stripping device 44 is brought into contact with the steam to diffuse ammonia, and is condensed

through a temperature decrease due to the diffusion into large water droplets, and the pH value thereof decreases, and thus the ammonia diffusion efficiency decreases. In view of the above, the large water
5 droplets are collected by the trays 47 and sprayed again as fine water droplets to improve the yield of ammonia.

Specifically, one tray 47 is connected to one tank 48, and the ammonia-containing water collected by
10 the one tray 47 is stored in the one tank 48. In addition, one sprayer 50 is installed below the one tray 47 (however, when another tray 47 is disposed below the one tray 47, the one sprayer 50 is installed below the one tray 47 and above the another tray 47).
15 Then, one pump 49 feeds the ammonia-containing water stored in the one tank 48 to the one sprayer 50, whereby the ammonia-containing water stored in the one tank 48 is sprayed from the one sprayer 50.

[0028]

20 The ammonia-containing water collected by the tray 47 has already released some ammonia. Thus, since the concentrations of ammonia and ammonia nitrogen in the ammonia-containing water are lower than those at the beginning, ammonia can be further efficiently
25 diffused from the ammonia-containing water having such lower concentrations when the ammonia-containing water is sprayed at a position where a steam temperature is higher, that is, a position below the tray 47, in other words, a position upstream of the tray 47 as
30 viewed in a flow direction of diffused ammonia (also a flow direction of the steam).

The ammonia stripping device 44 of FIG. 1 is configured to be partitioned into three stages, and thus there are in total two sets of one tray 47, one
35 tank 48, one pump 49, and one sprayer 50.

The ammonia solution F8 produced by the ammonia stripping device 44 is discharged in a gaseous state from an upper portion of the ammonia stripping device

44, cooled, and stored in the ammonia solution storage tank 51. The ammonia solution F8 contains a high concentration of ammonia (e.g., about 30 to about 50%).

5 [0029]

The ammonia stripping device 44 further includes, inside the stripping tower, a first sprayer 45 which is connected to the other end of the first pipe and sprays the high-concentration ammonia-containing water F5. In addition, the ammonia stripping device 44 also includes a second sprayer 46 which is connected to the other end of the third pipe, basically sprays the wastewater F1 from exhaust gas treatment, and exceptionally sprays a mixed liquid of the wastewater F1 from exhaust gas treatment and the high-concentration ammonia-containing water F5.

The first sprayer 45 and the second sprayer 46 are disposed at positions different from each other as viewed in the flow direction of the diffused ammonia, that is, the flow direction of the steam. Specifically, in the stripping tower, a first position P1 at which the first sprayer 45 is disposed is located downstream of a second position P2 at which the second sprayer 46 is disposed. In other words, when the first sprayer 45 and the second sprayer 46 are disposed in one stripping tower as illustrated in FIG. 1, the first position P1 is located above the second position P2. In the case where the ammonia stripping device 44 is configured by a plurality of stripping towers connected in series and where the first sprayer 45 and the second sprayer 46 are separately disposed in different stripping towers, the first position P1 is not necessarily located above the second position P2 as a matter of course. However, even in this case, in the stripping towers, the first position P1 at which the first sprayer 45 is disposed is located downstream of the second position P2 at which the second sprayer 46 is disposed when viewed in

the flow direction of the diffused ammonia, that is, the flow direction of the steam.

For example, in the ammonia stripping device 44 of FIG. 1, among the three-stage regions (an uppermost stage, a middle stage, and a lowermost stage) formed in one stripping tower, the first sprayer 45 is disposed at the uppermost stage and the second sprayer 46 is disposed at the middle stage, that is, the sprayer 45 and the sprayer 46 are disposed at stages different from each other. Note that the large water droplets described above are collected in the lowermost stage and are stored as residual water. Further, in the lowermost stage, the steam (waste steam F4) is supplied from above the residual water.

15 [0030]

In general, in an ammonia stripping device, the higher the steam temperature is and the higher the pH value of ammonia-containing water is, the more an ammonia diffusion performance is improved. Further, to efficiently diffuse ammonia in the multistage configuration as described above, it is desirable to effectively utilize all the stages.

20

Here, in one stripping tower, the steam temperature is highest in upstream, that is, in a lower portion which is the lowermost stage, and the steam temperature is lowest in downstream, that is, in the uppermost stage.

25

The high-concentration ammonia-containing water F5 sprayed from the first sprayer 45 has a pH value higher than the wastewater F1 from exhaust gas treatment or the mixed liquid of the wastewater F1 from exhaust gas treatment and the high-concentration ammonia-containing water F5 sprayed from the second sprayer 46.

30

Thus, the first sprayer 45 that sprays the high-concentration ammonia-containing water F5 having a sufficiently high pH value can effectively diffuse ammonia even when the steam temperature is somewhat

35

lowered. For this reason, the first sprayer 45 is disposed at the uppermost stage.

On the other hand, when the second sprayer 46 that sprays the ammonia-containing water (the wastewater F1 from exhaust gas treatment or the mixed liquid of the wastewater F1 from exhaust gas treatment and the high-concentration ammonia-containing water F5) having a pH value lower than the high-concentration ammonia-containing water F5 is disposed at the same position as the first sprayer 45 (the same position in the vertical direction in the uppermost stage), the ammonia-containing waters sprayed from the first sprayer 45 and the second sprayer 46 are mixed with each other and thereby the pH value is lowered, which may lower the ammonia diffusion performance. Therefore, the second sprayer 46 is installed at the second position P2 which is a region upstream of the first position P1 of the first sprayer 45, that is, a region where the steam temperature is higher than the steam temperature at the first position P1. In FIG. 1, the second sprayer 46 is installed at a middle stage (a stage different from the uppermost stage) where the steam temperature is higher than at the uppermost stage at which the first sprayer 45 is installed, and the low pH value of the ammonia-containing water (the wastewater F1 from exhaust gas treatment or the mixed liquid of the wastewater F1 from exhaust gas treatment and the high-concentration ammonia-containing water F5) sprayed from the second sprayer 46 is compensated by the high steam temperature, thereby comprehensively improving the ammonia diffusion performance.

Here, in FIG. 1, the first sprayer 45 and the second sprayer 46 are installed at different stages, but the same effect can be obtained even when the first sprayer 45 and the second sprayer 46 are installed at the same stage as far as they are located at different positions in the vertical direction in the ammonia stripping device. That is, ammonia can be

effectively diffused separately from the high-concentration ammonia-containing water F5 having a high pH value and the ammonia-containing water having a pH value lower than the high-concentration ammonia-containing water F5 by utilizing a difference in the steam temperature.

[0031]

Since the ammonia-containing water sprayed from the second sprayer 46 has a pH value lower than the high-concentration ammonia-containing water F5, the alkaline chemical supply device 55 may supply alkaline chemicals (e.g., sodium hydroxide NaOH) to the third flow path 43, that is, the third pipe to increase the pH value. However, since the first sprayer 45 and the second sprayer 46 are disposed as described above, the pH value of the ammonia-containing water only needs to be slightly higher than 10.5, which is a pH value enabling effective ammonia diffusion, and needs not to be equal to the pH value of the high-concentration ammonia-containing water F5. Thus, the amount of the alkaline chemicals required can be reduced as compared with the case where the pH value of the ammonia-containing water sprayed from the second sprayer 46 is made equal to the pH value of the high-concentration ammonia-containing water F5.

[0032]

Based on the above idea, when the pH value of the ammonia-containing water is made higher than the pH value of the high-concentration ammonia-containing water F5 by supplying alkaline chemicals or the like, the other end of the third pipe may be connected to the first sprayer 45 and the other end of the first pipe may be connected to the second sprayer 46.

In either case, the high-concentration ammonia-containing water F5 and the ammonia-containing water (the wastewater F1 from exhaust gas treatment or the mixed liquid of the wastewater F1 from exhaust gas treatment and the high-concentration ammonia-

containing water F5) are injected at different positions in the ammonia stripping device. That is, in the ammonia stripping device, of these two ammonia containing waters, the ammonia-containing water having a lower pH value is injected upstream and the ammonia-containing water having a higher pH value is injected downstream, in other words, at different positions in the vertical direction or different stages from each other, and ammonia is separately diffused from these ammonia-containing waters, and thus the ammonia solution F8 can be produced more efficiently than the case where these ammonia-containing waters are mixed and then sprayed.

[0033]

When the high-concentration ammonia-containing water F5 is caused to flow out into the second flow path 42 by the distributing device 39, the mixed liquid of the wastewater F1 from exhaust gas treatment and the high-concentration ammonia-containing water F5 is sprayed to the second sprayer 46 via the third flow path 43, and thus the pH value of the mixed liquid becomes higher than when only the wastewater F1 from exhaust gas treatment flows through the third flow path 43. Thus, the amount of the alkaline chemicals supplied to the third flow path 43 by the alkaline chemical supply device 55 can be reduced.

Further, in this case, although scale components such as magnesium and calcium are contained in the wastewater F1 from exhaust gas treatment, since the high-concentration ammonia-containing water F5 containing almost no scale components is mixed with the wastewater F1 from exhaust gas treatment, the concentration of the scale components is totally reduced, and thus scales can be prevented from being deposited in the ammonia stripping device 44. Accordingly, the ammonia stripping device 44 can be easily maintained.

Note that since the pH value of the high-concentration ammonia-containing water F5 sprayed from the first sprayer 45 is greater than 10.5, for example, about 11 to about 13, there is no need to add
5 alkaline chemicals.

A residual water F9 stored in the lowermost stage of the ammonia stripping device 44 is supplied to the general wastewater treatment facility 58 including at least the inorganic treatment device 60 in which
10 inorganic water treatment is performed, and subjected to water treatment, and then can be released, for example.

[0034]

In the embodiment, since at least part of the
15 boiler blowdown water F2 is used as a feedstock for the water electrolysis device 32, the total amount of ammonia-containing wastewater is reduced as compared with the case where the boiler blowdown water F2 is not used as the feedstock. Therefore, not only a load
20 in water treatment in the general wastewater treatment facility 58 is reduced, but also the ion removal device 30 can be downsized, and thus the ammonia and hydrogen production system 1 can be constructed at low cost as a whole.

25 Here, the general wastewater treatment facility 58 may include, in addition to the inorganic treatment device 60, an organic treatment device 59 at a preceding stage of the inorganic treatment device 60.

The organic treatment device 59 is wastewater
30 treatment equipment including a nitrification tank, a denitrification tank, an aeration tank, and the like, in which biological treatment (wastewater treatment by the action of microorganisms) is performed. When the general wastewater treatment facility 58 includes the
35 organic treatment device 59, the general wastewater treatment facility 58 can also perform water treatment of organic wastewater such as domestic wastewater generated in a combustion furnace plant.

[0035]

The hydrogen F7 stored in the hydrogen storage tank 33, a carbon dioxide F3 stored in the carbon dioxide storage tank 37, and the ammonia solution F8
5 stored in the ammonia solution storage tank 51 can be used for various purposes.

For example, the ammonia and hydrogen production system 1 may supply the hydrogen F7 to hydrogen utilization equipment 34 such as a fuel-cell, a
10 hydrogen gas turbine, or a hydrogen gas engine as a fuel, or to the methanation device 35 as a feedstock for methanation.

In addition, the ammonia and hydrogen production system 1 may supply the carbon dioxide F3 to the
15 methanation device 35 as a feedstock for methanation or to the urea production device 52 as a feedstock for urea production. The ammonia and hydrogen production system 1 may supply the carbon dioxide F3 to carbon dioxide utilization equipment 38 such as a plant
20 factory, a cultivation greenhouse, or a cultivation water tank that photosynthetically produces plants (plants, algae, flowers, vegetables, and the like).

The ammonia and hydrogen production system 1 may supply the ammonia solution F8 to the urea production
25 device 52 as a feedstock for urea production, or to ammonia utilization equipment 54 such as a chemical plant for producing chemical products using ammonia as a feedstock, an ammonia gas turbine, or an ammonia gas engine. The ammonia and hydrogen production system 1
30 may spray the ammonia solution F8 as a denitrification agent to a combustion furnace or a flue gas duct of a combustion furnace plant.

Furthermore, the ammonia and hydrogen production system 1 may supply the methane generated by the
35 methanation device 35 to methane utilization equipment 36 such as a building and equipment in which methane is used as a fuel (city gas), and a gas turbine and

gas engine that generate electric power by burning methane.

The ammonia and hydrogen production system 1 may supply the urea produced by the urea production device 52 to urea utilization equipment 53 such as a chemical plant that produces chemical products using urea and heat of the steam produced by the boiler 20 and a plant factory in which urea is used as a fertilizer.
[0036]

10 2. Modification Example

FIG. 2 is a block diagram illustrating an ammonia and hydrogen production system 1' according to a modification example.

The main difference between the embodiment and the modification example is the configuration of the separation device. In the embodiment, the separation device 10 includes only the ion removal device 30. However, in the modification example, a separation device 10' includes an ammonia stripping device 56 (second ammonia stripping device) that diffuses ammonia from the boiler blowdown water F2 by using steam and discharges the ammonia-containing water F5, and an ion removal device 57 (second ion removal device) that separates a residual water F11 of the ammonia stripping device 56 into an ion-containing wastewater F12 containing unnecessary ions and a treated water F6 containing no unnecessary ions.
25

The same components as those described in the embodiment are denoted by the same reference signs, and descriptions and effects thereof will be omitted.
30 [0037]

The ammonia stripping device 56 (second ammonia stripping device) has the same configuration as the ammonia stripping device 44 (first ammonia stripping device), and one stripping tower may be formed in multiple stages, or a plurality of stripping towers may be connected in series. Although the ammonia stripping device 44 (first ammonia stripping device)
35

is formed in three stages, the ammonia stripping device 56 (second ammonia stripping device) may have the same number of stages or different number of stages (two stages, four stages, five or more stages, or the like).

When the ammonia stripping device 56 (second ammonia stripping device) is formed by one stripping tower, the boiler blowdown water F2 is sprayed from a sprayer (not illustrated) provided at the uppermost stage of the stripping tower. On the other hand, steam (waste steam F4) is supplied to the lowermost stage of the stripping tower. By the contact between the steam and the boiler blowdown water F2 sprayed in the stripping tower, the ammonia-containing water F5 in a gaseous state containing diffused ammonia and steam is produced.

[0038]

The ammonia-containing water F5 produced by the separation device 10' is ammonia solution and does not contain unnecessary ions other than ammonia and ammonium nitrogen, unlike in the case of the separation device 10 in the embodiment. That is, the ammonia-containing water F5 produced by the separation device 10' does not contain scale components such as magnesium and calcium.

Therefore, when the ammonia-containing water F5 is caused to flow through the second flow path 42 by the distributing device 39 and is mixed with the wastewater F1 from exhaust gas treatment in the third flow path 43, the concentration of the scale components in the mixed liquid is more reduced than in the embodiment, and thus scales are more effectively prevented from being deposited in the ammonia stripping device 44. Accordingly, in the modification example, the ammonia stripping device 44 can be maintained more easily than in the embodiment.

[0039]

Note that the ion removal device 57 (second ion removal device) has the same configuration as the ion removal device 30 (first ion removal device), and includes a built-in RO membrane (reverse osmotic
 5 membrane) or a built-in ion exchange resin.

The ion-containing wastewater F12 separated by the ion removal device 57 (second ion removal device) is supplied to the inorganic treatment device 60 of the general wastewater treatment facility 58 and is
 10 subjected to water treatment.

Reference Signs List

[0040]

- 1, 1' Ammonia and hydrogen production system
- 15 10, 10' Separation device
- 11 Combustion furnace
- 12 Dust collecting device
- 13 Exhaust gas treatment device
- 14 Carbon dioxide separation device
- 20 15 Stack
- 20 Boiler
- 21 Steam drum
- 22 Waste heat recovery device
- 23 Steam turbine
- 25 24 Generator
- 25 Condenser
- 26 Deaerator
- 27 Water purification device
- 28 Chemical supply device
- 30 29 Blowdown piping
- 30 Ion removal device (first ion removal device)
- 32 Water electrolysis device
- 33 Hydrogen storage tank
- 34 Hydrogen utilization equipment
- 35 35 Methanation device
- 36 Methane utilization equipment
- 37 Carbon dioxide storage tank
- 38 Carbon dioxide utilization equipment

- 39 Distributing device
- 40 Funnel
- 41 First flow path
- 42 Second flow path
- 5 43 Third flow path
- 44 Ammonia stripping device (first ammonia stripping device)
- 45 First sprayer
- 46 Second sprayer
- 10 47 Tray
- 48 Tank
- 49 Pump
- 50 Sprayer
- 51 Ammonia solution storage tank
- 15 52 Urea production device
- 53 Urea utilization equipment
- 54 Ammonia utilization equipment
- 55 Alkaline chemical supply device
- 56 Ammonia stripping device (second ammonia stripping device)
- 20 57 Ion removal device (second ion removal device)
- 58 General wastewater treatment facility
- 59 Organic treatment device
- 60 Inorganic treatment device
- 25 P1 First position
- P2 Second position
- F1 Wastewater from exhaust gas treatment
- F2 Boiler blowdown water
- F3 Carbon dioxide
- 30 F4 Steam (waste steam)
- F5 Ammonia-containing water (high-concentration ammonia-containing water)
- F6 Treated water (pure water)
- F7 Hydrogen
- 35 F8 Ammonia solution
- F9 Residual water
- F10 Exhaust gas
- F11 Residual water

F12 Ion-containing wastewater

Claims

[Claim 1]

An ammonia and hydrogen production system applied to a combustion furnace plant, the ammonia and hydrogen production system comprising:

a boiler configured to generate steam by heat of a combustion furnace;

an exhaust gas treatment device configured to treat an exhaust gas of the combustion furnace and discharge wastewater from exhaust gas treatment;

a separation device configured to separate boiler blowdown water of the boiler into ammonia-containing water and treated water;

a water electrolysis device configured to produce hydrogen by performing electrolysis using the treated water;

a hydrogen storage tank configured to store the hydrogen;

a first ammonia stripping device configured to diffuse ammonia from the wastewater from exhaust gas treatment; and

an ammonia solution storage tank configured to store ammonia solution containing the diffused ammonia,

the exhaust gas and the boiler being supplied with chemicals containing ammonia or ammonia nitrogen,

the ammonia-containing water separated by the separation device being injected at a first position of the first ammonia stripping device, and

the wastewater from exhaust gas treatment discharged from the exhaust gas treatment device being injected at a second position of the first ammonia stripping device, the second position being different from the first position when viewed in a flow direction of the diffused ammonia.

[Claim 2]

The ammonia and hydrogen production system according to claim 1, further comprising a distributing device configured to cause the ammonia-containing water separated by the separation device to flow through a first flow path having a predetermined allowable flow rate and, when the ammonia-containing water is in excess of the predetermined allowable flow rate, cause some of the ammonia-containing water in excess of the predetermined allowable flow rate to flow through a second flow path,

wherein

the ammonia-containing water in the first flow path is injected at the first position, and

the ammonia-containing water in the second flow path is mixed with the wastewater from exhaust gas treatment and injected at the second position.

[Claim 3]

The ammonia and hydrogen production system according to claim 2, wherein

the first ammonia stripping device includes one stripping tower elongated in a vertical direction or a plurality of stripping towers continuously connected, and

the first position is located downstream of the second position when viewed in the flow direction of the diffused ammonia.

[Claim 4]

The ammonia and hydrogen production system according to claim 3, wherein

the separation device includes

a first ion removal device configured to remove unnecessary ions from the boiler blowdown water to obtain the treated water, or

a second ammonia stripping device configured to diffuse ammonia from the boiler blowdown water, and a second ion removal device configured to remove the

unnecessary ions from residual water of the second ammonia stripping device to obtain the treated water.

[Claim 5]

The ammonia and hydrogen production system according to claim 4, further comprising,
a carbon dioxide separation device configured to separate carbon dioxide from the exhaust gas,
a carbon dioxide storage tank configured to store the carbon dioxide separated, and
a methanation device configured to perform methanation by using the hydrogen stored in the hydrogen storage tank and the carbon dioxide stored in the carbon dioxide storage tank to produce methane.

[Claim 6]

The ammonia and hydrogen production system according to claim 5, further comprising a urea production device configured to produce urea using the carbon dioxide stored in the carbon dioxide storage tank and the ammonia solution stored in the ammonia solution storage tank.

[Claim 7]

The ammonia and hydrogen production system according to any one of claims 1 to 6, wherein the combustion furnace plant is any one of a waste incinerator plant, a thermal power plant, and a chemical plant.