

EXHAUST GAS TREATMENT SYSTEM AND EXHAUST GAS TREATMENT METHOD

TECHNICAL FIELD

[0001]

The present invention relates to an exhaust gas treatment system and an exhaust gas treatment method.

BACKGROUND ART

[0002]

Exhaust gas discharged from an incinerator is cooled in a cooling tower and then is passed through a filtration dust collector to remove solid and acid gas in the exhaust gas, and then the exhaust gas is discharged to the atmosphere from a chimney.

However, acid gas cannot be completely removed only by passing exhaust gas through the filtration dust collector. At present in many domestic incineration plants, dry exhaust gas treatment methods are used, in which slaked lime is continuously blown into the flue from the cooling tower to the filtration dust collector in order to remove acid gas by neutralization. For example, exhaust gas treatment methods and exhaust gas treatment devices are frequently used, in which a chemical agent for removing acid gas in exhaust gas by neutralization is added to fabric such as nonwoven fabric in a filtration dust collector which purifies exhaust gas discharged from a gas generation source such as an incinerator. However, exhaust gas is not sufficiently treated and acid gas such as sulfur oxide is leaked. Thus, the following proposals have been made to remove acid gas in exhaust gas.

[0003]

Patent Document 1 discloses a method for treating waste incinerator exhaust gas, in which when the measured value of acid gas concentration in exhaust gas at

the outlet or the inlet of a filtration dust collector exceeds a predetermined value and the state of excess continues for a predetermined time, a sodium chemical agent is supplied to the inlet of the filtration dust collector in an amount determined based on the measured value. Furthermore, Patent Document 2 discloses an exhaust gas treatment device comprising an upstream acid gas concentration meter which measures acid gas concentration in exhaust gas and a downstream acid gas concentration meter which measures acid gas concentration in exhaust gas at the downstream of a dust collector, in which a powder neutralizing agent is supplied to the exhaust gas between a reactor and the dust collector to neutralize the rest of acid gas. Patent Document 3 discloses a method for controlling addition of a desulfurization agent, in which a current control value is calculated from the first difference, i.e., a difference between the N-hour moving average of SO_x concentration N hours before and the current N-hour moving average of SO_x concentration, and the control value used for calculating the amount of a desulfurization agent to be added N hours before to determine the amount of the desulfurization agent to be added based on the current control value.

[0004]

However, all of Patent Documents 1 to 3 analyze sulfur oxide (SO_x) in acid gas, and it takes a considerable amount of time to get results of analysis of sulfur oxide; and thus when the concentration of sulfur oxide in exhaust gas significantly increases, the time lag for getting the results of analysis does not allow the treatment agent to be immediately added thereto in an amount necessary to treat the increased amount of sulfur oxide; and consequently, sulfur oxide which has not been sufficiently treated may be discharged to the air. Thus, a larger-than-necessary amount of a treatment agent for treating sulfur oxide needs to be added, and adding a larger amount of the treatment agent than necessary amount allows unreacted treatment agent to be mixed in solid components including fly ash and the like, which are to be separated and removed in the exhaust gas recovery unit, and therefore the amount of solid components to be recovered is increased. The

increased amount of solid components is not preferred because when the solid components are to be buried, for example, an extra storage space becomes necessary in reclaimed land.

Citation List

Patent Document

[0005]

Patent Document 1: Japanese Unexamined Patent Application, Publication No. 2019-070471

Patent Document 2: Japanese Unexamined Patent Application, Publication No. 2017-124348

Patent Document 3: Japanese Unexamined Patent Application, Publication No. 2017-176922

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

[0006]

The present invention has been made in view of the above circumstances and an object of the present invention is to provide an exhaust gas treatment system and an exhaust gas treatment method that predict the beginning of an increase in acid gas concentration at an early stage based on the change in oxygen gas concentration linked to the change in the acid gas concentration in exhaust gas to add an appropriate amount of treatment agent in a timely manner.

Means for Solving the Problems

[0007]

To solve the above problem, the gist of the present invention is as follows.

(1) An exhaust gas treatment system comprising: an exhaust gas treatment unit that treats an exhaust gas; an exhaust gas recovery unit that separates and

removes a solid component from the exhaust gas that has been treated in the exhaust gas treatment unit; a treatment agent storage unit that stores a treatment agent for treating the exhaust gas; a treatment agent addition management unit comprising an exhaust gas analysis unit, wherein the exhaust gas analysis unit is disposed at least at upstream or downstream of the exhaust gas recovery unit and analyzes at least an oxygen gas concentration in the exhaust gas, and wherein the treatment agent addition management unit calculates an amount of the treatment agent to be added necessary to treat an acid gas in the exhaust gas treated in the exhaust gas treatment unit based on an amount of change in the oxygen gas concentration analyzed in the exhaust gas analysis unit, and the treatment agent addition management unit gives an instruction to supply the calculated amount of the treatment agent; and a treatment agent supply unit that supplies the treatment agent in an amount instructed by the treatment agent addition management unit from the treatment agent storage unit to the exhaust gas treatment unit.

(2) The exhaust gas treatment system according to (1), wherein the exhaust gas analysis unit is disposed at downstream of the exhaust gas recovery unit.

(3) The exhaust gas treatment system according to (1) or (2), wherein the treatment agent has a property of neutralizing an acid gas in the exhaust gas.

(4) The exhaust gas treatment system according to any of (1) to (3), wherein the acid gas is a sulfur oxide gas.

(5) An exhaust gas treatment method comprising: calculating an amount of a treatment agent to be added necessary to treat an acid gas in an exhaust gas treated in an exhaust gas treatment unit, based on an amount of change in an oxygen gas concentration analyzed in an exhaust gas analysis unit in a treatment agent addition management unit, wherein the exhaust gas analysis unit is disposed at least at upstream or downstream of an exhaust gas recovery unit that separates gas from a solid component in the exhaust gas to recover and remove the solid component, and analyzes at least the oxygen gas concentration in the exhaust gas; giving an instruction to a treatment agent supply unit to supply the calculated

amount of the treatment agent; and supplying the instructed amount of the treatment agent from a treatment agent storage unit to the exhaust gas treatment unit, to thereby treat the acid gas in the exhaust gas.

Effects of the Invention

[0008]

The exhaust gas treatment system and the exhaust gas treatment method of the present invention can keep the concentration of sulfur oxide in exhaust gas discharged to the atmosphere low in a stable manner without a sudden increase, and also can reduce the amount of unreacted treatment agent in the solid component separated and removed in the exhaust gas recovery unit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 is a view illustrating a structure of an exhaust gas treatment system for performing the exhaust gas treatment method of the present invention;

Fig. 2 is a graph showing the change in SO₂ concentration, O₂ concentration and the amount of slaked lime introduced when a treatment agent is added thereto based on the results of analysis of SO₂ concentration in exhaust gas; and

Fig. 3 is a graph showing the change in SO₂ concentration, O₂ concentration and the amount of slaked lime introduced when a treatment agent is added thereto based on the results of analysis of O₂ concentration in exhaust gas.

PREFERRED MODE FOR CARRYING OUT THE INVENTION

[0010]

Hereinafter, embodiments of the present invention will be described. The following description is an example of embodiments of the present invention, and does not limit the claims.

[0011]

(Exhaust gas treatment system)

The exhaust gas treatment system 1 of the present embodiment comprises: a treatment agent addition management unit 13 comprising: an exhaust gas treatment unit 11 that treats the exhaust gas; an exhaust gas recovery unit 16 that separates and removes a solid component from the exhaust gas that has been treated in the exhaust gas treatment unit 11; a treatment agent storage unit 12 that stores a treatment agent for treating the exhaust gas; an exhaust gas analysis unit 131, 132 that is disposed at least at the upstream or the downstream of the exhaust gas recovery unit 16 and that analyzes at least oxygen gas (O_2) concentration in the exhaust gas, wherein the treatment agent addition management unit 13 calculates the amount of the treatment agent to be added necessary to treat acid gas in the exhaust gas treated in the exhaust gas treatment unit 11 based on the amount of change in oxygen gas concentration analyzed in the exhaust gas analysis unit 131, 132, and the treatment agent addition management unit 13 gives an instruction to supply the calculated amount of the treatment agent; and a treatment agent supply unit 14 that supplies the treatment agent in an amount instructed by the treatment agent addition management unit 13 from the treatment agent storage unit 12 to the exhaust gas treatment unit 11. Moreover, in the exhaust gas treatment system 1, the exhaust gas analysis units 131, 132 that analyze oxygen gas concentration in the exhaust gas are disposed.

[0012]

(Structure of exhaust gas treatment system)

Fig. 1 is a view illustrating a structure of an exhaust gas treatment system for performing the exhaust gas treatment method of the present invention. In Fig. 1, of the lines connecting the respective blocks, the solid line represents the flow of a substance and the dashed line represents the flow of information.

The exhaust gas treatment system 1 according to the present embodiment using a treatment agent is mainly composed of a treatment agent addition management unit 13 comprising an incinerator F, an exhaust gas treatment unit 11,

a treatment agent supply unit 12, a treatment agent storage unit 14, exhaust gas analysis units 131, 132, and an exhaust gas recovery unit 16. In addition, a flow meter 17 and a chimney 18 are provided. The structure of the exhaust gas treatment system 1 will be described in detail below.

[0013]

(Incinerator)

The incinerator F refers to a combustion facility such as a municipal waste incinerator, an industrial waste incinerator, a power boiler, a carbonization furnace and a private factory. Usually exhaust gas discharged from a municipal waste incinerator contains toxic acid gas such as hydrogen chloride (HCl), sulfur oxide (SO_x) and nitrogen oxide (NO_x), and solid components (hereinafter referred to as "fly ash") depending on the waste to be incinerated. Of them, sulfur oxide is included in the largest amount. The source of exhaust gas and components included therein are not particularly limited. The exhaust gas refers to gas generated by incinerating various types of waste. The "acid gas" means a gas which is acidic when dissolved in a solution, and examples thereof include gas containing hydrogen chloride and sulfur oxide.

[0014]

(Exhaust gas treatment unit)

The exhaust gas treatment unit 11 introduces and add a treatment agent to exhaust gas. Since exhaust gas is an acid gas containing sulfur oxide, the acid gas needs to be neutralized before being discharged to the atmosphere to suppress discharge of toxic gas to the environment. In the exhaust gas treatment unit 11, a neutralizing agent, which is a treatment agent, is added to exhaust gas to neutralize the gas.

A neutralizing agent is used as the treatment agent (hereinafter may be referred to as a "neutralizing agent"). The treatment agent can neutralize acid gas in exhaust gas by bringing it into contact with exhaust gas.

[0015]

The exhaust gas treatment unit 11 is not particularly limited as long as it allows exhaust gas to be reacted with a treatment agent which is solid by bringing it into contact therewith. For example, part of the flue (the flow path of gas) may be the exhaust gas treatment unit 11. Of them, part of the transfer pipe for transferring exhaust gas to the exhaust gas recovery unit 16 located downstream, such as a bag filter, may be used as the flue. Furthermore, the exhaust gas treatment unit 11 may be constituted by a closed container or various reactors additionally provided in the flue (the flow path of gas).

[0016]

It is not necessary to chemically neutralize all of the acid gas in exhaust gas in the exhaust gas treatment unit 11. The acid gas may be neutralized at the downstream thereof (e.g., in the flue from the exhaust gas treatment unit 11 to the exhaust gas recovery unit 16) as the treatment agent is transferred with exhaust gas. For example, this may be the case when slaked lime is used as the treatment agent because slaked lime reacts with acid gas slowly.

[0017]

Furthermore, exhaust gas may be treated by a continuous method. Alternatively, exhaust gas may be treated by a batch method using, for example, a closed container or various reactors for gas phase reaction. In any case, the amount of exhaust gas treated is not particularly limited, and may be appropriately designed considering the amount of exhaust gas produced by incineration of waste and the like.

[0018]

(Treatment agent storage unit)

The treatment agent storage unit 14 stores a treatment agent for treating exhaust gas. The exhaust gas treatment system 1 according to the present embodiment manages the treatment agent stored in the treatment agent storage unit 14. The treatment agent storage unit 14 is not particularly limited as long as it can store the treatment agent, and for example, a storage tank and a silo may be

used. The capacity and the shape of the treatment agent storage unit 14 are not particularly limited, and may be appropriately designed considering the space where the system is built, the schedule of treatment of exhaust gas, the amount of exhaust gas to be treated, how often exhaust gas is treated and how often the treatment agent is ordered.

[0019]

(Treatment agent addition management unit)

The treatment agent addition management unit 13 has exhaust gas analysis units 131 and 132 disposed at either or both of the upstream and the downstream of the exhaust gas treatment unit 11. In the treatment agent addition management unit 13, the exhaust gas analysis units 131, 132 analyze exhaust gas, and the treatment agent addition management unit 13 calculates the amount of the treatment agent to be added necessary for treating exhaust gas and gives an instruction to supply the calculated amount of the treatment agent. In this way, the amount of the treatment agent to be added is changed by the treatment agent addition management unit 13 based on properties of exhaust gas to be treated (e.g., acid gas concentration and flow rates) and the size of the exhaust gas treatment unit 11, in response to the amount of change in the analysis value. The "upstream" and the "downstream" as used herein means the upstream and the downstream in terms of the flow of exhaust gas.

[0020]

The instruction for the amount of the treatment agent to be added sent from the treatment agent addition management unit 13 is conveyed to the treatment agent supply unit 14 such as a volumetric feeder provided at the upstream of the exhaust gas treatment unit 11. The treatment agent supply unit 14 operates based on the instruction and a predetermined amount of the treatment agent can be added to the exhaust gas treatment unit 11.

[0021]

It is preferable that the treatment agent addition management unit 13 has a calculation circuit which calculates various values using values stored when the amount of the respective components including sulfur oxide is reduced depending on the number of times of treatment and the time of treatment of exhaust gas when exhaust gas is treated with a fixed amount of treatment agent added in the exhaust gas treatment unit 11 per a fixed amount of exhaust gas (e.g., a fixed flow rate, a fixed time or a batch). The method of control for the calculation includes a method in which acid gas in exhaust gas is analyzed and the amount of the treatment agent necessary to neutralize the gas is calculated (feedforward control), and a method in which the necessary amount of the treatment agent is calculated based on acid gas in exhaust gas after treatment (feedback control).

[0022]

(Exhaust gas analysis unit)

The exhaust gas analysis units 131, 132 each analyze properties of exhaust gas before and after the addition of the treatment agent, and may analyze the concentration of hydrogen chloride (HCl), sulfur oxide (SO_x) and nitrogen oxide (NO_x) in exhaust gas. The elements can also analyze the flow rate of exhaust gas. The treatment agent addition management unit 13 manages the analysis value obtained in the exhaust gas analysis units 131, 132.

It is preferable that the exhaust gas analysis units 131, 132 are provided at the downstream of the exhaust gas recovery unit 16. Although the exhaust gas analysis units 131, 132 may be provided at the upstream of the exhaust gas recovery unit 16, since a large amount of fly ash is present at the upstream of the exhaust gas recovery unit 16, analysis of exhaust gas in the exhaust gas analysis unit 132 after filtering and removing the fly ash can improve the accuracy of analysis of exhaust gas. Thus, the exhaust gas analysis unit 132 analyzes oxygen gas concentration instead of sulfur oxide concentration, and when the analysis results suggest that the oxygen gas concentration starts to decrease, the treatment agent is added thereto based on the oxygen gas concentration. Examples of

methods of analysis of oxygen gas concentration include a zirconia method, a magnetic method, laser spectroscopy and an electrode method. Any of the methods may be used, and a zirconia method is preferably used.

[0023]

In the zirconia method, a porous platinum electrode is attached and heated to both surfaces of a zirconia element, and when oxygen gas with a different partial pressure is brought into contact with the respective surfaces, an oxygen concentration cell is produced. The action of the cell produces electromotive force between electrodes, allowing analysis of oxygen gas concentration. Furthermore, a comparison of analysis results obtained in the exhaust gas analysis units 131 and 132 arranged at the upstream and the downstream of the exhaust gas treatment unit 11, respectively, allows more accurate calculation of the amount of the treatment agent needed to neutralize exhaust gas.

[0024]

Moreover, the amount of exhaust gas is analyzed in an exhaust gas flow meter 19 to improve the accuracy of calculation of the amount of the treatment agent to be used. There is little change in the amount of exhaust gas before and after addition of the treatment agent, and thus although the exhaust gas flow meter 19 is arranged together with the exhaust gas analysis unit 132 in Fig. 1, the position of the exhaust gas flow meter 19 is not limited to that example. By analyzing the amount of exhaust gas, the absolute amount of acid gas in exhaust gas can be calculated together with analysis values of acid gas concentration, and this allow more accurate calculation of the mass of the treatment agent required.

[0025]

(Treatment agent supply unit)

The treatment agent supply unit 14 supplies the treatment agent in an amount instructed by the treatment agent addition management unit 13 from the treatment agent supply unit 12 to the exhaust gas treatment unit 11.

The structure of the treatment agent supply unit 14 may be those which can supply a predetermined amount of the treatment agent to the exhaust gas treatment unit 11 from the treatment agent supply unit 12, and is not particularly limited. It may be constituted by a volumetric feeder, a pump or a powder feeder.
[0026]

(Treatment agent)

The treatment agent has a property of neutralizing acid gas in exhaust gas. The treatment agent may be in the form of liquid or powder (solid), and it is necessary that the treatment agent has a component which allows calculation of the amount of the treatment agent by analyzing exhaust gas.
[0027]

Examples of treatment agents include, but are not limited to, calcium hydroxide, calcium oxide, calcium carbonate, magnesium hydroxide, magnesium oxide, magnesium carbonate, calcium hydroxide-magnesium hydroxide, calcium oxide-magnesium oxide, calcium carbonate-magnesium carbonate, sodium hydroxide, sodium hydrogen carbonate and sodium carbonate. One treatment agent may be used alone, or two or more of them may be used in combination.
[0028]

When a powder treatment agent is used, the agent has an average particle size of preferably 1 μm or more, more preferably 2 μm or more, and further preferably 5 μm or more. When the treatment agent has an average particle size of 1 μm or more, an increase in differential pressure in the exhaust gas recovery unit 16 at the downstream side can be prevented, and an increase of acid gas concentration in exhaust gas due to reduced recovery efficiency can be prevented. Furthermore, the treatment agent has an average particle size of preferably 50 μm or less, more preferably 40 μm or less, and further preferably 30 μm or less. An average particle size of the treatment agent of 50 μm or less ensures the treatment agent to have a specific surface area sufficiently large for exhaust gas to be brought into contact.

[0029]

(Exhaust gas recovery unit)

The exhaust gas treatment system 1 has an exhaust gas recovery unit 16 such as a bag filter at the downstream of the exhaust gas treatment unit 11. The exhaust gas recovery unit 16 removes fly ash, which is a solid component in exhaust gas. If part of the treatment agent added to the exhaust gas treatment unit 11 is not used for neutralization reaction of exhaust gas treatment and remains unreacted, the fly ash removed at that stage contains the unreacted treatment agent. In addition, sulfur oxide produced by reaction with the treatment agent, unreacted hydrogen chloride (HCl), sulfur oxide (SO_x) and nitrogen oxide (NO_x) are included. After a certain period of time, the fly ash collected in the exhaust gas recovery unit 16 is recovered and discharged to the outside.

[0030]

(Meter for measuring supply amount)

The treatment agent addition management unit 13 may have a meter for measuring supply amounts (not shown) at the downstream of the treatment agent supply unit 14 and at the upstream of the exhaust gas treatment unit 11. The meter for measuring supply amounts measures the amount of the treatment agent supplied to the exhaust gas treatment unit 11 from the treatment agent supply unit 14.

[0031]

(Exhaust gas treatment method)

The exhaust gas treatment method according to the present embodiment comprises: calculating the amount of a treatment agent to be added necessary to treat acid gas in exhaust gas treated in an exhaust gas treatment unit 11 based on the amount of change in oxygen gas concentration analyzed in an exhaust gas analysis unit 131, 132 in a treatment agent addition management unit 13, wherein the exhaust gas analysis unit 131, 132 is disposed at least at the upstream or the downstream of the exhaust gas recovery unit 16 that separates gas from a solid

component in exhaust gas to recover and remove the solid component, and analyzes at least oxygen gas concentration in the exhaust gas; giving an instruction to a treatment agent supply unit 14 to supply the calculated amount of the treatment agent; and supplying the instructed amount of the treatment agent from the treatment agent storage unit 12 to the exhaust gas treatment unit 11, to thereby treat the acid gas in the exhaust gas.

[0032]

(Operation of exhaust gas treatment system)

The operation of the exhaust gas treatment system 1 in the exhaust gas treatment method will be described.

When exhaust gas is produced by incinerating waste in the incinerator F, the exhaust gas is treated through the following path. Exhaust gas generated in the incinerator F is cooled via a flue and a cooling tower (both not shown), and fly ash is removed or recovered in the exhaust gas recovery unit 16. Then the exhaust gas is transferred to the exhaust gas analysis unit 132 in the treatment agent addition management unit 13 through the exhaust gas recovery unit 16. The exhaust gas analysis unit 132 analyzes oxygen gas concentration in exhaust gas and then the treatment agent addition management unit 13 gives an instruction to add a treatment agent in an amount necessary to treat sulfur oxide in the exhaust gas based on the amount of change in oxygen gas concentration. Sulfur oxide in exhaust gas is neutralized in the exhaust gas treatment unit 11 with a treatment agent supplied from the treatment agent supply unit 12 based on the instruction from the treatment agent addition management unit 13. Then, the exhaust gas analysis unit 132 analyzes oxygen gas concentration or sulfur oxide concentration to verify that the sulfur oxide concentration in the exhaust gas is below the standard, and then the exhaust gas is discharged to the atmosphere through a chimney 18. Heavy metal and the like are fixed on fly ash which has been removed in the exhaust gas recovery unit 16, and the resultant is removed and buried.

[0033]

(Behavior of oxygen gas concentration)

In the present embodiment, the exhaust gas analysis unit 132 analyzes oxygen gas (O_2) concentration in exhaust gas. In a conventional treatment of acid gas in exhaust gas with a treatment agent, concentration of the acid gas in exhaust gas, for example, sulfur oxide (SO_x), which is to be neutralized, has been analyzed. However, since it takes much time to obtain results of analysis of acid gas (e.g., sulfur oxide SO_x) in the exhaust gas analysis unit 132 (for example, 4 minutes or more), even when an appropriate amount of a treatment agent is added to the exhaust gas treatment unit based on the acid gas concentration of the analysis results to treat exhaust gas, the concentration of acid gas in the exhaust gas to be treated may have been changed when the treatment agent is added. Thus, the amount of the treatment agent added is not always the right amount and the concentration of acid gas in exhaust gas cannot be kept low in a stable manner, and in some cases the concentration of acid gas is temporarily increased.

Then the present inventors have conducted intensive studies and have found that acid gas concentration is correlated to oxygen gas concentration in exhaust gas and when the acid gas concentration starts to increase, the oxygen gas concentration simultaneously starts to decrease. Furthermore, the time to get results after analysis of oxygen gas in exhaust gas (for example, about 2 minutes) is as short as less than half the time of analysis of acid gas. Thus, on the assumption that acid gas concentration starts to increase when oxygen gas concentration starts to decrease in analysis of oxygen gas concentration in exhaust gas, a necessary amount of a treatment agent was immediately added to the exhaust gas treatment unit based on the ratio of decrease of the oxygen gas concentration. As a result, it has been found that the concentration of acid gas can be kept low in a stable manner without temporary increase in the concentration of acid gas. Thus, in the present invention, an appropriate amount of a treatment agent is added to neutralize sulfur oxide in exhaust gas at the time of the start of decrease in oxygen gas concentration in exhaust gas based on the analysis result of oxygen gas

concentration in exhaust gas instead of the analysis result of sulfur oxide concentration in exhaust gas, and thus the concentration of acid gas can be kept low in a stable manner without temporary increase in the concentration of acid gas.

[0034]

The correlation between oxygen gas concentration and sulfur oxide concentration varies depending on properties of the apparatus for the exhaust gas treatment system, the size of the apparatus and conditions of reaction in which exhaust gas is generated. Thus, by previously investigating the relation between oxygen gas concentration and sulfur oxide concentration in individual exhaust gas treatment systems and preparing a calibration curve, and then also taking the amount of exhaust gas into consideration, the amount of the treatment agent necessary for treating acid gas in exhaust gas can be determined.

[0035]

(Time of analysis of sulfur oxide concentration)

To analyze sulfur oxide concentration, a method has been used, in which the concentration of sulfur dioxide is measured using absorption of light absorbed by sulfur dioxide, which is the main component of sulfur oxide, in the infrared region. More specifically, the amount of infrared absorption by sulfur dioxide near $7.3\ \mu\text{m}$ has been measured to analyze the concentration of sulfur dioxide in exhaust gas continuously. However, the current analysis of sulfur oxide takes a few minutes, at least 4 minutes to obtain results depending on the analysis principle. During that time exhaust gas flows into the chimney 18 from the incinerator F through the exhaust gas recovery unit 11. Thus, exhaust gas to which no treatment agent has been added is discharged into the atmosphere after the start of analysis until results are obtained.

[0036]

(Time of analysis of oxygen gas concentration)

Thus, the exhaust gas treatment system 1 of the present embodiment focuses on oxygen gas in exhaust gas and measures and analyzes oxygen gas concentration,

not sulfur oxide concentration in exhaust gas. For the method of measurement and analysis, a zirconia oximeter is provided at the upstream or the downstream of the exhaust gas analysis unit 132 in the exhaust gas treatment system 1 to conduct analysis. Usually in the analysis of oxygen gas concentration with a zirconia method, oxygen gas concentration can be analyzed in 2 minutes, which is shorter than the time taken for analysis of concentration of sulfur oxide. Thus, the time of analysis with an oximeter after exhaust gas reaches the exhaust gas analysis unit 132 can be short, and therefore even if the oximeter is located at the downstream of the exhaust gas recovery unit 16, the oximeter analyzes the oxygen gas concentration and provides analysis values, and then the treatment agent addition management unit 13 can give an instruction to the treatment agent supply unit 12 in a short time. The treatment agent supply unit 12 supplies a treatment agent and exhaust gas is treated in the exhaust gas treatment unit 11. This can reduce exhaust gas which is not neutralized by the treatment agent, and reduce exhaust gas which is leaked into the atmosphere without being neutralized.

[0037]

(Use of change in oxygen gas concentration)

As described above, by using both the time it takes to analyze oxygen gas concentration and sulfur oxide concentration, which are the targets of analysis in the exhaust gas analysis unit 132, and the behavior of change in oxygen gas concentration and sulfur oxide concentration in the exhaust gas treatment system 1, which is reflected in the difference of time, the amount of exhaust gas not neutralized by the treatment agent can be significantly reduced and the amount of exhaust gas leaked to the atmosphere without neutralization can be reduced. In this way, by minimizing delay, during which sulfur oxide is not neutralized, leakage of exhaust gas containing sulfur oxide through a chimney can be suppressed.

[0038]

(Addition of treatment agent in phases)

Furthermore, the mass of acid gas to be treated per hour has been determined from the amount of exhaust gas and the sulfur oxide concentration, and by multiplying the mass by the amount of the treatment agent determined in consideration of the neutralization reaction of a unit amount of sulfur oxide, the necessary amount of the treatment agent has been determined. Then addition of the treatment agent to exhaust gas has been controlled by a feedforward method or a feedback method. Thus, as in the conventional system of control based on the analysis of sulfur oxide concentration, the present embodiment incorporates the logic of controlling the amount of the treatment agent added based on the change in values of oxygen gas concentration analyzed in the exhaust gas analysis unit 132 into the treatment agent addition management unit 13 to control the treatment of sulfur oxide.

[0039]

However, the change in oxygen gas concentration is slower than the change in sulfur oxide concentration. Furthermore, although the change in oxygen gas concentration suggests the time of start of addition of the treatment agent, the oxygen gas concentration is not fully correspondent to the sulfur oxide concentration. Then, it is preferable to change the amount of the treatment agent to be added in phases in response to the change in the oxygen gas concentration without perfect correspondence to the change in the oxygen gas concentration. For example, when the oxygen gas concentration decreases, the amount of the treatment agent is not determined based on the amount of decrease, but a large amount of the treatment agent is added even if it is the first addition. The amount to be added in phases is previously determined based on the oxygen gas concentration. Then, when the decrease in the oxygen gas concentration slows down, the amount of the treatment agent added is significantly reduced. This treatment in phases allows sulfur oxide to be neutralized in response to the oxygen gas concentration in the exhaust gas treatment system 1.

[0040]

(Exhaust gas analysis unit at upstream)

Furthermore, while analysis values of oxygen gas concentration in the exhaust gas analysis unit 132 at the downstream of the exhaust gas recovery unit 16 have been used, analysis values obtained in the exhaust gas analysis unit 131 at the upstream of the exhaust gas recovery unit 16 may also be used for management in the treatment agent addition management unit 13. When the treatment agent supply unit 12 is located near the site where exhaust gas is analyzed in terms of distance and time, the treatment agent can be immediately added to exhaust gas.

EXAMPLES

[0041]

Hereinafter the present invention will be described in detail with reference to Examples. The present invention is not limited by these Examples.

[0042]

To neutralize sulfur oxide in exhaust gas and recover it in the exhaust gas recovery unit, usually the amount of sulfur oxide is analyzed behind the exhaust gas recovery unit. In the control of sulfur oxide, feedback control systems such as PID based on the analysis results of sulfur are used to control the amount of the treatment agent to be added. In many cases sulfur oxide concentration has been analyzed at the downstream of the exhaust gas recovery unit and a treatment agent has been supplied to exhaust gas at the upstream of the exhaust gas recovery unit based on the analysis results. To compare the effect of analysis of oxygen gas concentration and sulfur oxide concentration at the downstream of the exhaust gas recovery unit, how the sulfur oxide concentration changed when the respective concentrations were analyzed and how slaked lime, which was the treatment agent, was consumed were studied.

[0043]

(Comparative Example 1)

As Comparative Example 1, sulfur oxide concentration was analyzed and exhaust gas was treated by the same exhaust gas treatment method as a conventional one in a plant in which the above exhaust gas treatment system was installed.

In this example, the treatment agent was started to be added while monitoring the change in sulfur oxide concentration regardless of the change in oxygen gas concentration. Fig. 2 shows the change of sulfur oxide concentration and the time of addition of the treatment agent in that case. In the analysis of sulfur oxide concentration, the time of response after exhaust gas reached an infrared analyzer for sulfur oxide was a few minutes, and more specifically about 240 seconds up to 90% response. By contrast, oxygen gas concentration can be analyzed in about 120 seconds up to 90% response by a zirconia method.

[0044]

Exhaust gas was passed through the exhaust gas treatment unit in the exhaust gas treatment system shown in Fig. 1, and when the concentration of sulfur dioxide (SO_2), which is a sulfur oxide, started to increase, slaked lime, the treatment agent, was introduced thereinto as shown in Fig. 2. The SO_2 concentration started to increase rapidly at the exhaust gas analysis unit at the downstream of the exhaust gas recovery unit. After the SO_2 concentration reached the highest in about 1 to 2 minutes, the SO_2 concentration decreased by the effect of addition of the treatment agent. This shows that addition of the treatment agent to the exhaust gas treatment unit resulted in insufficient treatment of SO_2 concentration in exhaust gas. When exhaust gas mixed with the treatment agent reached the exhaust gas analysis unit, exhaust gas containing a large amount of sulfur oxide which was not treated with the treatment agent was discharged or leaked to the atmosphere through the chimney in 1 to 2 minutes.

[0045]

(Example 1)

Next, the treatment agent was added while monitoring change in the oxygen gas (O₂) concentration. Fig. 3 shows the change in O₂ concentration and the amount of the treatment agent. In Example 1, a calibration curve was prepared by previously measuring SO₂ concentration and O₂ concentration in exhaust gas, and a program in which the amount of the treatment agent to be added is changed in phases as described below was used. Of the values of the amount of addition in the conventional method of control and in the program, a larger value was selected. Table 1 shows the relation between the oxygen gas concentration (%) and the amount of slaked lime to be added (kg/h).

[0046]

[Table 1]

Oxygen gas concentration (%)	10.0 or more	7.0-10.0	6.0-7.0	4.5-6.0	4.5 or less
Amount of slaked lime added (kg/h)	77	150	200	250	300

[0047]

As shown in Fig. 3, 1 minute after exhaust gas was allowed to flow when oxygen concentration became lower than 10%, slaked lime, which is the treatment agent, was added thereto. However, exhaust gas with high concentration of sulfur oxide flowed into the exhaust gas analysis unit at the downstream of the exhaust gas recovery unit 2 minutes after the decrease in oxygen gas concentration. This means that when exhaust gas mixed with the treatment agent reached the exhaust gas analysis unit, exhaust gas containing a large amount of sulfur oxide which was not neutralized was discharged to the outside. However, slaked lime was started to be added about 1 minute before the increase in the sulfur oxide concentration. Thus, the peak of the sulfur oxide concentration is much smaller than that in Comparative Example 1. Furthermore, the amount of slaked lime added was not continuously changed in response to the change in the oxygen gas concentration,

but was changed in phases depending on the change in the oxygen gas concentration, and thus no unreacted sulfur oxide remained, although the amount of slaked lime consumed was relatively large. The results show that the above design has led to a very small amount of discharge and leakage of exhaust gas containing a large amount of sulfur oxide which has not been treated by a treatment agent to the outside.

[0048]

In Example 1, slaked lime was added at an earlier stage than in Comparative Example 1, and thus the time of addition is long and therefore the amount of slaked lime added was increased. This also shows that sulfur oxide in exhaust gas was thoroughly neutralized.

[0049]

As is clear from the data of slaked lime in Fig. 2 and Fig. 3, a fixed amount of a treatment agent is always added regardless of the concentration of oxygen and sulfur oxide in an actual exhaust gas treatment system. The "addition of a treatment agent" as used herein means that the amount of addition of the treatment agent is larger than usual.

Reference Signs List

[0050]

- 1 Exhaust gas treatment system
- 11 Exhaust gas treatment unit
- 12 Treatment agent storage unit
- 13 Treatment agent addition management unit
- 131, 132 Exhaust gas analysis unit
- 14 Treatment agent supply unit
- 16 Exhaust gas recovery unit
- 17 Exhaust gas flow meter
- 18 Chimney
- F Incinerator

CLAIMS

1. An exhaust gas treatment system comprising:
 - an exhaust gas treatment unit that treats an exhaust gas;
 - an exhaust gas recovery unit that separates and removes a solid component from the exhaust gas that has been treated in the exhaust gas treatment unit;
 - a treatment agent storage unit that stores a treatment agent for treating the exhaust gas;
 - a treatment agent addition management unit comprising an exhaust gas analysis unit, wherein the exhaust gas analysis unit is disposed at least at upstream or downstream of the exhaust gas recovery unit and analyzes at least an oxygen gas concentration in the exhaust gas, and wherein the treatment agent addition management unit calculates an amount of the treatment agent to be added necessary to treat an acid gas in the exhaust gas treated in the exhaust gas treatment unit based on an amount of change in the oxygen gas concentration analyzed in the exhaust gas analysis unit, and the treatment agent addition management unit gives an instruction to supply the calculated amount of the treatment agent; and
 - a treatment agent supply unit that supplies the treatment agent in an amount instructed by the treatment agent addition management unit from the treatment agent storage unit to the exhaust gas treatment unit.
2. The exhaust gas treatment system according to claim 1, wherein the exhaust gas analysis unit is disposed at downstream of the exhaust gas recovery unit.
3. The exhaust gas treatment system according to claim 1 or 2, wherein the treatment agent has a property of neutralizing an acid gas in the exhaust gas.

4. The exhaust gas treatment system according to any of claims 1 to 3, wherein the acid gas comprises sulfur oxide.

5. An exhaust gas treatment method comprising:

calculating an amount of a treatment agent to be added necessary to treat an acid gas in an exhaust gas treated in an exhaust gas treatment unit, based on an amount of change in an oxygen gas concentration analyzed in an exhaust gas analysis unit in a treatment agent addition management unit, wherein the exhaust gas analysis unit is disposed at least at upstream or downstream of an exhaust gas recovery unit that separates gas from a solid component in the exhaust gas to recover and remove the solid component, and analyzes at least the oxygen gas concentration in the exhaust gas;

giving an instruction to a treatment agent supply unit to supply the calculated amount of the treatment agent; and

supplying the instructed amount of the treatment agent from a treatment agent storage unit to the exhaust gas treatment unit, to thereby treat the acid gas in the exhaust gas.