SPECIFICATION

COMBUSTION FACILITY AND METHOD FOR OPERATING COMBUSTION FACILITY

TECHNICAL FIELD

[0001] The present disclosure relates to a combustion facility and a method for operating a combustion facility.

The present application claims priority based on Japanese Patent Application No. 2020-150574 filed on September 8, 2020, the entire content of which is incorporated herein by reference.

BACKGROUND ART

[0002] In a combustion facility for combusting a fuel (e.g., waste or biomass) containing metals, the metals contained in the ash produced by the combustion of the fuel usually react with chlorine compounds in the fuel to produce metal chlorides. When the temperature in the combustion gas drops, the metal chlorides contained in the combustion gas condense to form highly corrosive molten salts, which can cause corrosion of pipes of the facility or the like.

[0003] As a countermeasure against the corrosion of the facility due to such corrosive molten salts, it has been proposed to add a sulfur-containing additive to gaseous alkali metal chlorides contained in the combustion gas. For example, Patent Document 1 describes that a sulfur-containing additive is injected into the combustion gas when combusting a solid chlorine-containing fuel in a boiler provided with a superheater (heat transfer tube) downstream of a combustion chamber. This converts highly corrosive alkali metal chlorides contained in the combustion gas into relatively less corrosive alkali sulfates, thereby suppressing the corrosion of the superheater due to the alkali metal chlorides.

Citation List

Patent Literature

[0004] Patent Document 1: JP4028801B

SUMMARY

Problems to be Solved

[0005] Fuels such as waste and biomass combusted in a combustion facility may contain heavy metals. As with alkali metals, heavy metals also form chlorides in the combustion gas to become molten salts, which can cause the problem of corroding the facility.

[0006] In order to suppress corrosion in the combustion facility for combusting a fuel containing heavy metals, as in the case of alkali metals described above, a sulfur-containing additive may be added to convert highly corrosive heavy metal chlorides in the combustion gas into relatively less corrosive heavy metal sulfates. However, since a fuel generally contains a large amount of alkali metals, sulfating all alkali metals and heavy metals in order to suppress corrosion of the combustion facility requires a large amount of the sulfur-containing additive. This may increase the cost or the amount of SO_3 emitted with the combustion gas (SO_3 slip).

[0007] In view of the above, an object of at least one embodiment of the present invention is to provide a combustion facility and a method for operating a combustion facility whereby it is possible to effectively suppress corrosion of the facility while reducing the supply amount of a sulfur-containing additive.

Solution to the Problems

[0008] A combustion facility according to at least one embodiment of the present invention is provided with: a combustion apparatus including a combustion furnace for combusting a fuel containing an alkali metal and one or more heavy metals, and a gas duct into which a combustion gas from the combustion furnace is introduced; and an additive supply part configured to supply an additive containing sulfur to a position inside the combustion apparatus where a temperature during operation is within a range of not lower than 400°C and not higher than 750°C.

[0009] Further, a combustion facility according to at least one embodiment of the present

invention is provided with: a combustion furnace for combusting a fuel containing an alkali metal and one or more heavy metals; a heat transfer part disposed downstream of the combustion furnace, in which a heat transfer tube is disposed or which is formed by a wall including a heat transfer tube; and an additive supply part configured to supply an additive containing sulfur to the heat transfer part.

[0010] Further, a method for operating a combustion facility including a combustion furnace and a gas duct connected to the combustion furnace according to at least one embodiment of the present invention includes: a step of combusting a fuel containing an alkali metal and one or more heavy metals by the combustion furnace; and a step of putting an additive containing sulfur to a position inside the combustion furnace or the gas duct where a temperature during operation is within a range of not lower than 400°C and not higher than 750°C.

Advantageous Effects

[0011] At least one embodiment of the present invention provides a combustion facility and a method for operating a combustion facility whereby it is possible to effectively suppress corrosion of the facility while reducing the supply amount of a sulfur-containing additive.

BRIEF DESCRIPTION OF DRAWINGS

[0012] FIG. 1 is a schematic diagram of a combustion facility according to an embodiment.

FIG. 2 is a schematic configuration diagram of an additive supply apparatus of a combustion facility according to an embodiment.

FIG. 3 is a chart showing the vapor pressure curves of typical chlorides of heavy metals and alkali metals in a fuel.

FIG. 4 is a phase diagram of zinc (heavy metal) under a given condition.

FIG. 5 is a phase diagram of lead (heavy metal) under a given condition.

DETAILED DESCRIPTION

[0013] Embodiments of the present invention will now be described in detail with reference to the accompanying drawings. It is intended, however, that unless particularly identified, dimensions, materials, shapes, relative positions, and the like of components described in the embodiments shall be interpreted as illustrative only and not intended to limit the scope of the present invention.

[0014] (Configuration of combustion facility)

[0015] FIG. 1 is a schematic diagram of a combustion facility according to an embodiment. FIG. 2 is a schematic configuration diagram of an additive supply apparatus of a combustion facility according to an embodiment.

[0016] As shown in FIG. 1, the combustion facility 100 includes a combustion apparatus 1 for combusting a fuel, and an additive supply apparatus 50 for supplying an additive containing sulfur (hereinafter, referred to as sulfur-containing additive, or additive simply) into the combustion apparatus 1.

[0017] The combustion apparatus 1 includes a combustion furnace 12 for combusting a fuel therein, and a gas duct 4 connected to the combustion furnace 12. A combustion gas generated by combustion of the fuel in the combustion furnace 12 is introduced to the gas duct 4. The gas duct 4 is provided with a heat transfer tube 14. The gas duct 4 and the heat transfer tube 14 may constitute a boiler 2 for generating steam. The combustion apparatus 1 includes a heat transfer part 14' disposed downstream of the combustion furnace 12. The heat transfer tube 14 is disposed in the heat transfer part 14', or the heat transfer part 14' is formed by a wall including the heat transfer tube 14. The heat transfer part 14' may be part of the gas duct 4.

[0018] The combustion furnace 12 is supplied with the fuel from a fuel supply part 8 and the air from an air supply part 10, and is configured to combust the fuel inside the combustion furnace 12. The fuel supplied from the fuel supply part 8 is fuel containing heavy metals such as zinc (Zn) or lead (Pb) and alkali metals (e.g., sodium (Na) or potassium (K)). For example, waste such as municipal wastes and building materials or biomass is supplied to the combustion furnace 12 as the fuel.

[0019] In the combustion furnace 12, the combustion gas and ash are generated by

combustion of the fuel. Part of the ash accumulates in the lower portion of the combustion furnace 12 and is discharged outside the combustion furnace 12 through an ash discharge part (not shown). Further, part of the ash is introduced to the gas duct 4 as fly ash entrained in the combustion gas.

[0020] The heat transfer tube 14 is configured to heat a fluid (e.g., water) supplied into the heat transfer tube 14 by heat exchange with the hot combustion gas flowing through the gas duct. The heat transfer tube 14 may be configured to generate steam by heating the fluid. The steam thus generated may be used for driving a power generation turbine, for example.

[0021] As shown in FIG. 1, a temperature reducing part 16 for reducing the temperature of the combustion gas flowing through the gas duct 4 may be disposed downstream of the heat transfer tube 14 in the gas duct 4. The temperature reducing part 16 may be configured to reduce the temperature of the combustion gas by spraying water, for example. The temperature reducing part 16 may be configured to reduce the temperature of the combustion gas having passed through the heat transfer tube 14 to a temperature range in which synthesis of a predetermined substance (e.g., dioxins) does not progress.

[0022] As shown in FIG. 1, a capture part 18 for capturing ash (fly ash) entrained in the combustion gas from the gas duct 4 may be disposed downstream of the heat transfer tube 14 in the gas duct 4. The capture part 18 may be disposed downstream of the temperature reducing part 16 in the gas duct 4. The capture part 18 may be configured to separate ash from the combustion gas entraining the ash. As the capture part 18, for example, a dust collector such as a bag filter or an electric dust precipitator can be used.

[0023] In the combustion apparatus 1 shown in FIG. 1, the ash separated from the combustion gas by the capture part 18 is discharged from the capture part 18 via a discharge pipe 20 and a discharge valve 21.

[0024] The combustion gas from which the ash has been removed by the capture part 18 is discharged to the outside of the combustion apparatus 1 via an exhaust passage 5 and a stack 6 connected to the capture part 18. A fan 22 may be provided in the exhaust passage 5, and the combustion gas may be sucked by the fan 22.

[0025] As shown in FIGs. 1 and 2, the additive supply apparatus 50 includes an additive supply part 30 for supplying an additive containing sulfur to the combustion apparatus 1, and a control part 40 including a supply amount decision part 42 for deciding the supply amount of the additive by the additive supply part 30.

[0026] First, the additive supply part 30 will be described. In the exemplary embodiment shown in FIG. 1, the additive supply part 30 includes an additive tank 32 for storing the additive containing sulfur, an additive supply line 34 disposed between the additive tank 32 and the combustion apparatus 1, and a pump 36 and a valve 38 disposed in the additive supply line 34. The additive stored in the additive tank 32 is pressurized by the pump 36 and supplied into the combustion apparatus 1 through the additive supply line 34. The supply amount of the additive into the combustion apparatus 1 through the additive supply line 34 can be adjusted by the valve 38.

[0027] As the additive containing sulfur, sulfur or sulfur compounds can be used. More specifically, sulfuric acid-containing substances such as sulfuric acid and oleum, or sulfates such as iron sulfate, aluminum sulfate, ammonium sulfate, and ammonium hydrogensulfate can be used as the additive containing sulfur.

[0028] The additive supply part 30 is configured to supply the above-described additive to a position inside the combustion apparatus 1 where the temperature during operation (or the temperature of the combustion gas) is within the range of not lower than 400°C and not higher than 750°C. That is, the additive supply line 34 is connected to a portion of the combustion apparatus 1 where the internal temperature during operation (or the temperature of the combustion gas) is within the range of not lower than 400°C and not higher than 750°C.

[0029] In the combustion facility for combusting a fuel containing heavy metals and alkali metals, the heavy metals and alkali metals contained in the fuel form chlorides together with chlorine (Cl) contained in the fuel and volatilize in the combustion furnace. The heavy metal chlorides and alkali metal chlorides thus formed become molten salts in the combustion facility and can cause corrosion of the facility. Therefore, by supplying the sulfur-containing additive to the combustion furnace or the like and converting the chlorides into sulfates which have

higher melting points through reaction with the additive, corrosion caused by the heavy metals and alkali metals can be suppressed.

[0030] The reaction between the sulfur-containing additive and heavy metal chlorides or alkali metal chlorides in the combustion facility can be schematically explained as follows. Here, the case where ammonium sulfate is used as the additive will be described using lead (Pb) as a typical heavy metal and sodium (Na) as a typical alkali metal.

[0031] Specifically, ammonium sulfate as the additive thermally decomposes in the combustion furnace 12 as shown by the following formula (A) to generate SO_3 gas.

$$(NH_4)_2SO_4 \text{ (solid)} \rightarrow 2NH_3 \text{ (gas)} + SO_3 \text{ (gas)} + H_2O \text{ (gas)} \quad \text{(A)}$$

On the other hand, lead (Pb; heavy metal) and sodium (Na; alkali metal) contained in the fuel put into the combustion furnace 12 form chlorides $PbCl_2$ and NaCl together with chlorine (Cl) contained in the fuel and volatilize. Then, the volatilized chlorides react with the SO_3 gas generated by the formula (A) as shown by the following formulas (B) and (C) to produce sulfates.

$$PbCl_2 \text{ (gas)} + SO_3 \text{ (gas)} + H_2O \text{ (gas)} \rightarrow PbSO_4 \text{ (solid)} + 2HCl \text{ (gas)} \quad \text{(B)}$$

$$2NaCl \text{ (gas)} + SO_3 \text{ (gas)} + H_2O \text{ (gas)} \rightarrow Na_2SO_4 \text{ (solid)} + 2HCl \text{ (gas)} \quad \text{(C)}$$

[0032] Thus, in order to suppress corrosion in the combustion facility for combusting a fuel containing heavy metals, the sulfur-containing additive may be added to convert highly corrosive alkali metal chlorides and heavy metal chlorides in the combustion gas into relatively less corrosive (or relatively low melting point) sulfates. However, since a fuel generally contains a large amount of alkali metals, sulfating all alkali metals and heavy metals in order to suppress corrosion of the combustion facility requires a large amount of the sulfur-containing additive, resulting in an increase in the cost.

[0033] Generally, alkali metal chlorides have relatively higher melting points than heavy metal chlorides. For example, the melting point of alkali metal chlorides is about 515°C or higher for the eutectic of NaCl and KCl, and the melting point of heavy metal chlorides is about 250°C or higher for the eutectic of $PbCl_2$ and $ZnCl_2$. Therefore, when the temperature of components (e.g., heat transfer tube 14) of the combustion facility 100 is not very high (e.g.,

lower than melting points of alkali metals), even if alkali metal chlorides in the combustion gas adhere to the surfaces of the components, the alkali metal chlorides solidify and their corrosiveness decreases compared to when they are in the form of molten salts. On the other hand, even when the temperature of components of the combustion facility 100 is not very high, since heavy metal chlorides in the combustion gas have relatively low melting points and tend to exist as molten salts, they easily cause corrosion of the components. Therefore, when heavy metal chlorides having relatively low melting points are selectively sulfated among the relatively highly corrosive alkali metal chlorides and heavy metal chlorides contained in the combustion gas to form less corrosive sulfates, it is expected that the corrosion of the components can be effectively suppressed.

[0034] Here, FIG. 3 is a chart showing the vapor pressure curves of typical chlorides of heavy metals (lead, zinc) and alkali metals (sodium, potassium) in a fuel. In the graph of FIG. 3, p_{Pb}, p_{Zn}, p_{Na} and p_K indicate the concentrations (partial pressures) in the combustion apparatus when lead, zinc, sodium and potassium contained in a typical fuel are all volatilized, respectively, and TB_{PbCl2}, TB_{ZnCl2}, TB_{NaCl} and TB_{KCl} indicate the temperatures on the vapor pressure curves for the above-described elements at the above-described concentrations p_{Pb}, p_{Zn}, p_{Na} and p_K, respectively. That is, TB_{PbCl2}, TB_{ZnCl2}, TB_{NaCl}, and TB_{KCl} indicate the condensation points (or boiling points) of chlorides of the elements in the combustion apparatus when a typical fuel is combusted in the combustion apparatus.

[0035] As can be seen from the graph of FIG. 3, when combusting a fuel such as general waste or biomass, the condensation points of heavy metal chlorides (TB_{PbCl2} and TB_{ZnCl2}) in the combustion apparatus are about 400°C or lower, and the condensation points of alkali metal chlorides (TB_{NaCl} and TB_{KCl}) are about 750°C or higher. That is, when the content of alkali metals and heavy metals in a fuel (waste, biomass, etc.) is within the general range, in the combustion facility for combusting the fuel, in relation to the vapor pressure of each component, heavy metal chlorides in the combustion gas (chlorides derived from heavy metals in the fuel) vaporize at about 400°C or higher, and alkali metal chlorides in the combustion gas (chlorides derived from alkali metals in the fuel) condense at about 750°C or lower.

[0036] In this regard, in the above-described embodiment, the additive containing sulfur is supplied to the position inside the combustion apparatus 1 where the temperature is within the range of not lower than 400°C and not higher than 750°C (or position where the combustion gas temperature is within the range of not lower than 400°C and not higher than 750°C). That is, since the additive containing sulfur is supplied to the position in the combustion apparatus 1 where heavy metal chlorides exist as gas and alkali metal chlorides exist as condensate (liquid or solid), it is possible to promote the reaction between the heavy metal chlorides and sulfur components in the additive (for example, the reaction of formula (B)) while suppressing the reaction between the alkali metal chlorides and sulfur components in the additive (for example, the reaction of formula (C)). This is because the reaction between condensates of alkali metal chlorides and sulfur components in the additive (SO_3 in the combustion gas) is liquid-gas reaction or solid-gas reaction, while the reaction between heavy metal chlorides and sulfur components in the additive is gas-gas reaction, and liquid-gas reaction and solid-gas reaction have sufficiently lower reaction rates than that of gas-gas reaction. That is, according to the above-described embodiment, heavy metal chlorides in the combustion gas can be preferentially sulfated over alkali metal chlorides. Thus, it is possible to effectively suppress corrosion of the combustion facility while reducing the supply amount of the sulfur-containing additive.

[0037] In some embodiments, the additive supply part is configured to supply the additive containing sulfur to a position where the temperature during operation is within the range of not lower than 500°C and not higher than 700°C.

[0038] In the above-described embodiment, since the sulfur-containing additive is supplied to the position where the temperature during operation is not lower than 500°C in the combustion apparatus 1, the reaction between heavy metal chlorides in the combustion gas and the additive can be promoted more greatly. On the other hand, in the above-described embodiment, since the sulfur-containing additive is supplied to the position where the temperature during operation is not higher than 700°C in the combustion apparatus 1, the condensation of alkali metal chlorides in the combustion gas can be promoted, and thus the

reaction between alkali metal chlorides in the combustion gas and the additive can be suppressed more effectively. Thus, it is possible to more effectively suppress corrosion of the combustion facility while reducing the supply amount of the sulfur-containing additive more effectively.

[0039] In some embodiments, for example, as shown in FIG. 1, the additive supply part 30 may be configured to supply the additive into the gas duct 4 constituting the combustion apparatus 1. That is, the additive supply line 34 may be connected to the gas duct 4. Further, in some embodiments, for example, as shown in FIG. 1, the additive supply part 30 may be configured to supply the additive to the heat transfer part 14' of the combustion apparatus 1.

[0040] In the combustion facility 100 for combusting a fuel such as waste or biomass, the temperature in the heat transfer part 14' (gas duct 4) disposed downstream of the combustion furnace 12 is lower than the temperature of the combustion furnace 12 (e.g., about 800°C or higher), and is within the range of about not lower than 400°C and not higher than 750°C in most of the heat transfer part 14' or part of the gas duct 4. In this regard, according to the above-described embodiment, since the additive is supplied to the heat transfer part 14' or the gas duct 4 in the combustion apparatus 1, as already described, heavy metal chlorides in the combustion gas can be preferentially sulfated over alkali metal chlorides. Thus, it is possible to effectively suppress corrosion of the combustion facility while reducing the supply amount of the sulfur-containing additive.

[0041] In an embodiment, the additive supply part 30 is configured to supply the additive to a position upstream of the temperature reducing part 16 in the gas duct 4.

[0042] Generally, in the temperature reducing part 16, the combustion gas is cooled, and the temperature of the combustion gas rapidly drops. In this regard, in the above-described embodiment, since the additive is supplied to the position upstream of the temperature reducing part 16 in the gas duct 4 where the temperature of the combustion gas rapidly drops, it is easy to supply the additive to the position of the gas duct 4 (combustion apparatus 1) where the temperature is within the range of about not lower than 400°C and not higher than 750°C.

[0043] In an embodiment, the additive supply part 30 is configured to supply the additive

to a position upstream of the heat transfer tube 14 in the gas duct 4. In other words, in an embodiment, when the passage length between the heat transfer tube 14 and the connection position between the gas duct 4 and the combustion furnace 12 is defined as L, the additive is supplied to a position of the gas duct 4 where the length from the connection position is not less than 0 and not more than L.

[0044] In the above-described embodiment, since the additive is supplied to the position upstream of the heat transfer tube 14 in the gas duct 4, the additive can be supplied to the combustion gas before reaching the heat transfer tube 14 to sulfate heavy metal chlorides contained in the combustion gas. Thus, it is possible to effectively suppress corrosion of the heat transfer tube 14 caused by heavy metal molten salts.

[0045] In an embodiment, when the passage length between the heat transfer tube 14 and the connection position between the gas duct 4 and the combustion furnace 12 is defined as L, the additive is supplied to a position of the gas duct 4 where the length from the connection position is not less than 0 and not more than 3L/4 or not less than L/5 and not more than 2L/3.

[0046] In the above-described embodiment, the additive is supplied to the position of the gas duct 4 where the length from the connection position is not less than 0 or not less than L/5. That is, since the additive is supplied to the position where the internal temperature of the combustion apparatus 1 (or the combustion gas temperature) drops to an appropriate level, the condensation of alkali metal chlorides in the combustion gas can be promoted. Thus, it is possible to effectively suppress the reaction between alkali metal chlorides in the combustion gas and the additive.

[0047] Further, in the above-described embodiment, since the additive is supplied to the position of the gas duct 4 where the length from the connection position is not more than 3L/4 or not more than 2L/3, a distance (time) from when the additive is supplied to the combustion gas flowing through the gas duct 4 until the combustion gas reaches the heat transfer tube 14 can be easily secured. That is, since the reaction time between heavy metal chlorides in the combustion gas and the additive is secured, the sulfation reaction of the heavy metal chlorides easily proceeds before the combustion gas reaches the heat transfer tube 14. Thus, it is

possible to effectively suppress corrosion of the heat transfer tube 14 caused by heavy metal molten salts.

[0048] In an embodiment, when the passage length between the heat transfer tube 14 and the connection position between the heat transfer part 14' and the combustion furnace 12 is defined as L', the additive is supplied to a position of the heat transfer part 14' where the length from the connection position is not less than 0 and not more than 3L'/4 or not less than L'/5 and not more than 2L'/3.

[0049] In the above-described embodiment, the additive is supplied to the position of the heat transfer part 14' where the length from the connection position is not less than 0 or not less than L'/5. That is, since the additive is supplied to the position where the internal temperature of the combustion apparatus 1 (or the combustion gas temperature) drops to an appropriate level, the condensation of alkali metal chlorides in the combustion gas can be promoted. Thus, it is possible to effectively suppress the reaction between alkali metal chlorides in the combustion gas and the additive.

[0050] Further, in the above-described embodiment, since the additive is supplied to the position of the heat transfer part 14' where the length from the connection position is not more than 3L'/4 or not more than 2L'/3, a distance (time) from when the additive is supplied to the combustion gas flowing through the heat transfer part 14' until the combustion gas reaches the heat transfer tube 14 can be easily secured. That is, since the reaction time between heavy metal chlorides in the combustion gas and the additive is secured, the sulfation reaction of the heavy metal chlorides easily proceeds before the combustion gas reaches the heat transfer tube 14. Thus, it is possible to effectively suppress corrosion of the heat transfer tube 14 caused by heavy metal molten salts.

[0051] In some embodiments, the additive contains ammonium sulfate.

[0052] When ammonium sulfate is supplied as the additive, as explained using the formulas (A) to (C), ammonium sulfate decomposes in a high-temperature environment and then reacts with heavy metals, etc. On the other hand, the unreacted portion of ammonium sulfate after thermal decomposition returns to ammonium sulfate at a temperature of about 350°C or lower.

In this regard, according to the above-described embodiment, since ammonium sulfate is supplied as the additive, the unreacted portion that is not consumed by the reaction with heavy metals returns to ammonium sulfate, which is less corrosive, in the temperature range of about 350°C or lower. As a result, the formation of sulfuric acid deposits (i.e., condensation of sulfuric acid) derived from the unreacted additive can be suppressed. Thus, it is possible to effectively suppress corrosion of the combustion facility due to sulfuric acid deposits.

[0053] Next, the control part 40 including a supply amount decision part 42 will be described. As described above, the control part 40 includes a supply amount decision part 42 for deciding the supply amount of the additive by the additive supply part 30. The control part 40 may be configured to control the valve 38 of the additive supply part 30 so that the additive is supplied in the amount decided by the supply amount decision part 42.

[0054] The control part 40 includes a calculator equipped with a processor (e.g., CPU), a storage device (memory device; e.g., RAM), an auxiliary storage part, and an interface. The control part 40 receives signals from a detection part 26 and/or a concentration sensor 28, which will be described later, via an interface. The processor is configured to process the signals thus received. In addition, the processor is configured to process programs loaded into the storage device. Thereby, the function of the supply amount decision part 42 is implemented.

[0055] The processing contents in the control part 40 may be implemented as programs executed by the processor. The programs may be stored in the auxiliary memory. When executed, these programs are loaded into the storage device. The processor reads out the programs from the storage device to execute instructions included in the programs.

[0056] The supply amount decision part 42 is configured to decide the supply amount of the sulfur-containing additive on the basis of the content of one or more heavy metals in the fuel. That is, when the fuel contains multiple types of heavy metals, the supply amount decision part 42 decides the supply amount of the sulfur-containing additive on the basis of the content of at least one of the heavy metals in the fuel.

[0057] The content of one or more heavy metals in the fuel may be obtained by component analysis of the fuel.

[0058] Alternatively, the content of heavy metals contained in the ash generated by combustion of the fuel may be regarded as the content of heavy metals contained in the fuel. That is, the supply amount decision part 42 may decide the supply amount of the sulfur-containing additive on the basis of the content of one or more heavy metals contained in the ash.

[0059] The content of heavy metals in the ash produced by combustion of the fuel may be measured by a detection part 26. In the exemplary embodiment shown in FIG. 1, the detection part 26 is configured to detect the content of heavy metals in the ash captured by the capture part 18. The detection part 26 may collect the ash to be analyzed via the discharge pipe 20 through which the ash is discharged from the capture part 18, for example. A signal indicating the detection result of the heavy metal content in the ash by the detection part 26 is sent to the control part 40.

[0060] The detection part 26 may be configured to collect and analyze the ash generated by combustion of the fuel at regular intervals. Further, the heavy metal content obtained by the detection part 26 may be fed back to the supply amount decision part 42 at regular intervals. Thus, even if the amount of heavy metals contained in the fuel changes over time, an appropriate amount of additive can be added according to the change in the amount of heavy metals.

[0061] In some embodiments, the supply amount decision part 42 is configured to decide the supply amount of the additive so that the equivalent ratio of sulfur contained in the additive supplied per unit weight of the fuel to the number of moles of at least one of one or more heavy metals contained per unit weight of the fuel is within a specified range.

[0062] According to the above-described embodiment, since the supply amount of the additive is decided so that the equivalent ratio of sulfur contained in the additive supplied per unit weight of the fuel to the number of moles of heavy metals contained per unit weight of the fuel is within a specified range, a necessary and sufficient amount of additive can be supplied to appropriately convert the heavy metals contained in the fuel into relatively less corrosive sulfates. Thus, heavy metal chlorides in the combustion gas can be appropriately converted into relatively less corrosive sulfates.

[0063] More specifically, when the fuel contains lead and zinc which are heavy metals, the supply amount decision part 42 may be configured to decide the supply amount of the additive so that the equivalent ratio of sulfur contained in the additive supplied per unit weight of the fuel to the total number of moles of lead and zinc contained per unit weight of the fuel is not less than 0.5 and not more than 10 or not less than 1 and not more than 10. That is, the supply amount decision part 42 may be configured to decide the supply amount of the additive so that the number of moles m_{Pb} of lead and the number of moles m_{Zn} of zinc contained per unit weight of the fuel and the number of moles m_S of sulfur contained in the additive added per unit weight of the fuel satisfy the following formula (D) or (D').

$$0.5 \leq \{m_S/(m_{Pb}+m_{Zn})\} \leq 10 \quad (D)$$

$$1 \leq \{m_S/(m_{Pb}+m_{Zn})\} \leq 10 \quad (D')$$

[0064] As is apparent from the formulas (A) and (B), lead in the fuel and sulfur in the additive react in a 1:1 mole ratio. Similarly, zinc in the fuel and sulfur in the additive react in a 1:1 mole ratio.

[0065] According to the above-described embodiment, since the supply amount of the additive is decided so that the equivalent ratio of sulfur contained in the additive supplied per unit weight of the fuel to the total number of moles of lead and zinc contained per unit weight of the fuel is not less than 0.5 or not less than 1, most of the heavy metal chlorides in the combustion gas can be appropriately converted into relatively less corrosive sulfates. Generally, the content of alkali metals in a fuel such as waste or biomass is about 10 times the content of heavy metals. In this regard, according to the above-described embodiment, the supply amount of the additive is decided so that the equivalent ratio is not more than 10. Accordingly, even if the excess (unreacted) additive that is not consumed in the reaction with heavy metal chlorides in the combustion gas remains as strongly corrosive sulfuric acid deposits (sulfuric acid condensate), the sulfuric acid deposits can be eliminated by reaction with alkali metal chlorides contained in the combustion gas or adhering to the combustion facility, so that corrosion of the facility due to the sulfuric acid deposits can be suppressed. Thus, it is possible to more effectively suppress corrosion of the combustion facility while reducing the supply

amount of the sulfur-containing additive.

[0066] In some embodiments, the supply amount decision part 42 is configured to select a heavy metal as a reference for calculating the supply amount of the additive from one or more heavy metals contained in the fuel, on the basis of the hydrochloric acid (HCl) concentration in the combustion gas generated by combustion of the fuel. That is, when the fuel contains multiple types of heavy metals, the supply amount decision part 42 selects at least one of the heavy metals as the reference heavy metal for calculating the supply amount of the additive.

[0067] The concentration of hydrochloric acid in the combustion gas may be obtained by measuring with a concentration sensor 28 disposed in the combustion apparatus 1. A signal indicating the concentration measured by the concentration sensor 28 is sent to the control part 40. The concentration sensor 28 may be configured to detect the concentration of hydrochloric acid in the combustion gas in the combustion furnace 12, the gas duct 4, or the exhaust passage 5.

[0068] The concentration sensor 28 may be configured to measure the hydrochloric acid concentration in the combustion gas at regular intervals. Further, the hydrochloric acid content obtained by the concentration sensor 28 may be fed back to the supply amount decision part 42 at regular intervals. Thus, even if the hydrochloric acid concentration in the combustion gas changes over time, an appropriate amount of additive can be added according to the change in the hydrochloric acid concentration.

[0069] Some heavy metals precipitate as stable compounds with low corrosiveness in the combustion gas, depending on conditions such as the concentration of hydrochloric acid in the combustion gas. In this regard, according to the above-described embodiment, the heavy metal as the reference for calculating the supply amount of the additive is selected on the basis of the hydrochloric acid concentration in the combustion gas. Therefore, for example, by selecting a heavy metal other than the above-described heavy metals (heavy metals that precipitate as stable compounds with low corrosiveness in the combustion gas) as the reference heavy metal for calculating the supply amount of the additive, the supply amount of the sulfur-containing additive can be reduced more effectively.

[0070] More specifically, when the fuel contains lead and zinc which are heavy metals, the supply amount decision part 42 may be configured to decide the supply amount of the additive so that, when the hydrochloric acid concentration is not more than 1000 ppm, the equivalent ratio of sulfur (divalent) contained in the additive supplied per unit weight of the fuel to the number of moles of lead (divalent) contained per unit weight of the fuel is not less than 0.5 and not more than 10 or not less than 1 and not more than 10, i.e., the number of moles m_{Pb} and the number of moles m_S satisfy the following formula (E) or (E').

$$0.5 \leq \{m_S/m_{Pb}\} \leq 10 \quad \text{(E)}$$

$$1 \leq \{m_S/m_{Pb}\} \leq 10 \quad \text{(E')}$$

[0071] Here, FIGs. 4 and 5 are examples of phase diagrams of heavy metals in the presence of HCl (gas), SO_2 (gas), O_2 (gas), and H_2O (gas). FIG. 4 is the phase diagram for zinc, and FIG. 5 is the phase diagram for lead. The phase diagrams of FIGs. 4 and 5 are under the conditions of a temperature of 573 K, a total pressure of 1 atm, a partial pressure of O_2 of 0.01 atm, and a partial pressure of H_2O of 0.1 atm. In each phase diagram, the vertical axis represents the partial pressure of HCl, and the horizontal axis represents the partial pressure of SO_2.

[0072] As shown in the phase diagram of FIG. 4, under the conditions that the hydrochloric acid (HCl) concentration in the atmosphere is not more than 1000 ppm (i.e., the hydrochloric acid partial pressure (vertical axis of the phase diagram of FIG. 4) is not more than 10^{-3} atm) and the SO_2 concentration is very low, zinc precipitates as stable zinc oxide (ZnO). On the other hand, as shown in the phase diagram of FIG. 5, lead forms chlorides or sulfates under the conditions within HCl and SO_2 concentration ranges of this phase diagram.

[0073] Thus, under the condition that the hydrochloric acid concentration in the combustion gas is not more than 1000 ppm, since zinc in the combustion gas stably exists as lead oxide with low corrosiveness, there is no need to supply the sulfur-containing additive to sulfate zinc. On the other hand, under the above-described condition, since lead can exist as chlorides, there is need to sulfate lead to suppress corrosion of the facility.

[0074] In this regard, according to the above-described embodiment, when the hydrochloric

acid concentration in the combustion gas is not more than 1000 ppm, lead is selected as the reference for calculating the supply amount of the additive excluding zinc, so the supply amount of the sulfur-containing additive can be reduced more effectively. Additionally, according to the above-described embodiment, since the equivalent ratio of sulfur in the additive to the content of lead in the fuel is not less than 0.5 or not less than 1, most of lead in the combustion gas can be appropriately converted into relatively less corrosive sulfates, and since the equivalent ratio is not more than 10, corrosion of the facility due to sulfuric acid deposits derived from the excess (unreacted) additive can be suppressed. Thus, it is possible to more effectively suppress corrosion of the combustion facility while reducing the supply amount of the sulfur-containing additive.

[0075] In some embodiments, the additive supply part 30 is configured to supply the additive to the position in the combustion apparatus 1 where the temperature is within the range of not lower than 400°C and not higher than 740°C under an operating condition that the temperature of the heat transfer tube 14 or a fluid flowing through the heat transfer tube 14 is not higher than 450°C.

[0076] In the above-described embodiment, the sulfur-containing additive is supplied to the position in the combustion apparatus 1 where the temperature is within the range of not lower than 400°C and not higher than 740°C under an operating condition that the temperature of the heat transfer tube 14 disposed in the gas duct 4 or a fluid flowing through the heat transfer tube 14 is not higher than 450°C, which is lower than the melting point (about 515°C or higher) of alkali metal chlorides. That is, even if alkali metal chlorides in the combustion gas adhere to the surfaces of the components, the sulfur-containing additive is supplied to the position within the above-described temperature range under the condition that the alkali metal chlorides solidify. Thus, by preferentially sulfating heavy metal chlorides in the combustion gas over alkali metal chlorides, it is possible to effectively suppress corrosion of the combustion facility while reducing the supply amount of the sulfur-containing additive.

[0077] (Operation method for combustion facility)

Hereinafter, a method for operating a combustion facility according to some embodiments

will be described. The combustion facility to which the operation method according to some embodiments is applied includes a combustion furnace and a gas duct connected to the combustion furnace. In the following description, several operation methods are described as being applied to the above-described combustion facility 100.

[0078] In the operation method according to some embodiments, first, a fuel containing an alkali metal and one or more heavy metals is combusted in the combustion furnace 12 (step S1).

[0079] Then, an additive containing sulfur is put to a position in the combustion furnace 12 or the gas duct 4 where the temperature during operation is within the range of not lower than 400°C and not higher than 750°C (step S2). Alternatively, the additive containing sulfur is fed into the gas duct 4. This step may be performed by the additive supply part 30 described above.

[0080] In the above method, the additive containing sulfur is supplied to the position in the combustion furnace 12 or the gas duct 4 where the temperature is within the range of not lower than 400°C and not higher than 750°C. That is, since the additive containing sulfur is supplied to the position in the combustion facility where heavy metal chlorides exist as gas and alkali metal chlorides exist as condensate, it is possible to promote the reaction (liquid-gas reaction or solid-gas reaction) between the heavy metal chlorides and sulfur components in the additive while suppressing the reaction (gas-gas reaction) between the alkali metal chlorides and sulfur components in the additive. That is, heavy metal chlorides in the combustion gas can be preferentially sulfated over alkali metal chlorides. Thus, with the above method, it is possible to effectively suppress corrosion of the combustion facility while reducing the supply amount of the sulfur-containing additive.

[0081] In some embodiments, the step S2 is performed under a condition that the temperature of the heat transfer tube 14 disposed in the gas duct 4 or a fluid flowing through the heat transfer tube 14 is not higher than 450°C.

[0082] In some embodiments, the supply amount of the additive may be decided on the basis of the content of one or more heavy metals in the fuel (step S3).

[0083] In an embodiment, in the step S3, the supply amount of the additive may be decided

so that the equivalent ratio of sulfur contained in the additive supplied per unit weight of the fuel to the number of moles of at least one of one or more heavy metals contained per unit weight of the fuel is within a specified range.

[0084] In an embodiment, in the step S3, the supply amount of the additive may be decided so that the equivalent ratio of sulfur contained in the additive supplied per unit weight of the fuel to the total number of moles of lead and zinc contained per unit weight of the fuel is not less than 0.5 and not more than 10.

[0085] In some embodiments, in the step S3, a heavy metal as a reference for calculating the supply amount of the additive may be selected from one or more heavy metals contained in the fuel, on the basis of the hydrochloric acid concentration in the combustion gas generated by combustion of the fuel.

[0086] More specifically, when the hydrochloric acid concentration in the combustion gas is not more than 1000 ppm, the supply amount of the additive may be decided so that the equivalent ratio of sulfur contained in the additive supplied per unit weight of the fuel to the number of moles of lead contained per unit weight of the fuel is not less than 0.5 and not more than 10.

[0087] The contents described in the above embodiments would be understood as follows, for instance.

[0088] (1) A combustion facility according to at least one embodiment of the present invention is provided with: a combustion apparatus including a combustion furnace for combusting a fuel containing an alkali metal and one or more heavy metals, and a gas duct into which a combustion gas from the combustion furnace is introduced; and an additive supply part configured to supply an additive containing sulfur to a position inside the combustion apparatus where a temperature during operation is within a range of not lower than 400°C and not higher than 750°C.

[0089] Generally, alkali metal chlorides have relatively higher melting points than heavy metal chlorides. Therefore, when the temperature of components (e.g., heat transfer tube) of the combustion facility is not very high, even if alkali metal chlorides in the combustion gas

adhere to the surfaces of the components, the alkali metal chlorides solidify and their corrosiveness decreases compared to when they are in the form of molten salts. On the other hand, even when the temperature of components of the combustion facility 100 is not very high, since heavy metal chlorides in the combustion gas have relatively low melting points and tend to exist as molten salts, they easily cause corrosion of the components. Therefore, when heavy metal chlorides having relatively low melting points are selectively sulfated among the relatively highly corrosive alkali metal chlorides and heavy metal chlorides contained in the combustion gas to form less corrosive sulfates, it is expected that the corrosion of the components can be effectively suppressed.

[0090] Here, when the content of alkali metals and heavy metals in a fuel (waste, biomass, etc.) is within the general range, in the combustion facility for combusting the fuel, in relation to the vapor pressure of each component, heavy metal chlorides in the combustion gas (chlorides derived from heavy metals in the fuel) vaporize at 400°C or higher, and alkali metal chlorides in the combustion gas (chlorides derived from alkali metals in the fuel) condense at 750°C or lower. In this regard, in the above configuration (1), the additive containing sulfur is supplied to the position in the combustion facility where the temperature is within the range of not lower than 400°C and not higher than 750°C. That is, since the additive containing sulfur is supplied to the position in the combustion facility where heavy metal chlorides exist as gas and alkali metal chlorides exist as condensate, it is possible to promote the reaction (gas-gas reaction) between the heavy metal chlorides and sulfur components in the additive while suppressing the reaction (liquid-gas reaction or solid-gas reaction) between the alkali metal chlorides and sulfur components in the additive. That is, heavy metal chlorides in the combustion gas can be preferentially sulfated over alkali metal chlorides. Thus, with the above configuration (1), it is possible to effectively suppress corrosion of the combustion facility while reducing the supply amount of the sulfur-containing additive.

[0091] (2) In some embodiments, in the above configuration (1), the combustion facility is provided with a supply amount decision part configured to decide a supply amount of the additive by the additive supply part on the basis of a content of the one or more heavy metals

in the fuel. The supply amount decision part is configured to decide the supply amount of the additive so that an equivalent ratio of sulfur contained in the additive supplied per unit weight of the fuel to the number of moles of at least one of the one or more heavy metals contained per unit weight of the fuel is within a specified range.

[0092] According to the above configuration (2), since the supply amount of the additive is decided so that the equivalent ratio of sulfur contained in the additive supplied per unit weight of the fuel to the number of moles of heavy metals contained per unit weight of the fuel is within a specified range, a necessary and sufficient amount of additive can be supplied to appropriately convert the heavy metals contained in the fuel into relatively less corrosive sulfates. Thus, heavy metal chlorides in the combustion gas can be appropriately converted into relatively less corrosive sulfates.

[0093] (3) In some embodiments, in the above configuration (2), the one or more heavy metals include lead and zinc, and the supply amount decision part is configured to decide the supply amount of the additive so that an equivalent ratio of sulfur contained in the additive supplied per unit weight of the fuel to the total number of moles of lead and zinc contained per unit weight of the fuel is not less than 0.5 and not more than 10.

[0094] Examples of typical heavy metals contained in a fuel such as waste or biomass include lead and zinc. According to the above configuration (3), since the supply amount of the additive is decided so that the equivalent ratio of sulfur contained in the additive supplied per unit weight of the fuel to the total number of moles of lead and zinc contained per unit weight of the fuel is not less than 0.5, most of the heavy metal chlorides in the combustion gas can be appropriately converted into relatively less corrosive sulfates. Generally, the content of alkali metals in a fuel such as waste or biomass is about 10 times the content of heavy metals. In this regard, according to the above configuration (3), the supply amount of the additive is decided so that the equivalent ratio is not more than 10. Accordingly, even if the excess (unreacted) additive that is not consumed in the reaction with heavy metal chlorides in the combustion gas remains as strongly corrosive sulfuric acid deposits, the sulfuric acid deposits can be eliminated by reaction with alkali metal chlorides contained in the combustion gas or

adhering to the combustion facility, so that corrosion of the facility due to the sulfuric acid deposits can be suppressed. Thus, it is possible to more effectively suppress corrosion of the combustion facility while reducing the supply amount of the sulfur-containing additive.

[0095] (4) In some embodiments, in the above configuration (2), the supply amount decision part is configured to select a heavy metal as a reference for calculating the supply amount of the additive from the one or more heavy metals, on the basis of a hydrochloric acid concentration in the combustion gas generated by combustion of the fuel.

[0096] Some heavy metals precipitate as stable compounds with low corrosiveness in the combustion gas, depending on conditions such as the concentration of hydrochloric acid in the combustion gas. In this regard, according to the above configuration (4), the heavy metal as the reference for calculating the supply amount of the additive is selected on the basis of the hydrochloric acid concentration in the combustion gas. Therefore, for example, by selecting a heavy metal other than the above-described heavy metals (heavy metals that precipitate as stable compounds with low corrosiveness in the combustion gas) as the reference heavy metal for calculating the supply amount of the additive, the supply amount of the sulfur-containing additive can be reduced more effectively.

[0097] (5) In some embodiments, in the above configuration (4), the one or more heavy metals include lead and zinc, and the supply amount decision part is configured to decide the supply amount of the additive so that, when the hydrochloric acid concentration in the combustion gas is not more than 1000 ppm, an equivalent ratio of sulfur contained in the additive supplied per unit weight of the fuel to the number of moles of lead contained per unit weight of the fuel is not less than 0.5 and not more than 10.

[0098] Zinc precipitates as stable zinc oxide under the condition that the hydrochloric acid concentration in the combustion gas is not more than 1000 ppm. In this regard, according to the above configuration (5), when the hydrochloric acid concentration in the combustion gas is not more than 1000 ppm, lead is selected as the reference for calculating the supply amount of the additive, excluding zinc, so the supply amount of the sulfur-containing additive can be reduced more effectively as described in (4). Additionally, according to the above

configuration (5), since the equivalent ratio of sulfur in the additive to the content of lead in the fuel is not less than 0.5, most of lead in the combustion gas can be appropriately converted into relatively less corrosive sulfates, and since the equivalent ratio is not more than 10, corrosion of the facility due to sulfuric acid deposits derived from the excess (unreacted) additive can be suppressed. Thus, it is possible to more effectively suppress corrosion of the combustion facility while reducing the supply amount of the sulfur-containing additive.

[0099] (6) In some embodiments, in any one of the above configurations (1) to (5), the additive contains ammonium sulfate.

[0100] When ammonium sulfate is supplied as the additive, ammonium sulfate decomposes in a high-temperature environment and then reacts with heavy metals, etc. On the other hand, the unreacted portion of ammonium sulfate after thermal decomposition returns to ammonium sulfate at a temperature of about 350°C or lower. In this regard, according to the above configuration (6), since ammonium sulfate is supplied as the additive, the unreacted portion that is not consumed by the reaction with heavy metals returns to ammonium sulfate, which is less corrosive, in the temperature range of about 350°C or lower. As a result, the formation of sulfuric acid deposits derived from the unreacted additive can be suppressed. Thus, it is possible to effectively suppress corrosion of the combustion facility due to sulfuric acid deposits.

[0101] (7) In some embodiments, in any one of the above configurations (1) to (6), the combustion apparatus includes a heat transfer part disposed downstream of the combustion furnace, in which a heat transfer tube is disposed or which is formed by a wall including a heat transfer tube, and the additive supply part is configured to supply the additive to the heat transfer part.

[0102] In the combustion facility, the temperature in the heat transfer part disposed downstream of the combustion furnace is lower than the temperature of the combustion furnace, and is within the range of about not lower than 400°C and not higher than 750°C in most of the heat transfer part. In this regard, according to the above configuration (7), since the additive is supplied to the heat transfer part in the combustion facility, as described in (1), heavy metal chlorides in the combustion gas can be preferentially sulfated over alkali metal chlorides.

Thus, it is possible to effectively suppress corrosion of the combustion facility while reducing the supply amount of the sulfur-containing additive.

[0103] (8) In some embodiments, in any one of the above configurations (1) to (7), the combustion facility includes a heat transfer tube disposed inside the gas duct. The additive supply part is configured to supply the additive to the position under a condition that a temperature of the heat transfer tube or a fluid flowing through the heat transfer tube is not higher than 450°C.

[0104] In the above configuration (8), the sulfur-containing additive is supplied to the position in the combustion apparatus 1 where the temperature is within the range of not lower than 400°C and not higher than 740°C under an operating condition that the temperature of the heat transfer tube disposed in the gas duct or a fluid flowing through the heat transfer tube is not higher than 450°C, which is lower than the melting point of alkali metal chlorides. That is, even if alkali metal chlorides in the combustion gas adhere to the surfaces of the components, the sulfur-containing additive is supplied to the position within the above-described temperature range under the condition that the alkali metal chlorides solidify. Thus, as described in (1), by preferentially sulfating heavy metal chlorides in the combustion gas over alkali metal chlorides, it is possible to effectively suppress corrosion of the combustion facility while reducing the supply amount of the sulfur-containing additive.

[0105] (9) In some embodiments, in any one of the above configurations (1) to (8), the additive supply part is configured to supply an additive containing sulfur to a position where a temperature during operation is within a range of not lower than 500°C and not higher than 700°C.

[0106] In the above configuration (9), since the sulfur-containing additive is supplied to the position where the temperature during operation is not lower than 500°C, the reaction between heavy metal chlorides in the combustion gas and the additive can be promoted more greatly. On the other hand, in the above configuration (9), since the sulfur-containing additive is supplied to the position where the temperature during operation is not higher than 700°C, the condensation of alkali metal chlorides in the combustion gas can be promoted, and thus the

reaction between alkali metal chlorides in the combustion gas and the additive can be suppressed more effectively. Thus, it is possible to more effectively suppress corrosion of the combustion facility while reducing the supply amount of the sulfur-containing additive more effectively.

[0107] (10) A combustion facility according to at least one embodiment of the present invention is provided with: a combustion furnace for combusting a fuel containing an alkali metal and one or more heavy metals; a heat transfer part disposed downstream of the combustion furnace, in which a heat transfer tube is disposed or which is formed by a wall including a heat transfer tube; and an additive supply part configured to supply an additive containing sulfur to the heat transfer part.

[0108] In the combustion facility, the temperature in the heat transfer part disposed downstream of the combustion furnace is lower than the temperature of the combustion furnace, and is within the range of about not lower than 400°C and not higher than 750°C in most of the gas duct. In this regard, in the above configuration (7), the additive containing sulfur is supplied to the heat transfer part where the temperature is mostly within the range of not lower than 400°C and not higher than 750°C. That is, since the additive containing sulfur is supplied to the position in the combustion facility where heavy metal chlorides exist as gas and alkali metal chlorides exist as condensate, it is possible to promote the reaction (gas-gas reaction) between the heavy metal chlorides and sulfur components in the additive while suppressing the reaction (liquid-gas reaction or solid-gas reaction) between the alkali metal chlorides and sulfur components in the additive. That is, heavy metal chlorides in the combustion gas can be preferentially sulfated over alkali metal chlorides. Thus, it is possible to effectively suppress corrosion of the combustion facility while reducing the supply amount of the sulfur-containing additive.

[0109] (11) A method for operating a combustion facility including a combustion furnace and a gas duct connected to the combustion furnace according to at least one embodiment of the present invention includes: a step of combusting a fuel containing an alkali metal and one or more heavy metals by the combustion furnace; and a step of putting an additive containing

sulfur to a position inside the combustion furnace or the gas duct where a temperature during operation is within a range of not lower than 400°C and not higher than 750°C.

[0110] In the above method (11), the additive containing sulfur is supplied to the position in the combustion furnace 12 or the gas duct 4 where the temperature is within the range of not lower than 400°C and not higher than 750°C. That is, since the additive containing sulfur is supplied to the position in the combustion facility where heavy metal chlorides exist as gas and alkali metal chlorides exist as condensate, it is possible to promote the reaction (gas-gas reaction) between the heavy metal chlorides and sulfur components in the additive while suppressing the reaction (liquid-gas reaction or solid-gas reaction) between the alkali metal chlorides and sulfur components in the additive. That is, heavy metal chlorides in the combustion gas can be preferentially sulfated over alkali metal chlorides. Thus, with the above method (11), it is possible to effectively suppress corrosion of the combustion facility while reducing the supply amount of the sulfur-containing additive.

[0111] Embodiments of the present invention were described in detail above, but the present invention is not limited thereto, and various amendments and modifications may be implemented.

[0112] Further, in the present specification, an expression of relative or absolute arrangement such as “in a direction”, “along a direction”, “parallel”, “orthogonal”, “centered”, “concentric” and “coaxial” shall not be construed as indicating only the arrangement in a strict literal sense, but also includes a state where the arrangement is relatively displaced by a tolerance, or by an angle or a distance whereby it is possible to achieve the same function.

For instance, an expression of an equal state such as “same” “equal” and “uniform” shall not be construed as indicating only the state in which the feature is strictly equal, but also includes a state in which there is a tolerance or a difference that can still achieve the same function.

Further, an expression of a shape such as a rectangular shape or a cylindrical shape shall not be construed as only the geometrically strict shape, but also includes a shape with unevenness or chamfered corners within the range in which the same effect can be achieved.

On the other hand, an expression such as “comprise”, “include”, and “have” are not intended to be exclusive of other components.

Reference Signs List

[0113]

1	Combustion apparatus
2	Boiler
4	Gas duct
5	Exhaust passage
6	Stack
8	Fuel supply part
10	Air supply part
12	Combustion furnace
14	Heat transfer tube
14’	Heat transfer part
16	Temperature reducing part
18	Capture part
20	Discharge pipe
21	Discharge valve
22	Fan
26	Detection part
28	Concentration sensor
30	Additive supply part
32	Additive tank
34	Additive supply line
36	Pump
38	Valve
40	Control part

42 Supply amount decision part

50 Additive supply apparatus

100 Combustion facility