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EXHAUST GAS TREATMENT APPARATUS, COMBUSTION FACILITY, POWER GENERATION FACILITY, AND EXHAUST GAS TREATMENT METHOD

Abstract

An exhaust gas treatment apparatus includes: a first reduction catalyst, disposed in a flow path of combustion exhaust gas of a fuel; a reductant supply part, disposed upstream of the first reduction catalyst; a reductant decreasing catalyst, disposed downstream of the first reduction catalyst; at least one second reduction catalyst, disposed downstream of the reductant decreasing catalyst; a first concentration measuring part measuring a first concentration which is a concentration of the specific substance in the combustion exhaust gas at a position downstream of the first reduction catalyst and upstream of the reductant decreasing catalyst; a second concentration measuring part for measuring a second concentration which is a concentration of the specific substance in the combustion exhaust gas at a position downstream of the reductant decreasing catalyst; and a decision part configured to decide whether to increase or decrease a supply amount of the reductant from the reductant supply part.

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Background/Summary

TECHNICAL FIELD

[0001] The present disclosure relates to an exhaust gas treatment apparatus, a combustion facility, a power generation facility, and an exhaust gas treatment method.

[0002] The present application claims priority based on Japanese Patent Application No. 2022-071415 filed on Apr. 25, 2022, the entire content of which is incorporated herein by reference.

BACKGROUND ART

[0003] Specific substances (e.g., nitrogen oxides (NOx)) contained in combustion exhaust gas from combustion facilities such as power generation boilers, gas turbines, and combustion furnaces may be removed or reduced by decomposing them into harmless substances (in the case of nitrogen oxides, nitrogen and water) using reductants in the presence of catalysts.

[0004] Patent Documents 1 and 2 describe providing a catalyst (reduction catalyst) that promotes the reduction reaction of nitrogen oxides in the exhaust gas flow path and adding a reductant (ammonia or urea) to the exhaust gas upstream of the reduction catalyst to reduce and decompose nitrogen oxides in the exhaust gas by reaction with the reductant on the catalyst. In the apparatuses of Patent Documents 1 and 2, the supply amount of the reductant is adjusted based on detection results of the concentration of nitrogen oxides downstream of the reduction catalyst.

CITATION LIST

Patent Literature

[0005] Patent Document 1: JP4986839B [0006] Patent Document 2: JP6926581B

SUMMARY

Problems to be Solved

[0007] In an exhaust gas treatment apparatus such as a denitration apparatus, by supplying an excess amount of reductant to specific substances (such as NOx) to be reduced, it is possible to efficiently reduce the specific substances from exhaust gas. Here, if a catalyst (e.g., a catalyst that promotes the decomposition reaction of the reductant) is provided to reduce the amount of unreacted reductant (excess reductant), the above-mentioned specific substances may be generated as by-products on the catalyst, and too much reductant supply may increase the amount of specific substances emitted. Therefore, even if the concentration of specific substances at the outlet of the exhaust gas treatment apparatus is measured, it is unclear from the concentration whether the supply amount of the reductant is insufficient or excessive, and the supply amount of the reductant cannot be appropriately decided.

[0008] In view of the above circumstances, an object of at least one embodiment of the present invention is to provide an exhaust gas treatment apparatus, a combustion facility, a power generation facility, and an exhaust gas treatment method that enable appropriate adjustment of the reductant supply amount with a simple configuration even if a reductant is excessively supplied to a specific substance.

Solution to the Problems

[0009] An exhaust gas treatment apparatus according to at least one embodiment of the present invention includes: a first reduction catalyst, disposed in a flow path of combustion exhaust gas of a fuel, for promoting reduction reaction of a specific substance contained in the combustion exhaust gas; a reductant supply part for supplying a reductant for reducing the specific substance in the combustion exhaust gas, the reductant supply part being disposed upstream of the first reduction catalyst; a reductant decreasing catalyst for decreasing the reductant in the combustion exhaust gas, the reductant decreasing catalyst being disposed downstream of the first reduction catalyst in the flow path; at least one second reduction catalyst for promoting reduction reaction of the specific substance, the at least one second reduction catalyst being disposed downstream of the reductant decreasing catalyst in the flow path; a first concentration measuring part for measuring a first concentration which is a concentration of the specific substance in the combustion exhaust gas in the flow path at a position downstream of the first reduction catalyst and upstream of the reductant decreasing catalyst; a second concentration measuring part for measuring a second concentration which is a concentration of the specific substance in the combustion exhaust gas in the flow path at a position downstream of the reductant decreasing catalyst; and a decision part configured to decide whether to increase or decrease a supply amount of the reductant from the reductant supply part, on the basis of the first concentration and the second concentration of the specific substance.

[0010] Further, a combustion facility according to at least one embodiment of the present invention includes: a combustion apparatus configured to burn a fuel; and the above-described exhaust gas treatment apparatus configured to treat combustion exhaust gas of the fuel from the combustion apparatus.

[0011] Further, a power generation facility according to at least one embodiment of the present invention includes: the above-described combustion facility; a turbine configured to be driven by the combustion exhaust gas from the combustion apparatus or steam produced by using heat of the combustion exhaust gas from the combustion apparatus; and a generator configured to be driven by the turbine.

[0012] An exhaust gas treatment method according to at least one embodiment of the present invention is an exhaust gas treatment method using an exhaust gas treatment apparatus that includes: a first reduction catalyst, disposed in a flow path of combustion exhaust gas of a fuel, for promoting reduction reaction of a specific substance contained in the combustion exhaust gas; a reductant supply part for supplying a reductant for reducing the specific substance in the combustion exhaust gas, the reductant supply part being disposed upstream of the first reduction catalyst; a reductant decreasing catalyst for decreasing the reductant in the combustion exhaust gas, the reductant decreasing catalyst being disposed downstream of the first reduction catalyst in the flow path; and at least one second reduction catalyst for promoting reduction reaction of the specific substance, the at least one second reduction catalyst being disposed downstream of the reductant decreasing catalyst in the flow path. The exhaust gas treatment method includes: a step of measuring a first concentration which is a concentration of the specific substance in the combustion exhaust gas in the flow path at a position downstream of the first reduction catalyst and upstream of the reductant decreasing catalyst; a step of measuring a second concentration which is a concentration of the specific substance in the combustion exhaust gas in the flow path at a position downstream of the reductant decreasing catalyst; and a step of deciding whether to increase or decrease a supply amount of the reductant from the reductant supply part, on the basis of the first concentration and the second concentration of the specific substance.

Advantageous Effects

[0013] At least one embodiment of the present invention provides an exhaust gas treatment apparatus, a combustion facility, a power generation facility, and an exhaust gas treatment method that enable appropriate adjustment of the reductant supply amount with a simple configuration even if a reductant is excessively supplied to a specific substance.

Description

BRIEF DESCRIPTION OF DRAWINGS
[0014] FIG. **1** is a schematic diagram of a combustion facility and a power generation facility according to an embodiment.
[0015] FIG. **2** is a schematic diagram of an exhaust gas treatment apparatus according to an embodiment.
[0016] FIG. **3** is a schematic diagram of an exhaust gas treatment apparatus according to an embodiment.
[0017] FIG. **4** is a schematic diagram of an exhaust gas treatment apparatus according to an embodiment.
[0018] FIG. **5** is a schematic configuration diagram of a control device constituting the exhaust gas treatment apparatus according to an embodiment.
[0019] FIG. **6** is a flowchart of an exhaust gas treatment method according to an embodiment.
[0020] FIG. **7** is a graph for describing the process of the exhaust gas treatment method according to an embodiment.
[0021] FIG. **8** is a graph for describing the process of the exhaust gas treatment method according to an embodiment.
[0022] FIG. **9** is a flowchart of an exhaust gas treatment method according to an embodiment.
[0023] FIG. **10** is a graph for describing the process of the exhaust gas treatment method according to an embodiment.
DETAILED DESCRIPTION
[0024] 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.
(Configuration of Combustion Facility/Power Generation Facility)
[0025] FIG. **1** is a schematic diagram of an example of a combustion facility and a power generation facility to which an exhaust gas treatment apparatus according to some embodiments is applicable. FIGS. **2** to **4** are each a schematic diagram of the exhaust gas treatment apparatus according to an embodiment. In some embodiments, a combustion facility **1** includes a combustion apparatus **100** (see FIG. **1**) configured to burn fuel, and an exhaust gas treatment apparatus **102** (see FIGS. **2** to **4**) configured to treat combustion exhaust gas from the combustion apparatus **100**.
[0026] The combustion facility **1** shown in FIG. **1** is a gas turbine combined cycle (GTCC) power generation facility with a gas turbine facility **2** including a combustor **12** as the combustion apparatus **100**, a steam turbine facility **4**, and a heat recovery steam generator (HRSG) **6**.
[0027] The gas turbine facility **2** includes a compressor **10**, the above-described combustor **12**, and a turbine **14**. The compressor **10** is configured to compress air to produce compressed air. The combustor **12** is configured to generate combustion gas by combustion reaction between the compressed air from the compressor **10** and fuel. The turbine **14** is configured to be rotary driven by the combustion gas from the combustor **12**. To the turbine **14**, a generator **18** is connected via a rotational shaft **16**, so that the generator **18** is driven by rotational energy of the turbine **14** to generate electric power. The combustion gas having finished work in the turbine **14** is discharged from the turbine **14** as the combustion exhaust gas. The fuel supplied to the combustor **12** (combustion apparatus **100**) may include carbon-containing fuels such as natural gas or coal

gasification gas and/or nitrogen-containing fuels such as ammonia.
[0028] The heat recovery steam generator **6** is configured to generate steam by heat of the combustion exhaust gas from the gas turbine facility **2**. As shown in FIG. **2**, the heat recovery steam generator **6** has a duct **30** (sees FIG. **2** to **4**) to which the combustion exhaust gas from the gas turbine facility **2** is introduced and a heat transfer tube **34** disposed in a flow path **32** of the combustion exhaust gas defined by the duct **30**. Into the heat transfer tube **34**, condensate from a condenser **26** of the steam turbine facility **4** is introduced. In the heat transfer tube **34**, steam is generated by heat exchange between the condensate and the combustion exhaust gas flowing in the duct **30**. The exhaust gas having passed through the duct **30** of the heat recovery steam generator **6** is discharged through a stack **38**.
[0029] The steam turbine facility **4** includes a turbine **20** configured to be driven by the steam from the heat recovery steam generator **6**. To the turbine **20**, a generator **24** is connected via a rotational shaft **22**, so that the generator **24** is driven by rotational energy of the turbine **20** to generate electric power. The steam having finished work in the turbine **20** is led to the condenser **26**, condensed into condensate water in the condenser **26**, and supplied to the heat recovery steam generator **6**.
[0030] The above-described combustion facility **1** or gas turbine facility **2** is a power generation facility that includes a turbine **14** configured to be driven by combustion exhaust gas driven by combustion exhaust gas from a combustor **12** (combustion apparatus **100**) and a generator **18** configured to be driven by the turbine **14**. Further, the above-described combustion facility **1** or steam turbine facility **4** is a power generation facility that includes a turbine **20** configured to be driven by steam produced by using heat of combustion exhaust gas from a combustor **12** (combustion apparatus **100**) and a generator **24** configured to be driven by the turbine **20**.
(Configuration of Exhaust Gas Treatment Apparatus)
[0031] As shown in FIGS. **2** to **4**, the exhaust gas treatment apparatus **102** includes a reductant supply part **40**, a first reduction catalyst **50**, at least one reductant decreasing catalyst **52** (**52**A to **52**C), and at least one second reduction catalyst **54** (**54**A to **54**C).
[0032] The reductant supply part **40** is configured to supply a reductant for reducing a specific substance contained in combustion exhaust gas from the combustion apparatus **100** to the combustion exhaust gas that flows through the flow path **32**. By supplying the reductant to the combustion exhaust gas containing the specific substance, the specific substance in the combustion exhaust gas can be reduced, thereby decreasing the specific substance in the combustion exhaust gas. For example, if the specific substance is NOx, the reaction between NOx and the second reductant decomposes NOx in the combustion exhaust gas into nitrogen and water, decreasing NOx in the combustion exhaust gas. The reductant supply part **40** is disposed upstream of the first reduction catalyst **50** in the flow of the combustion exhaust gas.
[0033] In some embodiments, for example as shown in FIGS. **2** to **4**, the reductant supply part **40** may be disposed upstream of the first reduction catalyst **50** in the flow path **32** of the combustion exhaust gas of fuel. As shown in FIGS. **2** to **4**, the reductant supply part **40** may include a nozzle **42** configured to inject a liquid or gas containing the reductant into the flow path **32**. The nozzle **42** may be supplied with a liquid or gas containing the reductant stored in a reductant storage part **44** via a supply line **46**. The supply line **46** may be provided with a valve **48** for adjusting the amount of the second reductant supplied through the reductant supply part **40**.
[0034] In some embodiments, the reductant supply part **40** may be configured to supply a fuel containing the reductant (e.g., ammonia) to the combustion apparatus **100** (e.g., the combustor **12** of the gas turbine facility **2**). That is, the reductant supply part **40** may function as a fuel supply part for supplying fuel to the combustion apparatus **100**. In this case, the unburned content of the reductant (fuel) that has not been burned in the combustion apparatus **100** is supplied to the combustion exhaust gas that flows through the flow path **32** as the reductant for reducing the specific substance contained in combustion exhaust gas from the combustion apparatus **100**.
[0035] The specific substance may be nitrogen oxides (NOx) such as NO or NO.sub.2. If the

specific substance is NOx, the reductant is a substance that acts to reduce NOx and may include, for example, ammonia or urea. The reductant may be supplied to the combustion exhaust gas in the form of an aqueous solution (e.g., ammonia water or urea water).

[0036] The first reduction catalyst **50** is disposed downstream of the reductant supply part **40** in the flow path **32**. The first reduction catalyst **50** is configured to promote the reduction reaction between the specific substance (e.g., NOx) in the combustion exhaust gas and the reductant (including the reductant supplied from the reductant supply part **40**). If the specific substance is NOx and the reductant includes ammonia or urea, the first reduction catalyst **50** may include a metal or metal compound containing, for example, titanium, vanadium, tungsten, or molybdenum.

[0037] The at least one reductant decreasing catalyst **52** (**52**A to **52**C) is disposed downstream of the first reduction catalyst **50** in the flow path **32**. The reductant decreasing catalyst **52** is configured to decrease the reductant (unreacted reductant that has not been consumed in the reduction reaction of the specific substance) in the combustion exhaust gas. The reductant decreasing catalyst **52** may function to promote the decomposition reaction of the reductant in the combustion exhaust gas. If the reductant includes ammonia or urea, the reductant decreasing catalyst **52** may include a metal or metal compound containing, for example, platinum, copper, iron, cobalt, palladium, iridium, nickel or ruthenium.

[0038] The at least one second reduction catalyst **54** (**54**A to **54**C) is disposed downstream of the reductant decreasing catalyst **52** in the flow path **32**. The second reduction catalyst **54** (**54**A to **54**C) functions to promote the reduction reaction between the specific substance in the combustion exhaust gas and the reductant. The specific substance in the combustion exhaust gas reaching the second reduction catalyst **54** may include specific substances produced by fuel combustion or other reactions in the combustion apparatus **100** and/or specific substances produced as byproducts of the decomposition reaction of the reductant on the reductant decreasing catalyst **52** of the exhaust gas treatment apparatus **102**. If the specific substance is NOx and the reductant includes ammonia or urea, the second reduction catalyst **54** (**54**A to **54**C) may include a metal or metal compound containing, for example, titanium, vanadium, tungsten, or molybdenum.

[0039] In the exemplary embodiment shown in FIGS. **2** and **3**, one reductant decreasing catalyst **52** and one second reduction catalyst **54** are disposed downstream of the first reduction catalyst **50** in the flow path **32**. In the exemplary embodiment shown in FIG. **4**, a plurality of (three in the illustrated example) reductant decreasing catalysts **52** (**52**A to **52**C) and a plurality of (three in the illustrated example) second reduction catalysts **54** (**54**A to **54**C) are disposed downstream of the first reduction catalyst **50**.

[0040] As shown in FIG. **4**, a plurality of units each including the reductant decreasing catalyst **52** and the second reduction catalyst **54** installed immediately after the reductant decreasing catalyst **52** may be provided downstream of the first reduction catalyst **50** in the flow path **32**.

[0041] As shown in FIGS. **2** to **4**, the exhaust gas treatment apparatus **102** is equipped with a first concentration measuring part **72** and a second concentration measuring part **74** each of which is configured to measure the concentration of the specific substance (e.g., NOx) in the flow path **32** of the combustion exhaust gas.

[0042] The first concentration measuring part **72** is configured to measure the first concentration, which is the concentration of the specific substance in the combustion exhaust gas in the flow path **32** at a position downstream of the first reduction catalyst **50** and upstream of the reductant decreasing catalyst **52**.

[0043] The second concentration measuring part **74** is configured to measure the second concentration, which is the concentration of the specific substance in the combustion exhaust gas in the flow path **32** at a position downstream of the reductant decreasing catalyst **52**.

[0044] As shown in FIGS. **2** to **4**, the exhaust gas treatment apparatus **102** may be further equipped with a third concentration measuring part **76** configured to measure the third concentration, which is the concentration of the specific substance in the flow path **32** of the combustion exhaust gas at a position downstream of the second reduction catalyst **54**. When the flow path **32** of the combustion exhaust gas has a plurality of second reduction catalysts **54**, the third concentration measuring part **76** is configured to measure, as the third concentration, the concentration of the specific substance at a position downstream of the most downstream second reduction catalyst **54** of the plurality of second reduction catalysts **54** (see FIG. **4**).

[0045] If the specific substance is NOx, the NOx concentration in the combustion exhaust gas can be measured according to JIS K 0104 by using a chemiluminescent NOx meter (JIS B 7982), or by non-dispersive infrared method (NDIR method), or by zinc reduction naphthylethylenediamine absorptiometry (Zn-NEDA method). The first concentration measuring part **72**, the second concentration measuring part **74**, and/or the third concentration measuring part **76** may be configured to measure the NOx concentration using any of these methods.

[0046] In the exemplary embodiments shown in FIGS. **2** and **4**, the second concentration measuring part **74** is configured to measure the concentration (second concentration) of the specific substance in the flow path **32** at a position downstream of the second reduction catalyst **54** (in FIG. **4**, downstream of the most downstream one of the plurality of second reduction catalysts **54**). That is, in this case, the second concentration is equal to the third concentration.

[0047] In the exemplary embodiment shown in FIG. **3**, the second concentration measuring part **74** is configured to measure the concentration (second concentration) of the specific substance in the flow path **32** at a position downstream of the reductant decreasing catalyst **52** and upstream of the second reduction catalyst **54**.

[0048] In the exemplary embodiment shown in FIG. **4**, the exhaust gas treatment apparatus **102** is further equipped with a fourth concentration measuring part **82** configured to measure the fourth concentration which is the concentration of the specific substance at a position downstream of the most upstream second reduction catalyst **54** (in FIG. **4**, second reduction catalyst **54**A) and upstream of the most downstream second reduction catalyst **54** (in FIG. **4**, second reduction catalyst **54**C) of the plurality of second reduction catalysts **54**. In FIG. **4**, the fourth concentration measuring part **82** is disposed downstream of the second reduction catalyst **54**A and upstream of the reductant decreasing catalyst **52**B, but it can be provided at any position between the second reduction catalyst **54**A and the second reduction catalyst **54**C, for example, downstream of the second reduction catalyst **54**B and upstream of the reductant decreasing catalyst **52**C.

[0049] Further, as shown in FIGS. **2** to **4**, the exhaust gas treatment apparatus **102** is equipped with a control device **60** for controlling the supply of the reductant from the reductant supply part **40** on the basis of the first concentration, the second concentration, and/or the third concentration of the specific substance (e.g., NOx).

[0050] The control device **60** includes a calculator equipped with a processor (e.g., CPU or GPU), a storage device (memory device; e.g., RAM), an auxiliary storage part, and an interface. The control device **60** receives signals indicating measured values of the first to third concentrations from the first concentration measuring part **72**, the second concentration measuring part **74**, and/or the third concentration measuring part **76** via the interface. The processor is configured to process the signals thus received. Whereby, the function of each functional unit (decision part **62**, determination part **64**, and/or reductant supply amount adjusting part **66**) described below is realized. The processor may calculate an opening degree command value for the valve **48** on the basis of the concentration measurement by the first concentration measuring part **72**, the second concentration measuring part **74**, and/or the third concentration measuring part **76**. The control device **60** may provide the calculated opening degree command value to an actuator for changing the opening degree of the valve **48**.

[0051] The processing contents in the control device **60** is implemented as programs executed by the processor. The programs may be stored in the auxiliary storage part. 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.

[0052] FIG. **5** is a schematic configuration diagram of the control device **60** of the exhaust gas treatment apparatus **102** according to an embodiment. As shown in FIG. **5**, the control device **60** according to an embodiment includes a decision part **62**. The control device **60** may also include a determination part **64** or a reductant supply amount adjusting part **66**.
[0053] The decision part **62** is configured to decide whether to increase or decrease the supply amount of the reductant from the reductant supply part **40**, on the basis of the first concentration and the second concentration of the specific substance (e.g., NOx).
[0054] The determination part **64** is configured to determine whether it is necessary to adjust the supply amount of the reductant from the reductant supply part **40**, on the basis of the third concentration of the specific substance (e.g., NOx).
[0055] The reductant supply amount adjusting part **66** is configured to adjust the supply amount of the reductant from the reductant supply part **40** so that the third concentration of the specific substance (e.g., NOx) is within a predetermined range. The reductant supply amount adjusting part **66** may be configured to regulate the opening degree of the valve **48** in the supply line **46** for supplying the reductant in order to adjust the supply amount of the reductant from the reductant supply part **40**.
[0056] According to the exhaust gas treatment apparatus **102** with the above-described configuration, since the first concentration measuring part **72** and the second concentration measuring part **74** for respectively measuring the concentrations (first concentration and second concentration) of the specific substance (substance to be reduced by the reductant; e.g., nitrogen oxides (NOx)) in the combustion exhaust gas upstream and downstream of the reductant decreasing catalyst **52**, which is disposed downstream of the first reduction catalyst **50**, are provided, even when the reductant is excessively supplied to the specific substance, it is possible to appropriately decide the direction of increase or decrease of the supply amount of the reductant (i.e., whether to increase or decrease the supply amount of the reductant) on the basis of measurement results of the first and second concentrations. Therefore, the supply amount of the reductant to reduce the specific substance can be appropriately adjusted with a simple configuration including the first concentration measuring part **72** and the second concentration measuring part **74**. Alternatively, the supply amount of the reductant to reduce the specific substance can be appropriately adjusted with a simple configuration that does not include a sensor for measuring the reductant concentration.
(Flow of Exhaust Gas Treatment Method)
[0057] The flow of an exhaust gas treatment method according to some embodiments will now be described in more detail. In the following description, a case will be described in which combustion exhaust gas from the combustion apparatus **100** is treated by the exhaust gas treatment apparatus **102** of any of FIGS. **2** to **4**. However, a part or whole of the procedure described below may be performed by another apparatus or manually. In the following example, nitrogen oxides (NOx; specific substance) are contained in the combustion exhaust gas, and ammonia, which can reduce NOx (specific substance), is used as the reductant.
[0058] FIG. **6** is a flowchart of an exhaust gas treatment method according to an embodiment. FIGS. **7** and **8** are each a graph for describing the procedure of the exhaust gas treatment method according to an embodiment, showing an example of the relationship between the concentration ratio of ammonia (reductant) to NOx (specific substance) at the inlet of the first reduction catalyst **50** (i.e., at a position downstream of the reductant supply part **40** and upstream of the first reduction catalyst **50** in the flow path **32**) (horizontal axis) and the first to third concentrations (NOx concentrations at predetermined positions) (vertical axis). FIGS. **7** and **8** correspond to the apparatus configuration of the exhaust gas treatment apparatus **102** shown in FIGS. **2** and **4**, respectively.
[0059] First, the graph will be described. As shown in the graphs of FIGS. **7** and **8**, as the supply amount of ammonia (reductant) from the reductant supply part **40** to NOx (specific substance) in the combustion exhaust gas increases (i.e., as the value on the horizontal axis increases), the first

concentration (NOx concentration downstream of the first reduction catalyst **50** and upstream of the reductant decreasing catalyst **52**) decreases. This is because the amount of NOx that reacts with ammonia increases as the amount of ammonia supplied from the reductant supply part **40** increases.
[0060] On the other hand, as the supply amount of ammonia from the reductant supply part **40** to NOx in the combustion exhaust gas increases (i.e., as the value on the horizontal axis increases), the second and third concentrations (NOx concentration downstream of the reductant decreasing catalyst **52**) decrease until the concentration ratio of ammonia to NOx (NH.sub.3/NOx) reaches A**0** but increase when this ratio exceeds A**0**. This is because NOx is produced as byproducts when the unreacted content, which has not consumed in the reduction reaction with NOx on the first reduction catalyst **50**, of the reductant supplied from the reductant supply part **40** decomposes on the reductant decreasing catalyst **52** (ammonia decomposition catalyst).
[0061] The following explanation is given according to the flowchart, also referring to the graphs of FIGS. **7** and **8**. In the method of the flowchart shown in FIG. **6**, first, as a precondition, the reductant supply part **40** supplies ammonia to the combustion exhaust gas flowing through the flow path **32** so that the supply amount of ammonia (reductant) to NOx (specific substance) is excessive (i.e., the concentration ratio of ammonia to NOx (NH.sub.3/NOx) exceeds 1) (S**101**).
[0062] Then, the first concentration measuring part **72**, the second concentration measuring part **74**, and the third concentration measuring part **76** measure the NOx concentration at predetermined positions described above (S**102**).
[0063] Then, the determination part **64** acquires the measured value of NOx concentration by the third concentration measuring part **76** (third concentration, i.e., NOx concentration at the outlet of the exhaust gas treatment apparatus **102**) and compares the third concentration with a control value C.sub.A (see FIGS. **7** and **8**) (S**103**).
[0064] If the third concentration is less than the control value C.sub.A in step S**103** (Yes in S**103**), the third concentration (NOx concentration at the outlet of the exhaust gas treatment apparatus **102**) is less than the control value C.sub.A and within a permissible range, so the determination part **64** determines that it is unnecessary to adjust the supply amount of ammonia from the reductant supply part **40**, and the process returns to step S**101**.
[0065] On the other hand, if the third concentration is equal to or greater than the control value C.sub.A in step S**103** (No in S**103**), the third concentration (NOx concentration at the outlet of the exhaust gas treatment apparatus **102**) is equal to or greater than the control value C.sub.A and outside the permissible range, so the determination part **64** determines that it is necessary to adjust the supply amount of ammonia from the reductant supply part **40**, and the process proceeds to the next step S**104** to change the ammonia supply amount.
[0066] In step S**104**, the decision part **62** acquires the measured value of NOx concentration by the first concentration measuring part **72** (first concentration, i.e., NOx concentration upstream of the reductant decreasing catalyst **52**) and the measured value of NOx concentration by the second concentration measuring part **74** (second concentration, i.e., NOx concentration downstream of the reductant decreasing catalyst **52**) and compares the first concentration with the second concentration.
[0067] If the first concentration is smaller than the second concentration in step S**104** (Yes in S**104**; i.e., the value on the horizontal axis is greater than A**2** in FIGS. **7** and **8**), the decision part **62** decides to decrease the supply amount of ammonia from the reductant supply part **40** (S**106**). This is because the fact that the first concentration is greater than the second concentration means that the amount of NOx produced by the decomposition reaction of ammonia on the reductant decreasing catalyst **52** is greater, and therefore the ammonia supply must be reduced to decrease the amount of NOx produced by the decomposition of unreacted ammonia.
[0068] On the other hand, if the first concentration is equal to or greater than the second concentration in step S**104** (No in S**104**; i.e., the value on the horizontal axis is equal to or smaller than A**1** in FIGS. **7** and **8**), the decision part **62** decides to increase the supply amount of ammonia

from the reductant supply part **40** (S**108**). This is because the fact that the first concentration is equal to or smaller than the second concentration means that NOx in the combustion exhaust gas has not been sufficiently decreased by reaction with ammonia and the ammonia supply is insufficient, thus requiring an increase in the supply amount of ammonia from the reductant supply part **40**.

[0069] Once the direction of increasing or decreasing ammonia is decided by the procedure of steps S**104** to S**108**, the reductant supply amount adjusting part **66** adjusts the supply amount of ammonia from the reductant supply part **40** so that, for example, the third concentration (NOx concentration at the outlet of the exhaust gas treatment apparatus **102**) is less than the control value C.sub.A (for example, by regulating the opening degree of the valve **48**) (S**110**).

[0070] Then return to step S**101** and repeat the same procedure.

[0071] FIG. **9** is a flowchart of an exhaust gas treatment method according to another embodiment. FIG. **10** is a graph similar to FIG. **7** for describing the process of the exhaust gas treatment method according to an embodiment. FIG. **10** correspond to the apparatus configuration of the exhaust gas treatment apparatus **102** shown in FIG. **2**. In this embodiment, the second concentration measuring part **74** is configured to measure the NOx concentration in the flow path **32** at a position downstream of the reductant decreasing catalyst **52** and downstream of the second reduction catalyst **54**.

[0072] The following explanation is given according to the flowchart, also referring to the graph of FIG. **10**. In the method of the flowchart shown in FIG. **9**, first, as a precondition, the reductant supply part **40** supplies ammonia to the combustion exhaust gas flowing through the flow path **32** so that the supply amount of ammonia (reductant) to NOx (specific substance) is excessive (i.e., the concentration ratio of ammonia to NOx (NH.sub.3/NOx) exceeds 1) (S**201**).

[0073] Then, the first concentration measuring part **72** and the second concentration measuring part **74** measure the NOx concentration at predetermined positions described above (S**202**).

[0074] Then, the determination part **64** acquires the measured value of NOx concentration by the second concentration measuring part **74** (second concentration, i.e., NOx concentration at the outlet of the exhaust gas treatment apparatus **102**) and compares the second concentration with a control value C.sub.A (see FIG. **10**) (S**203**).

[0075] If the second concentration is less than the control value C.sub.A in step S**203** (Yes in S**203**), the second concentration (NOx concentration at the outlet of the exhaust gas treatment apparatus **102**) is less than the control value C.sub.A and within a permissible range, so the determination part **64** determines that it is unnecessary to adjust the supply amount of ammonia from the reductant supply part **40**, and the process returns to step S**201**.

[0076] On the other hand, if the second concentration is equal to or greater than the control value C.sub.A in step S**203** (No in S**203**), the second concentration (NOx concentration at the outlet of the exhaust gas treatment apparatus **102**) is equal to or greater than the control value C.sub.A and outside the permissible range, so the determination part **64** determines that it is necessary to adjust the supply amount of ammonia from the reductant supply part **40**, and the process proceeds to the next step S**204** to change the ammonia supply amount.

[0077] In step S**204**, the decision part **62** acquires the measured value of NOx concentration by the first concentration measuring part **72** (first concentration, i.e., NOx concentration upstream of the reductant decreasing catalyst **52**) and compares the first concentration with a preset threshold C.sub.th (see FIG. **10**). The threshold C.sub.th may be the same value as the control value C.sub.A as shown in FIG. **10**, or it may be different from the control value C.sub.A.

[0078] If the first concentration is smaller than the threshold C.sub.th in step S**204** (Yes in S**204**; i.e., the value on the horizontal axis is greater than A**2** in FIG. **10**), the decision part **62** decides to decrease the supply amount of ammonia from the reductant supply part **40** (S**206**). This is because the fact that the first concentration is greater than the threshold means that the amount of NOx produced by the decomposition reaction of ammonia on the reductant decreasing catalyst **52** is

greater, and therefore the ammonia supply must be reduced to decrease the amount of NOx produced by the decomposition of unreacted ammonia.
[0079] On the other hand, if the first concentration is equal to or greater than the threshold C.sub.th in step S**204** (No in S**204**; i.e., the value on the horizontal axis is equal to or smaller than A**1** in FIG. **10**), the decision part **62** decides to increase the supply amount of ammonia from the reductant supply part **40** (S**208**). This is because the fact that the first concentration is equal to or smaller than the second concentration means that NOx in the combustion exhaust gas has not been sufficiently decreased by reaction with ammonia and the ammonia supply is insufficient, thus requiring an increase in the supply amount of ammonia from the reductant supply part **40**.
[0080] Once the direction of increasing or decreasing ammonia is decided by the procedure of steps S**204** to S**208**, the reductant supply amount adjusting part **66** adjusts the supply amount of ammonia from the reductant supply part **40** so that, for example, the second concentration (NOx concentration at the outlet of the exhaust gas treatment apparatus **102**) is less than the control value C.sub.A (for example, by regulating the opening degree of the valve **48**) (S**210**).
[0081] Then return to step S**201** and repeat the same procedure.
[0082] According to the exhaust gas treatment method (e.g., the method shown in each flowchart of FIGS. **6** and **9**), since the concentrations (first concentration and second concentration) of NOx (specific substance) in the combustion exhaust gas upstream and downstream of the reductant decreasing catalyst **52**, which is disposed downstream of the first reduction catalyst **50**, are measured, even when ammonia (reductant) is excessively supplied to NOx to efficiently reduce NOx, it is possible to appropriately decide the direction of increase or decrease of the supply amount of ammonia (i.e., whether to increase or decrease the supply amount of ammonia) on the basis of measurement results of the first and second concentrations. Therefore, the amount supply of ammonia for reducing NOx can be appropriately adjusted with a simple configuration including the first concentration measuring part **72** and the second concentration measuring part **74**. Alternatively, the supply amount of ammonia for reducing NOx can be appropriately adjusted with a simple configuration that does not include a sensor for measuring the reductant concentration.
[0083] The contents described in the above embodiments would be understood as follows, for instance.
[0084] (1) An exhaust gas treatment apparatus (**102**) according to at least one embodiment of the present invention includes: a first reduction catalyst (**50**), disposed in a flow path (**32**) of combustion exhaust gas of a fuel, for promoting reduction reaction of a specific substance (e.g., NOx) contained in the combustion exhaust gas; a reductant supply part (**40**) for supplying a reductant (e.g., ammonia) for reducing the specific substance in the combustion exhaust gas, the reductant supply part being disposed upstream of the first reduction catalyst; a reductant decreasing catalyst (**52**) for decreasing the reductant in the combustion exhaust gas, the reductant decreasing catalyst being disposed downstream of the first reduction catalyst in the flow path; at least one second reduction catalyst (**54**) for promoting reduction reaction of the specific substance, the at least one second reduction catalyst being disposed downstream of the reductant decreasing catalyst in the flow path; a first concentration measuring part (**72**) for measuring a first concentration which is a concentration of the specific substance in the combustion exhaust gas in the flow path at a position downstream of the first reduction catalyst and upstream of the reductant decreasing catalyst; a second concentration measuring part (**76**) for measuring a second concentration which is a concentration of the specific substance in the combustion exhaust gas in the flow path at a position downstream of the reductant decreasing catalyst; and a decision part (**62**) configured to decide whether to increase or decrease a supply amount of the reductant from the reductant supply part, on the basis of the first concentration and the second concentration of the specific substance.
[0085] With the above configuration (1), since the first concentration measuring part and the second concentration measuring part for respectively measuring the concentrations (first concentration and second concentration) of the specific substance (substance to be reduced by the

reductant; e.g., nitrogen oxides (NOx)) in the combustion exhaust gas upstream and downstream of the reductant decreasing catalyst, which is disposed downstream of the first reduction catalyst, are provided, even when the reductant is excessively supplied to the specific substance, it is possible to appropriately decide the direction of increase or decrease of the supply amount of the reductant (i.e., whether to increase or decrease the supply amount of the reductant) on the basis of measurement results of the first and second concentrations. Therefore, the supply amount of the reductant to reduce the specific substance can be appropriately adjusted with a simple configuration including the first concentration measuring part and the second concentration measuring part.

[0086] (2) In some embodiments, in the above configuration (1), the exhaust gas treatment apparatus includes: a third concentration measuring part (**76**) for measuring a third concentration which is a concentration of the specific substance in the combustion exhaust gas in the flow path at a position downstream of the at least one second reduction catalyst; and a determination part (**64**) configured to determine whether it is necessary to adjust the supply amount of the reductant from the reductant supply part, on the basis of the third concentration.

[0087] With the above configuration (2), the third concentration of the specific substance in the combustion exhaust gas at a position downstream of the second reduction catalyst, which is disposed downstream of the reductant decreasing catalyst, (i.e., the concentration of the specific substance at the outlet of the exhaust gas treatment apparatus) is measured, and the necessity of adjusting the supply amount of the reductant is determined on the basis of the third concentration. Therefore, it is possible to decide whether to increase or decrease the supply amount of the reductant on the basis of the configuration (1), after determining the necessity of adjusting the supply amount of the reductant on the basis of the third concentration.

[0088] (3) In some embodiments, in the above configuration (2), the third concentration measuring part is disposed downstream of a most downstream second reduction catalyst of the at least one second reduction catalyst in the flow path.

[0089] With the above configuration (3), since the third concentration of the specific substance in the combustion exhaust gas at a position downstream of the most downstream second reduction catalyst of the at least one second reduction catalyst, (i.e., the concentration of the specific substance at the outlet of the exhaust gas treatment apparatus) is measured, it is possible to appropriately determine whether it is necessary to adjust the supply amount of the reductant on the basis of the third concentration.

[0090] (4) In some embodiments, in the above configuration (2) or (3), the exhaust gas treatment apparatus includes a reductant supply amount adjusting part (**66**) configured to adjust the supply amount of the reductant from the reductant supply part so that the third concentration is within a predetermined range.

[0091] With the above configuration (4), when the determination part determines that it is necessary to adjust the supply amount of the reductant from the reductant supply part, the reductant supply amount is adjusted so that the third concentration in the combustion exhaust gas is within the predetermined range (e.g., below a regulation value or control value). This allows the concentration of the specific substance in the combustion exhaust gas discharged from the exhaust gas treatment apparatus to be within an appropriate range.

[0092] (5) In some embodiments, in any one of the above configurations (2) to (4), the second concentration measuring part is disposed downstream of the at least one second reduction catalyst in the flow path.

[0093] With the above configuration (5), the second concentration measuring part is disposed downstream of the second reduction catalyst, as with the third concentration measuring part. Therefore, a measuring tool (e.g., concentration sensor) for measuring the concentration of the specific substance can be used as both the second concentration measuring part and the third concentration measuring part. Therefore, the supply amount of the reductant can be appropriately adjusted with a simpler configuration.

[0094] (6) In some embodiments, in any one of the above configurations (1) to (5), the decision part is configured to decide whether to increase or decrease the supply amount of the reductant, on the basis a comparison between the first concentration and the second concentration.
[0095] With the above configuration (6), it is possible to appropriately decide whether to increase or decrease the supply amount of the reductant, on the basis a comparison between the first concentration and the second concentration of the specific substance in the combustion exhaust gas. Therefore, the supply amount of the reductant to reduce the specific substance can be appropriately adjusted with a simple configuration including the first concentration measuring part and the second concentration measuring part.
[0096] (7) In some embodiments, in the above configuration (6), the decision part is configured to decide to decrease the supply amount of the reductant when the first concentration is smaller than the second concentration.
[0097] With the above configuration (7), when the first concentration of the specific substance in the combustion exhaust gas is smaller than the second concentration, it is decided to decrease the supply amount of the reductant. Thus, it is possible to appropriately adjust the supply amount of the reductant, on the basis a comparison between the first concentration and the second concentration.
[0098] In some embodiments, in the above configuration (6) or (7), the decision part is configured to decide to increase the supply amount of the reductant when the first concentration is equal to or greater than the second concentration.
[0099] With the above configuration (8), when the first concentration of the specific substance in the combustion exhaust gas is equal to or greater than the second concentration, it is decided to increase the supply amount of the reductant. Thus, it is possible to appropriately adjust the supply amount of the reductant, on the basis a comparison between the first concentration and the second concentration.
[0100] (9) In some embodiments, in the above configuration (1), the second concentration measuring part is disposed downstream of the at least one second reduction catalyst in the flow path. The exhaust gas treatment apparatus includes a determination part (**64**) configured to determine whether it is necessary to adjust the supply amount of the reductant from the reductant supply part, on the basis of the second concentration. The decision part is configured to, when the determination part determines that it is necessary to adjust the supply amount of the reductant, decide whether to increase or decrease the supply amount of the reductant from the reductant supply part, on the basis a comparison between the first concentration and a threshold.
[0101] With the above configuration (9), the necessity of adjusting the supply amount of the reductant is determined on the basis of the second concentration, and when it is necessary to adjust the supply amount of the reductant, it is possible to appropriately decide whether to increase or decrease the supply amount of the reductant on the basis of a comparison between the first concentration and the threshold. Therefore, the supply amount of the reductant to reduce the specific substance can be appropriately adjusted with a simple configuration including the first concentration measuring part and the second concentration measuring part.
[0102] (10) In some embodiments, in any one of the above configurations (1) to (9), the specific substance includes a nitrogen oxide.
[0103] With the above configuration (10), since the first concentration measuring part and the second concentration measuring part for respectively measuring the concentrations (first concentration and second concentration) of nitrogen oxides (NOx) in the combustion exhaust gas upstream and downstream of the reductant decreasing catalyst, which is disposed downstream of the first reduction catalyst, are provided, even when the reductant is excessively supplied to nitrogen oxides, it is possible to appropriately decide the direction of increase or decrease of the supply amount of the reductant (i.e., whether to increase or decrease the supply amount of the reductant) on the basis of measurement results of the first and second concentrations. Therefore, the supply amount of the reductant to reduce nitrogen oxides can be appropriately adjusted with a

simple configuration including the first concentration measuring part and the second concentration measuring part.
[0104] (11) In some embodiments, in the above configuration (10), the reductant includes ammonia or urea.
[0105] With the above configuration (11), since the first concentration measuring part and the second concentration measuring part for respectively measuring the concentrations (first concentration and second concentration) of nitrogen oxides (NOx) in the combustion exhaust gas upstream and downstream of the reductant decreasing catalyst, which is disposed downstream of the first reduction catalyst, are provided, even when ammonia or urea as the reductant is excessively supplied to nitrogen oxides, it is possible to appropriately decide the direction of increase or decrease of the supply amount of ammonia or urea (reductant) (i.e., whether to increase or decrease the supply amount of the reductant) on the basis of measurement results of the first and second concentrations. Therefore, the supply amount of ammonia or urea (reductant) to reduce nitrogen oxides can be appropriately adjusted with a simple configuration including the first concentration measuring part and the second concentration measuring part.
[0106] (12) A combustion facility (**1**) according to at least one embodiment of the present invention includes: a combustion apparatus (**100**) configured to burn a fuel; and the exhaust gas treatment apparatus (**102**) described in any one of the above (1) to (11) configured to treat combustion exhaust gas of the fuel from the combustion apparatus.
[0107] With the above configuration (12), since the first concentration measuring part and the second concentration measuring part for respectively measuring the concentrations (first concentration and second concentration) of the specific substance (substance to be reduced by the reductant; e.g., nitrogen oxides (NOx)) in the combustion exhaust gas upstream and downstream of the reductant decreasing catalyst, which is disposed downstream of the first reduction catalyst, are provided, even when the reductant is excessively supplied to the specific substance, it is possible to appropriately decide the direction of increase or decrease of the supply amount of the reductant (i.e., whether to increase or decrease the supply amount of the reductant) on the basis of measurement results of the first and second concentrations. Therefore, the supply amount of the reductant to reduce the specific substance can be appropriately adjusted with a simple configuration including the first concentration measuring part and the second concentration measuring part.
[0108] (13) A power generation facility according to at least one embodiment of the present invention includes: the combustion facility (**1**) described in (12); a turbine (**14** or **20**) configured to be driven by the combustion exhaust gas from the combustion apparatus or steam produced by using heat of the combustion exhaust gas from the combustion apparatus; and a generator (**18** or **24**) configured to be driven by the turbine.
[0109] With the above configuration (13), since the first concentration measuring part and the second concentration measuring part for respectively measuring the concentrations (first concentration and second concentration) of the specific substance (substance to be reduced by the reductant; e.g., nitrogen oxides (NOx)) in the combustion exhaust gas upstream and downstream of the reductant decreasing catalyst, which is disposed downstream of the first reduction catalyst, are provided, even when the reductant is excessively supplied to the specific substance, it is possible to appropriately decide the direction of increase or decrease of the supply amount of the reductant (i.e., whether to increase or decrease the supply amount of the reductant) on the basis of measurement results of the first and second concentrations. Therefore, the supply amount of the reductant to reduce the specific substance can be appropriately adjusted with a simple configuration including the first concentration measuring part and the second concentration measuring part.
[0110] (14) An exhaust gas treatment method according to at least one embodiment of the present invention is an exhaust gas treatment method using an exhaust gas treatment apparatus (**102**) that includes: a first reduction catalyst (**50**), disposed in a flow path (**32**) of combustion exhaust gas of a fuel, for promoting reduction reaction of a specific substance contained in the combustion exhaust

gas; a reductant supply part (**40**) for supplying a reductant for reducing the specific substance in the combustion exhaust gas, the reductant supply part being disposed upstream of the first reduction catalyst; a reductant decreasing catalyst (**52**) for decreasing the reductant in the combustion exhaust gas, the reductant decreasing catalyst being disposed downstream of the first reduction catalyst in the flow path; and at least one second reduction catalyst (**54**) for promoting reduction reaction of the specific substance, the at least one second reduction catalyst being disposed downstream of the reductant decreasing catalyst in the flow path. The exhaust gas treatment method includes: a step of measuring a first concentration which is a concentration of the specific substance in the combustion exhaust gas in the flow path at a position downstream of the first reduction catalyst and upstream of the reductant decreasing catalyst; a step of measuring a second concentration which is a concentration of the specific substance in the combustion exhaust gas in the flow path at a position downstream of the reductant decreasing catalyst; and a step of deciding whether to increase or decrease a supply amount of the reductant from the reductant supply part, on the basis of the first concentration and the second concentration of the specific substance.

[0111] With the above method (**14**), since the concentrations (first concentration and second concentration) of the specific substance (substance to be reduced by the reductant; e.g., nitrogen oxides (NOx)) in the combustion exhaust gas upstream and downstream of the reductant decreasing catalyst, which is disposed downstream of the first reduction catalyst, are measured, even when the reductant is excessively supplied to the specific substance, it is possible to appropriately decide the direction of increase or decrease of the supply amount of the reductant (i.e., whether to increase or decrease the supply amount of the reductant) on the basis of measurement results of the first and second concentrations. Therefore, the supply amount of the reductant to reduce the specific substance can be appropriately adjusted with a simple configuration capable of measuring the first concentration and the second concentration.

[0112] 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.

[0113] 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.

[0114] 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.

[0115] 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.

[0116] On the other hand, an expression such as “comprise”, “include”, and “have” are not intended to be exclusive of other components.

REFERENCE SIGNS LIST

[0117] **1** Combustion facility [0118] **2** Gas turbine facility [0119] **4** Steam turbine facility [0120] **6** Heat recovery steam generator [0121] **10** Compressor [0122] **12** Combustor [0123] **14** Turbine [0124] **16** Rotational shaft [0125] **18** Generator [0126] **20** Turbine [0127] **22** Rotational shaft [0128] **24** Generator [0129] **26** Condenser [0130] **30** Duct [0131] **32** Flow path [0132] **34** Heat transfer tube [0133] **38** Stack [0134] **40** Reductant supply part [0135] **42** Nozzle [0136] **44** Reductant storage part [0137] **46** Supply line [0138] **48** Valve [0139] **50** First reduction catalyst [0140] **52**, **52**A to **52**C Reductant decreasing catalyst [0141] **54**, **54**A to **54**C Second reduction catalyst [0142] **60** Control device [0143] **62** Decision part [0144] **64** Determination part [0145] **66** Reductant supply amount adjusting part [0146] **72** First concentration measuring part [0147] **74** Second concentration measuring part [0148] **76** Third concentration measuring part [0149] **82**

Fourth concentration measuring part [0150] **100** Combustion apparatus [0151] **102** Exhaust gas treatment apparatus

Claims

1. An exhaust gas treatment apparatus, comprising: a first reduction catalyst, disposed in a flow path of combustion exhaust gas of a fuel, for promoting reduction reaction of a specific substance contained in the combustion exhaust gas; a reductant supply part for supplying a reductant for reducing the specific substance in the combustion exhaust gas, the reductant supply part being disposed upstream of the first reduction catalyst; a reductant decreasing catalyst for decreasing the reductant in the combustion exhaust gas, the reductant decreasing catalyst being disposed downstream of the first reduction catalyst in the flow path; at least one second reduction catalyst for promoting reduction reaction of the specific substance, the at least one second reduction catalyst being disposed downstream of the reductant decreasing catalyst in the flow path; a first concentration measuring part for measuring a first concentration which is a concentration of the specific substance in the combustion exhaust gas in the flow path at a position downstream of the first reduction catalyst and upstream of the reductant decreasing catalyst; a second concentration measuring part for measuring a second concentration which is a concentration of the specific substance in the combustion exhaust gas in the flow path at a position downstream of the reductant decreasing catalyst; and a decision part configured to decide whether to increase or decrease a supply amount of the reductant from the reductant supply part, on the basis of the first concentration and the second concentration of the specific substance.
2. The exhaust gas treatment apparatus according to claim 1, comprising: a third concentration measuring part for measuring a third concentration which is a concentration of the specific substance in the combustion exhaust gas in the flow path at a position downstream of the at least one second reduction catalyst; and a determination part configured to determine whether it is necessary to adjust the supply amount of the reductant from the reductant supply part, on the basis of the third concentration.
3. The exhaust gas treatment apparatus according to claim 2, wherein the third concentration measuring part is disposed downstream of a most downstream second reduction catalyst of the at least one second reduction catalyst in the flow path.
4. The exhaust gas treatment apparatus according to claim 2, comprising a reductant supply amount adjusting part configured to adjust the supply amount of the reductant from the reductant supply part so that the third concentration is within a predetermined range.
5. The exhaust gas treatment apparatus according to claim 2, wherein the second concentration measuring part is disposed downstream of the at least one second reduction catalyst in the flow path.
6. The exhaust gas treatment apparatus according to claim 1, wherein the decision part is configured to decide whether to increase or decrease the supply amount of the reductant, on the basis a comparison between the first concentration and the second concentration.
7. The exhaust gas treatment apparatus according to claim 6, wherein the decision part is configured to decide to decrease the supply amount of the reductant when the first concentration is smaller than the second concentration.
8. The exhaust gas treatment apparatus according to claim 6, wherein the decision part is configured to decide to increase the supply amount of the reductant when the first concentration is equal to or greater than the second concentration.
9. The exhaust gas treatment apparatus according to claim 1, wherein the second concentration measuring part is disposed downstream of the at least one second reduction catalyst in the flow path, wherein the exhaust gas treatment apparatus comprises a determination part configured to determine whether it is necessary to adjust the supply amount of the reductant from the reductant

supply part, on the basis of the second concentration, and wherein the decision part is configured to, when the determination part determines that it is necessary to adjust the supply amount of the reductant, decide whether to increase or decrease the supply amount of the reductant from the reductant supply part, on the basis a comparison between the first concentration and a threshold.

10. The exhaust gas treatment apparatus according to claim 1, wherein the specific substance includes a nitrogen oxide.

11. The exhaust gas treatment apparatus according to claim 10, wherein the reductant includes ammonia or urea.

12. A combustion facility, comprising: a combustion apparatus configured to burn a fuel; and an exhaust gas treatment apparatus according to claim 1 configured to treat combustion exhaust gas of the fuel from the combustion apparatus.

13. A power generation facility, comprising: a combustion facility according to claim **12**; a turbine configured to be driven by the combustion exhaust gas from the combustion apparatus or steam produced by using heat of the combustion exhaust gas from the combustion apparatus; and a generator configured to be driven by the turbine.

14. An exhaust gas treatment method using an exhaust gas treatment apparatus that includes: a first reduction catalyst, disposed in a flow path of combustion exhaust gas of a fuel, for promoting reduction reaction of a specific substance contained in the combustion exhaust gas; a reductant supply part for supplying a reductant for reducing the specific substance in the combustion exhaust gas, the reductant supply part being disposed upstream of the first reduction catalyst; a reductant decreasing catalyst for decreasing the reductant in the combustion exhaust gas, the reductant decreasing catalyst being disposed downstream of the first reduction catalyst in the flow path; and at least one second reduction catalyst for promoting reduction reaction of the specific substance, the at least one second reduction catalyst being disposed downstream of the reductant decreasing catalyst in the flow path, the exhaust gas treatment method comprising: a step of measuring a first concentration which is a concentration of the specific substance in the combustion exhaust gas in the flow path at a position downstream of the first reduction catalyst and upstream of the reductant decreasing catalyst; a step of measuring a second concentration which is a concentration of the specific substance in the combustion exhaust gas in the flow path at a position downstream of the reductant decreasing catalyst; and a step of deciding whether to increase or decrease a supply amount of the reductant from the reductant supply part, on the basis of the first concentration and the second concentration of the specific substance.