DESCRIPTION

Title of Invention

NONCATALYTIC DENITRATION SYSTEM, COMBUSTION EQUIPMENT, DENITRATION METHOD, AND EXPANSION NOZZLE

[Technical Field]

[0001]

The present disclosure relates to a noncatalytic denitration system, combustion equipment, a denitration method, and an expansion nozzle.

This application claims the priority of Japanese Patent Application No. 2023-051311 filed in Japan on March 28, 2023, the content of which is incorporated herein by reference.

[Background Art]

[0002]

Patent Document 1 discloses a noncatalytic denitration apparatus that performs denitration by using urea water or ammonia water as a denitration agent for a gas inside a boiler. In the noncatalytic denitration apparatus, denitration agent blowing nozzles for blowing a denitration agent into the boiler are arranged at a plurality of locations having different heights. Depending on an operation load situation of the boiler, the denitration agent blowing nozzle located at a height position where reaction efficiency of the denitration agent is maximized is obtained from the plurality of denitration agent blowing nozzles, and the denitration agent is blown only by using the obtained denitration agent blowing nozzle. In this manner, a decrease in denitration efficiency is prevented.

[0003]

Patent Document 2 discloses combustion equipment as follows. A nitrogen oxide concentration corresponding to an obtained exhaust gas amount is obtained by using a relationship between the exhaust gas amount at a position in front of reducing agent supply actually measured in advance in a combustion furnace and the nitrogen oxide concentration on a combustion furnace outlet side. A denitration rate is obtained, based on the obtained nitrogen oxide concentration and the nitrogen oxide concentration as a target value. A supply amount of the reducing agent is determined, based on data indicating a relationship between the denitration rate obtained in advance and an equivalent ratio (reducing agent/nitrogen oxide) of the reducing agent for achieving the denitration rate. In this combustion equipment, a plurality of supplying nozzles are disposed at a plurality of locations (for example, three locations) at a distance in a range of 1 to 3 m in a flow direction of an exhaust gas, and the supplying nozzle to be used is selected from the plurality of supplying nozzles depending on a combustion load.

[Citation List]

[Patent Document]

[0004]

[Patent Document 1] Japanese Unexamined Patent Application Publication No. 2006-64291

[Patent Document 2] Japanese Patent No. 6049809

[Summary of Invention]

[Technical Subject]

[0005]

However, when a plurality of nozzles selected depending on a situation are disposed as in Patent Document 1 or Patent Document 2, in some cases, a disposition of

the plurality of nozzles or construction of a peripheral structure relating to the disposition of the plurality of nozzles may be complicated.

[0006]

The present disclosure is made to solve the above-described subject, and aims to provide a noncatalytic denitration system, combustion equipment, a denitration method, and an expansion nozzle, which can improve constructability.

[Subject to be solved]

[0007]

According to the present disclosure, in order to solve the above-described subject, there is provided a noncatalytic denitration system. The noncatalytic denitration system includes a denitration agent supply unit installed in a flow path through which a combustion gas flows in combustion equipment and including a nozzle configured to adjust a discharge angle of a denitration agent with respect to a flow direction of the combustion gas, and a control unit that controls the discharge angle of the nozzle, based on information relating to a temperature of the combustion gas.

[0008]

According to the present disclosure, in order to solve the above-described subject, there is provided combustion equipment including a flow path through which a combustion gas flows, and a noncatalytic denitration system. The noncatalytic denitration system includes a denitration agent supply unit installed in the flow path and including a nozzle configured to adjust a discharge angle of the denitration agent with respect to a flow direction of the combustion gas, and a control unit that controls the discharge angle of the nozzle based on information relating to a temperature of the combustion gas.

[0009]

According to the present disclosure, in order to solve the above-described subject, there is provided a denitration method of discharging a denitration agent into a flow path through which a combustion gas flows in combustion equipment. The denitration method includes changing a discharge angle with respect to a flow direction of the combustion gas, the discharge angle at which the denitration agent is discharged from a nozzle, based on information relating to a temperature of the combustion gas.

[0010]

According to the present disclosure, in order to solve the above-described subject, there is provided an expansion nozzle including a stationary portion connectable to a pipe portion to which a denitration agent is supplied in combustion equipment, a movable portion including a nozzle pivotally connected to the stationary portion and configured to discharge the denitration agent flowing from the pipe portion to the stationary portion to an outside, and an adjustment mechanism configured to adjust an angle of the movable portion with respect to the stationary portion.

[Advantageous Effects of Invention]

[0011]

According to the noncatalytic denitration system, the combustion equipment, the denitration method, and the expansion nozzle in the present disclosure, constructability can be improved.

[Brief Description of Drawings]

[0012]

Fig. 1 is a view showing an overall configuration of combustion equipment of a first embodiment of the present disclosure.

Fig. 2 is an enlarged perspective view showing a region surrounded by a line F2 in Fig. 1.

Fig. 3 is a sectional view showing a nozzle of the first embodiment of the present disclosure.

Fig. 4 is a sectional view showing the nozzle of the first embodiment of the present disclosure.

Fig. 5 is a block diagram showing a functional configuration relating to denitration in the first embodiment of the present disclosure.

Fig. 6 is a view showing a relationship between a reaction temperature and a denitration rate in the first embodiment of the present disclosure.

Fig. 7 is a view for describing control of a discharge angle of the first embodiment of the present disclosure.

Fig. 8 is a flowchart showing a control flow of the first embodiment of the present disclosure.

Fig. 9 is a view for describing an operational effect of discharge angle adjustment of the first embodiment of the present disclosure.

Fig. 10 is a sectional view showing a nozzle of a modification example of the first embodiment of the present disclosure.

Fig. 11 is a perspective view showing a furnace of a second embodiment of the present disclosure.

Fig. 12 is a view for describing another aspect of a temperature measurement unit of the second embodiment of the present disclosure.

Fig. 13 is a view for describing an infrared image of the second embodiment of the present disclosure.

Fig. 14 is a block diagram showing a functional configuration relating to denitration in the second embodiment of the present disclosure.

Fig. 15 is a view for describing control of a discharge amount in the second

embodiment of the present disclosure.

Fig. 16 is a flowchart showing a control flow of the second embodiment of the present disclosure.

Fig. 17 is a view for describing an operational effect of discharge amount adjustment in the second embodiment of the present disclosure.

Fig. 18 is a hardware configuration diagram showing a computer configuration of an embodiment of the present disclosure.

[Description of Embodiments]

[0013]

Hereinafter, embodiments of the present disclosure will be described with reference to the drawings. In the following description, the same reference numerals are assigned to configurations having the same or similar functions. Repeated description of the configurations may be omitted. In the present disclosure, "based on XX" means "at least based on XX", and may include a case where one element exists based on another element in addition to XX. In addition, "based on XX" is not limited to a case where XX is directly used, and may also include a case where calculation or processing is performed on XX. In the present disclosure, "XX or YY" is not limited to a case of either XX or YY, and may also include a case of both XX and YY. The same applies to a case where the number of selective elements is three or more. "XX" and "YY" are any elements (for example, any information).

[0014]

In the embodiments described below, for convenience of description, a side from a furnace body 20 to a hopper 11 (to be described later) is defined as “front”, and a direction opposite thereto is defined as “rear”. In addition, “left” and “right” are defined with reference to a direction from the furnace body 20 toward the hopper 11.

[0015]

(First Embodiment)

<1. Overall Configuration of Incineration Equipment>

Fig. 1 is a view showing an overall configuration of combustion equipment 1 according to the first embodiment. For example, the combustion equipment 1 is incineration equipment that uses municipal waste, industrial waste, biomass, or the like as an incineration target G. Hereinafter, for convenience of description, the "incineration target G" will be referred to as "refuse G". For example, the combustion equipment 1 is a stoker furnace. The combustion equipment 1 is not limited to the stoker furnace, and may be combustion equipment of a different type. In the present embodiment, for example, the combustion equipment 1 includes an incinerator 2, a heat recovery steam generator 3, a temperature reduction tower 4, a dust collector 5, a flue 6, a chimney 7, and a control device 100.

[0016]

The incinerator 2 is a furnace that combusts the refuse G while transporting the refuse G loaded into the hopper 11 (to be described later). The incinerator 2 generates an exhaust gas as a result of combustion of the refuse G inside the incinerator 2. The generated exhaust gas is fed to the heat recovery steam generator 3 provided in an upper portion of the incinerator 2. The heat recovery steam generator 3 heats water by exchanging heat between the exhaust gas generated in the incinerator 2 and the water, and generates steam. The exhaust gas passing through the heat recovery steam generator 3 is cooled at the temperature reduction tower 4, and thereafter, is fed to the dust collector 5. The exhaust gas is discharged to an atmosphere through the flue 6 and the chimney 7 after soot or dust is removed by the dust collector 5.

[0017]

<2. Incinerator>

Next, the incinerator 2 will be described in detail. For example, the incinerator 2 includes a supply mechanism 10, a furnace body 20, a stoker 30, a plurality of wind boxes 41, a discharge chute 42, a furnace 43, and a blowing mechanism 50.

[0018]

(Supply Mechanism)

The supply mechanism 10 is a mechanism that temporarily stores the refuse G delivered by a crane (not shown) and sequentially supplies the refuse G toward a treatment space V of the furnace body 20 (to be described later). For example, the supply mechanism 10 includes, the hopper 11 and a feeder 12.

[0019]

The hopper 11 is a storage portion provided to supply the refuse G into the furnace body 20. The refuse G delivered by the crane (not shown) is loaded into the hopper 11. The hopper 11 has an inlet portion 11a into which the refuse G is loaded from the outside and an outlet portion 11b that guides the supplied refuse G toward the treatment space V inside the furnace body 20 (to be described later).

[0020]

The feeder 12 is provided in the outlet portion 11b of the hopper 11. The feeder 12 has a plate shape along a bottom portion of the outlet portion 11b of the hopper 11, and is disposed along the bottom portion of the outlet portion 11b of the hopper 11. The feeder 12 is driven by an extruding device (not shown), and extrudes the refuse G accumulated inside the hopper 11 toward the treatment space V of the furnace body 20.

[0021]

(Furnace Body)

The furnace body 20 is equipment provided adjacent to the hopper 11 and

combusting the refuse G while transporting the refuse G. Hereinafter, a transport direction of the refuse G in the combustion equipment 1 will be referred to as a "transport direction D". The furnace body 20 includes a drying stage 20a, a combustion stage 20b, and a post-combustion stage 20c in this order from an upstream side toward a downstream side in the transport direction D. The drying stage 20a is a region where the refuse G supplied from the hopper 11 is dried prior to the combustion on the stoker 30. The combustion stage 20b and the post-combustion stage 20c are regions where the refuse G in a dried state after passing through the drying stage 20a is combusted on the stoker 30. In the combustion stage 20b, diffusion combustion occurs due to a thermal decomposition gas generated from the refuse G, and a luminous flame F is generated. In the post-combustion stage 20c, fixed carbon combustion occurs after the diffusion combustion of the refuse G. Therefore, the luminous flame F is not generated. The combustion stage 20b and the post-combustion stage 20c are examples of the treatment space V for combusting the refuse G.

[0022]

(Stoker)

The stoker 30 includes a plurality of fire grates 31. The plurality of fire grates 31 form a stoker surface 30a that serves as a bottom surface (for example, a bottom surface of the treatment space V) of the furnace body 20. The refuse G is supplied in a layered shape to the stoker surface 30a by the supply mechanism 10. The stoker surface 30a is provided over the drying stage 20a, the combustion stage 20b, and the post-combustion stage 20c which are described above. The plurality of fire grates 31 include a fixed fire grate and a movable fire grate. The fixed fire grate is fixed to an upper surface of the wind box 41 (to be described later). The movable fire grate reciprocates along the transport direction D at a constant speed. In this manner, the

refuse G is transported to the downstream side while the refuse G located on the movable fire grate and the fixed fire grate (on the stoker surface 30a) is stirred and mixed.

[0023]

(Wind Boxes)

The wind box 41 is provided below the stoker 30, and supplies combustion air into the furnace body 20 through the stoker 30. A plurality of the wind boxes 41 are arranged in the transport direction D.

[0024]

(Discharge Chute)

The discharge chute 42 is a device that drops the refuse G completely combusted and turned into ash to an ash extrusion device located below the furnace body 20. The discharge chute 42 is provided in a furnace back end of the furnace body 20.

[0025]

(Furnace)

The furnace 43 extends upward from an upper portion of the furnace body 20. The exhaust gas generated by the combustion of the refuse G inside the treatment space V is fed to the heat recovery steam generator 3 through the furnace 43. The exhaust gas is an example of a "combustion gas". The furnace 43 is an example of a “flow path through which the combustion gas flows”. The furnace 43 will be described in detail later.

[0026]

(Blowing Mechanism)

The blowing mechanism 50 supplies air (for example, combustion air) into the furnace body 20. For example, the blowing mechanism 50 includes a blower 51, a primary air line 52, an air preheater 53, a secondary air line 54, and a damper 55.

[0027]

The blower 51 is a pressure blower that pumps the air (for example, the combustion air) into the furnace body 20. For example, the blower 51 includes a first blower 51A and a second blower 51B. The first blower 51A pumps the combustion air into the furnace body 20 (for example, the treatment space V) through the primary air line 52 and the wind box 41. The second blower 51B pumps the combustion air into the furnace 43 through the secondary air line 54.

[0028]

The primary air line 52 connects the first blower 51A and the wind box 41. One or more (for example, a plurality of) primary air dampers 55A are provided in an intermediate portion of the primary air line 52. The primary air damper 55A changes a flow rate of the combustion air flowing through the primary air line 52 in accordance with an opening degree of the primary air damper 55A. The air preheater 53 is a heat exchanger that preheats the air pumped from the first blower 51A. For example, the air preheater 53 is provided in an intermediate portion of the primary air line 52.

[0029]

The secondary air line 54 connects the second blower 51B and the furnace 43. Secondary air supplied into the furnace 43 moves toward the refuse G from above the stoker 30. One or more (for example, a plurality of) secondary air dampers 55B are provided in an intermediate portion of the secondary air line 54. The secondary air damper 55B changes a flow rate of the combustion air flowing through the secondary air line 54 in accordance with an opening degree of the secondary air damper 55B. In the present embodiment, the primary air damper 55A and the secondary air damper 55B will be collectively referred to as a “damper 55”.

[0030]

<3. Heat Recovery Steam Generator>

Next, the heat recovery steam generator 3 will be described. For example, the heat recovery steam generator 3 includes a boiler body 61 and a pipe channel 62. The boiler body 61 is connected to the furnace 43 of the incinerator 2. The exhaust gas generated in the incinerator 2 flows into the boiler body 61. The pipe channel 62 extends inside the boiler body 61. The pipe channel 62 is provided with a plurality of superheaters and a plurality of temperature reducers. Water is supplied from a water supply unit to an inlet portion of the pipe channel 62. At least a portion of the water flowing through the pipe channel 62 is heated by heat exchange inside the boiler body 61, and flows toward an external device (for example, a turbine) as main steam.

[0031]

<4. Furnace>

Next, the furnace 43 will be described in detail.

Fig. 2 is an enlarged perspective view showing a region surrounded by a line F2 in Fig. 1. In the present embodiment, for example, the furnace 43 includes a furnace wall 70, a plurality of nozzles 80, and a temperature measurement unit 90.

[0032]

(Furnace wall)

The furnace wall 70 forms a flow path through which the exhaust gas flows in the furnace 43. For example, the furnace wall 70 is formed in a cylindrical shape defined by a front wall 71, a rear wall 72, a left wall 73, and a right wall 74, and extends in a vertical direction. The furnace wall 70 is formed of a refractory material.

[0033]

(Nozzle)

The plurality of nozzles 80 are nozzles that discharge a denitration agent into

the furnace 43. For example, the denitration agent is an ammonia gas, but may be ammonia water, a urea gas, urea water, or the like. The plurality of nozzles 80 include a plurality of nozzles 81 (for example, four nozzles 81A to 81D) included in a first group G1 and a plurality of nozzles 82 (for example, four nozzles 82A to 82D) included in a second group G2. Hereinafter, when the nozzles 81A to 81D and the nozzles 82A to 82D are not distinguished, the nozzles 81A to 81D and the nozzles 82A to 82D will be simply referred to as a "nozzle 80".

[0034]

The plurality of nozzles 81 included in the first group G1 are disposed at a first height H1 in the furnace 43. For example, the first height H1 is a position where a height from a certain reference surface (for example, the stoker surface 30a) is 9 m. However, the first height H1 is not limited to the height of the above-described specific example. The nozzles 81A and 81B are provided on the left wall 73 of the furnace 43, and discharge the denitration agent into the furnace 43 from the left wall 73. On the other hand, the nozzle 81C and the nozzle 81D are provided on the right wall 74 of the furnace 43, and discharge the denitration agent into the furnace 43 from the right wall 74.

[0035]

In addition, from another viewpoint, when viewed from above, the nozzles 81A and 81C are disposed corresponding to a front space FS (refer to Fig. 1) located on a front side with respect to a center in an internal space of the furnace 43, and discharge the denitration agent to the front space FS. On the other hand, when viewed from above, the nozzle 81B and the nozzle 81D are disposed corresponding to a rear space BS (refer to Fig. 1) located on a rear side of the center in the internal space of the furnace 43, and discharge the denitration agent to the rear space BS.

[0036]

The plurality of nozzles 82 included in the second group G2 are disposed at a second height H2 different from the first height H1 in the furnace 43. For example, the second height H2 is a position where the height from the reference surface is 11 m. However, the second height H2 is not limited to the height of the above-described specific example. The nozzles 82A and 82B are provided on the left wall 73 of the furnace 43, and discharge the denitration agent into the furnace 43 from the left wall 73. On the other hand, the nozzle 82C and the nozzle 82D are provided on the right wall 74 of the furnace 43, and discharge the denitration agent into the furnace 43 from the right wall 74.

[0037]

In addition, from another viewpoint, when viewed from above, the nozzles 82A and 82C are disposed corresponding to the front space FS (refer to Fig. 1) in the internal space of the furnace 43, and discharge the denitration agent to the front space FS. On the other hand, when viewed from above, the nozzle 82B and the nozzle 82D are disposed corresponding to the rear space BS (refer to Fig. 1) in the internal space of the furnace 43, and discharge the denitration agent to the rear space BS.

[0038]

However, the disposition and the number of the nozzles 80 are not limited to the above-described example. At least one of the nozzles 80 may be provided. In the present embodiment, each of the nozzles 81A to 81D and the nozzles 82A to 82D is an example of a “first nozzle”.

[0039]

(Temperature Measurement Unit)

The temperature measurement unit 90 is a temperature measurement unit that

measures a temperature (temperature of the exhaust gas) inside the furnace 43. For example, the temperature measurement unit 90 includes a first temperature measurement unit 91 and a second temperature measurement unit 92. For example, the first temperature measurement unit 91 is a temperature sensor (for example, a thermocouple) provided at the first height H1, and measures the temperature of the exhaust gas at the first height H1. For example, the second temperature measurement unit 92 is a temperature sensor (for example, a thermocouple) provided at the second height H2, and measures the temperature of the exhaust gas at the second height H2.

[0040]

However, the disposition and the number of the first temperature measurement unit 91 and the second temperature measurement unit 92 are not limited to the above-described example. For example, the first temperature measurement unit 91 and the second temperature measurement unit 92 may be disposed at height positions different from the first height H1 and the second height H2. In addition, any one of the first temperature measurement unit 91 and the second temperature measurement unit 92 may be omitted. In addition, each of the first temperature measurement unit 91 and the second temperature measurement unit 92 is not limited to the thermocouple. Each of the first temperature measurement unit 91 and the second temperature measurement unit 92 may be a measurement unit which can measure the temperature of the exhaust gas, and may be an infrared camera or the like.

[0041]

<5. Noncatalytic Denitration System>

In the present embodiment, the combustion equipment 1 includes a noncatalytic denitration system 200. The noncatalytic denitration system 200 includes a denitration agent supply unit 210 and a nozzle angle control unit 110 (refer to Fig. 5) (to be described

later).

[0042]

For example, the denitration agent supply unit 210 includes the nozzle 80 described above, a denitration agent supply line 211, and a pressure feeder 212. The denitration agent supply line 211 is connected to each of the nozzles 80. The pressure feeder 212 is connected to each of the nozzles 80 through the denitration agent supply line 211. The pressure feeder 212 pumps the denitration agent to each of the nozzles 80 through the denitration agent supply line 211.

[0043]

<6. Structure of Nozzle>

Next, a structure of the nozzle 80 will be described in detail.

Figs. 3 and 4 are sectional views showing the nozzle 80. In the present embodiment, the nozzle 80 has a structure which can adjust a discharge angle of the denitration agent with respect to the flow direction of the exhaust gas. In the present embodiment, the flow direction of the exhaust gas is a vertical direction from a lower side to an upper side. The nozzle 80 has a structure which can adjust a discharge angle (that is, an angle in an up-down direction) of the denitration agent with respect to the vertical direction. For example, the nozzle 80 includes a pipe portion 85, a stationary portion 86, a movable portion 87, and an adjustment mechanism 88.

[0044]

(Pipe Portion)

The pipe portion 85 is fixed to the furnace wall 70, and the denitration agent is supplied from the denitration agent supply line 211. For example, the pipe portion 85 is formed from a straight pipe, and linearly extends in a horizontal direction toward the inside of the furnace 43. For example, the pipe portion 85 passes through a hole portion

70h provided on the furnace wall 70.

[0045]

(Stationary Portion)

The stationary portion 86 is a portion that supports the movable portion 87 to be pivotable. The stationary portion 86 is provided between the pipe portion 85 and the movable portion 87, and is connected to the pipe portion 85.

[0046]

For example, the stationary portion 86 has a spherical or cylindrical outer shape. That is, when viewed in a cross section along the vertical direction (cross section shown in Fig. 3), an outer shape of the stationary portion 86 includes a first arc portion 86a and a second arc portion 86b. The first arc portion 86a is an arc portion located in a lower end portion of the stationary portion 86 and protruding downward. The second arc portion 86b is an arc portion located in an upper end portion of the stationary portion 86 and protruding upward.

[0047]

The stationary portion 86 internally has a space. The inside of the stationary portion 86 communicates with the inside of the pipe portion 85, and the denitration agent passing through the pipe portion 85 flows into the stationary portion 86. The stationary portion 86 includes an opening portion 86h through which the denitration agent flowing into the stationary portion 86 passes toward the movable portion 87.

[0048]

(Movable Portion)

The movable portion 87 is a portion connected to the stationary portion 86 to be pivotable, and capable of discharging the denitration agent to the outside. The movable portion 87 is disposed in a tip portion of the nozzle 80, and faces the inside of the furnace

43. For example, the movable portion 87 is connected to the stationary portion 86 to be pivotable via a pivoting axis 87j along the horizontal direction. The movable portion 87 is pivotable obliquely upward and obliquely downward with respect to the stationary portion 86.

[0049]

For example, the movable portion 87 has a spherical or cylindrical outer shape along an outer surface (or an inner surface) of the stationary portion 86. That is, when viewed in a cross section along the vertical direction (cross section shown in Fig. 3), an outer shape of the movable portion 87 includes a third arc portion 87a and a fourth arc portion 87b. The third arc portion 87a is an arc portion located in a lower end portion of the movable portion 87 and protruding downward. The fourth arc portion 87b is an arc portion located in an upper end portion of the movable portion 87 and protruding upward. In the present embodiment, the third arc portion 87a of the movable portion 87 slides along the first arc portion 86a of the stationary portion 86, and the fourth arc portion 87b of the movable portion 87 slides along the second arc portion 86b of the stationary portion 86. In this manner, the movable portion 87 is pivotable obliquely upward and obliquely downward with respect to the stationary portion 86. According to this configuration, a connection portion between the stationary portion 86 and the movable portion 87 is sealed in a planar shape, and thus, a leakage of the denitration agent from the connection portion between the stationary portion 86 and the movable portion 87 is suppressed.

[0050]

The movable portion 87 internally has a space. The inside of the movable portion 87 communicates with the inside of the stationary portion 86, and the denitration agent passing through the stationary portion 86 flows into the movable portion 87. The

movable portion 87 includes a discharge port 87h that discharges the denitration agent flowing into the movable portion 87 toward the inside of the furnace 43 (that is, toward the exhaust gas).

[0051]

(Adjustment Mechanism)

The adjustment mechanism 88 is a mechanism capable of adjusting an angle (that is, a pivoting position) of the movable portion 87 with respect to the stationary portion 86. For example, the adjustment mechanism 88 includes a first wire 88a, a second wire 88b, a first retraction portion 88c, and a second retraction portion 88d.

[0052]

The first wire 88a is connected to the third arc portion 87a of the movable portion 87. For example, the first wire 88a extends to the outside of the furnace wall 70 through a gap between an outer peripheral surface of the pipe portion 85 and an inner peripheral surface of the hole portion 70h of the furnace wall 70.

[0053]

The second wire 88b is connected to the fourth arc portion 87b of the movable portion 87. For example, the second wire 88b extends to the outside of the furnace wall 70 through a gap between the outer peripheral surface of the pipe portion 85 and the inner peripheral surface of the hole portion 70h of the furnace wall 70.

[0054]

The first retraction portion 88c is connected to the first wire 88a. For example, the first retraction portion 88c includes a drive device such as a motor. The first retraction portion 88c releases holding of the first wire 88a in a standby state where a predetermined control command is not issued from the control device 100. On the other hand, when the first retraction portion 88c receives the predetermined control

command from the control device 100, the first retraction portion 88c retracts the first wire 88a toward the outside of the furnace wall 70. In this manner, the movable portion 87 pivots downward with respect to the stationary portion 86. As a result, a discharge direction of the denitration agent is directed obliquely downward (refer to Fig. 4).

[0055]

Here, the hole portion 70h of the furnace wall 70 includes an enlarged diameter portion 70ha (for example, a chamfered portion) in which an internal space of the hole portion 70h is enlarged in a pivoting range of the movable portion 87. In this manner, even when the movable portion 87 pivots, the movable portion 87 and the furnace wall 70 are prevented from coming into contact with each other.

[0056]

The second retraction portion 88d is connected to the second wire 88b. For example, the second retraction portion 88d includes a drive device such as a motor. The second retraction portion 88d releases holding of the second wire 88b in a standby state where the predetermined control command is not issued from the control device 100. On the other hand, when the second retraction portion 88d receives the predetermined control command from the control device 100, the second retracting portion 88d retracts the second wire 88b outward of the furnace wall 70. In this manner, the movable portion 87 pivots upward with respect to the stationary portion 86. As a result, the discharge direction of the denitration agent is directed obliquely upward.

[0057]

In the present embodiment, an example of the expansion nozzle 300 is formed by the stationary portion 86, the movable portion 87, and the adjustment mechanism 88. For example, the expansion nozzle 300 is a functional component that is additionally installed in existing combustion equipment provided with a straight pipe-shaped

denitration agent discharge nozzle. In this manner, the nozzle 80 capable of adjusting a discharge angle of the denitration agent is added to the existing combustion equipment. For example, the pipe portion 85 is the existing nozzle provided in the existing combustion equipment. The expansion nozzle 300 is connected to the pipe portion 85 which is the existing nozzle. In this manner, the nozzle 80 capable of adjusting the discharge angle of the denitration agent is provided.

[0058]

<7. Control Device>

Next, the control device 100 will be described.

The control device 100 comprehensively controls the combustion equipment 1. For example, the control device 100 controls the combustion of the refuse G in the treatment space V of the furnace body 20. The control device 100 is an example of a "control unit".

[0059]

Fig. 5 is a block diagram showing a functional configuration relating to the denitration. For example, the control device 100 includes a nozzle angle control unit 110. The nozzle angle control unit 110 controls the discharge angle of the nozzle 80, based on information relating to the temperature of the exhaust gas.

[0060]

In the present embodiment, the nozzle angle control unit 110 controls the discharge angle of the plurality of nozzles 80, based on a measurement result of the temperature measurement unit 90. For example, the nozzle angle control unit 110 controls the discharge angle of the nozzles 81A to 81D included in the first group G1, based on a measurement result of the first temperature measurement unit 91. On the other hand, the nozzle angle control unit 110 controls the discharge angle of the nozzles

82A to 82D included in the second group G2, based on a measurement result of the second temperature measurement unit 92.

[0061]

Hereinafter, a case where the discharge angle of the nozzles 81A to 81D included in the first group G1 is controlled based on the measurement result of the first temperature measurement unit 91 will be described in detail. In the following description of controlling the discharge angle of the nozzles 82A to 82D included in the second group G2, based on the measurement result of the second temperature measurement unit 92, the “first temperature measurement unit 91” may be read as the “second temperature measurement unit 92”, the “first group G1” may be read as the “second group G2”, and the “nozzles 81A to 81D” may be read as the “nozzles 82A to 82D”.

[0062]

Fig. 6 is a view showing a relationship between a reaction temperature (exhaust gas temperature) and a denitration rate. Here, a reaction process of the noncatalytic denitration using ammonia (or urea) as the reducing agent is mainly divided into (1) NOx removal (main reaction) by a reduction reaction and (2) NOx generation (side reaction) by an oxidation reaction.

[0063]

As shown in Fig. 6, for example, the denitration rate is maximized at a reaction temperature near 950°C, the denitration rate decreases when the reaction temperature is higher than a certain temperature range (hereinafter, referred to as a "predetermined temperature range TR"), and the denitration rate also decreases when the reaction temperature is lower than the predetermined temperature range TR. The reason is as follows. When the reaction temperature is too low, the main reaction does not proceed,

and when the reaction temperature is too high, the side reaction cancels the main reaction. Therefore, in order to increase the denitration rate, it is preferable to discharge the denitration agent to the exhaust gas in the predetermined temperature range TR.

[0064]

Fig. 7 is a view for describing control of the discharge angle. In the present embodiment, when the temperature (exhaust gas temperature) measured by the first temperature measurement unit 91 falls within the predetermined temperature range TR, the nozzle angle control unit 110 adjusts the discharge angle of the nozzle 80 to 0 degrees, and horizontally discharges the denitration agent.

[0065]

When the temperature measured by the first temperature measurement unit 91 is lower than the predetermined temperature range TR, the nozzle angle control unit 110 controls the adjustment mechanism 88 such that the movable portion 87 pivots downward with respect to the stationary portion 86, and controls the discharge angle of the nozzle 80 such that the discharge direction of the denitration agent is directed obliquely downward. In this manner, the discharge angle of the nozzle 80 is adjusted such that the denitration agent can be discharged toward the upstream side in the flow direction of the exhaust gas. For example, when the temperature measured by the first temperature measurement unit 91 is lower than the predetermined temperature range TR, the nozzle angle control unit 110 adjusts the discharge angle of the nozzle 80 such that the discharge direction of the denitration agent is directed downward as the temperature measured by the first temperature measurement unit 91 is lower.

[0066]

In the present embodiment, the discharge angle of the nozzle 80 is adjusted in accordance with a magnitude of a difference between the temperature measured by the

first temperature measurement unit 91 and a lower limit value of the predetermined temperature range TR. For example, when the temperature measured by the first temperature measurement unit 91 is lower than the predetermined temperature range TR, the discharge angle of the nozzle 80 is adjusted within an angle range from 0 degrees to -45 degrees. The description "the discharge angle is adjusted in accordance with the magnitude of the difference between the measured temperature and the lower limit value of the predetermined temperature range TR" is not limited to a case where the discharge angle is adjusted to be linearly proportional to the magnitude of the difference as shown in Fig. 7, and may mean a case where the discharge angle is adjusted in stages (for example, in a stepwise manner of one stage or two stages) in accordance with the magnitude of the difference.

[0067]

When the temperature measured by the first temperature measurement unit 91 is higher than the predetermined temperature range TR, the nozzle angle control unit 110 controls the adjustment mechanism 88 such that the movable portion 87 pivots upward with respect to the stationary portion 86, and controls the discharge angle of the nozzle 80 such that the discharge direction of the denitration agent is directed obliquely upward. In this manner, the discharge angle of the nozzle 80 is adjusted such that the denitration agent can be discharged toward the downstream side in the flow direction of the exhaust gas. For example, when the temperature measured by the first temperature measurement unit 91 is higher than the predetermined temperature range TR, the nozzle angle control unit 110 adjusts the discharge angle of the nozzle 80 such that the discharge direction of the denitration agent is directed further upward as the temperature measured by the first temperature measurement unit 91 is higher.

[0068]

In the present embodiment, the discharge angle of the nozzle 80 is adjusted in accordance with the magnitude of the difference between the temperature measured by the first temperature measurement unit 91 and the upper limit value of the predetermined temperature range TR. For example, when the temperature measured by the first temperature measurement unit 91 is higher than the predetermined temperature range TR, the discharge angle of the nozzle 80 is adjusted within an angle range from 0 degrees to +45 degrees. The description "the discharge angle is adjusted in accordance with the magnitude of the difference between the measured temperature and the upper limit value of the predetermined temperature range TR" is not limited to a case where the discharge angle is adjusted to be linearly proportional to the magnitude of the difference as shown in Fig. 7, and means a case where the discharge angle is adjusted in stages (for example, in a stepwise manner of one stage or two stages) in accordance with the magnitude of the difference.

[0069]

The predetermined temperature range TR described above is an example of a “predetermined reference”. The “predetermined reference” is not limited to a certain temperature range, and may be a predetermined temperature value (for example, 950°C). That is, the "predetermined temperature range TR" in the description of the present disclosure may be appropriately read as a "predetermined temperature".

[0070]

Hitherto, an example in which the discharge angle of the nozzles 81A to 81D included in the first group G1 is controlled based on the measurement result of the first temperature measurement unit 91 has been described. This control is independently performed on the nozzles 81A to 81D included in the first group G1 and the nozzles 82A to 82D included in the second group G2. Therefore, for example, when the

temperature measured by the first temperature measurement unit 91 is higher than the predetermined temperature range TR and the temperature measured by the second temperature measurement unit 92 is lower than the predetermined temperature range TR, the discharge angle of the nozzles 81A to 81D included in the first group G1 is adjusted such that the discharge direction of the denitration agent is directed obliquely upward, and the discharge angle of the nozzles 82A to 82D included in the second group G2 is adjusted such that the discharge direction of the denitration agent is directed obliquely downward.

[0071]

<8. Control Flow>

Next, a control flow will be described.

Fig. 8 is a flowchart showing a control flow relating to the adjustment of the discharge angle of the nozzles 81A to 81D included in the first group G1. First, the temperature of the exhaust gas at the first height H1 is measured by the first temperature measurement unit 91 (S101).

[0072]

Next, the nozzle angle control unit 110 determines whether or not the temperature measured by the first temperature measurement unit 91 falls within the predetermined temperature range TR (S102). When the temperature measured by the first temperature measurement unit 91 falls within the predetermined temperature range TR (S102: YES), the nozzle angle control unit 110 adjusts the discharge angle of the nozzle 80 to be horizontal (S103), and completes a series of processes.

[0073]

On the other hand, when the temperature measured by the first temperature measurement unit 91 does not fall within the predetermined temperature range TR (S102:

NO), the nozzle angle control unit 110 determines whether or not the temperature measured by the first temperature measurement unit 91 is higher than the predetermined temperature range TR (S104).

[0074]

When the temperature measured by the first temperature measurement unit 91 is higher than the predetermined temperature range TR (S104: YES), the nozzle angle control unit 110 adjusts the discharge angle of the nozzle 80 to be obliquely upward in accordance with the temperature measured by the first temperature measurement unit 91 (S105), and completes a series of processes.

[0075]

On the other hand, when the temperature measured by the first temperature measurement unit 91 is lower than the predetermined temperature range TR (S104: NO), the nozzle angle control unit 110 adjusts the discharge angle of the nozzle 80 to be obliquely downward in accordance with the temperature measured by the first temperature measurement unit 91 (S106), and completes a series of processes.

[0076]

The processes in S101 to S106 described above are repeatedly performed at a predetermined cycle.

[0077]

<9. Operational Effects>

In the combustion equipment, when the exhaust gas temperature fluctuates, there is a subject in that the denitration rate decreases. In order to solve this subject, as a comparative example, it is conceivable to adopt a configuration in which the plurality of nozzles are disposed in a vertical height direction, and the nozzle located at a desired height is selected to blow the denitration agent therefrom. In the

configuration of the comparative example, construction for installing the plurality of nozzles becomes complicated, and in many cases, a boiler pipe is disposed on the wall surface in the vicinity of the denitration nozzle. Since a large number of the boiler pipes need to be bent according to the installation of the plurality of nozzles, the construction is difficult.

[0078]

In addition, in the configuration of the comparative example, a large number of the nozzles for blowing the denitration agent are required, and even when the nozzles are not used, a small amount of gas needs to be continuously loaded to prevent clogging. Therefore, as the number of the nozzles increases, more utility gases (gases for diluting the denitration agent such as steam or a recirculation gas) are required, and equipment such as a pressure feeder needs to increase in size.

[0079]

On the other hand, the noncatalytic denitration system 200 of the present embodiment includes the denitration agent supply unit 210 including the nozzle 80 installed in the furnace 43 through which the exhaust gas flows and configured to adjust the discharge angle of the denitration agent with respect to the flow direction of the exhaust gas, and the nozzle angle control unit 110 that controls the discharge angle of the nozzle 80, based on information relating to the temperature of the exhaust gas. According to this configuration, the denitration agent can be loaded such that the denitration agent can react at a temperature close to a target temperature (for example, the predetermined temperature range TR) by changing the discharge angle of the nozzle 80. Therefore, it is possible to cope with temperature fluctuations inside the furnace without installing the plurality of nozzles in the height direction. In addition, according to the configuration of the present embodiment, the number of required

nozzles 80 decreases. Therefore, the amount of the gas flowing when the nozzles are not used may be reduced. Therefore, the equipment can decrease in size.

[0080]

In a noncatalytic denitration process in the combustion equipment 1 such as a refuse incinerator, the combustion gas flows in a vertically upward direction at a denitration agent loading location, and the temperature of the combustion gas is lower toward the upper side, and is higher toward the lower side. Therefore, when the temperature at the denitration agent loading location is higher than the target temperature, the denitration agent is blown at an upward angle, and when the temperature is lower than the target temperature, the denitration agent is blown at a downward angle. In this manner, even in a situation where the operation state greatly fluctuates, a high denitration rate can be maintained.

[0081]

Fig. 9 is a view for describing an operational effect of adjusting the discharge angle of the nozzle 80, and shows a simulation result indicating a comparison between a case where the discharge angle of the nozzle 80 is adjusted and a case where the discharge angle of the nozzle 80 is not adjusted. As shown in Fig. 9, it can be understood that the denitration rate is improved when the discharge angle of the nozzle 80 is adjusted, compared to when the discharge angle of the nozzle 80 is not adjusted.

[0082]

For example, in a case shown in Fig. 9, the denitration agent is blown from two height positions having different heights, and in an average operation situation, whereas the temperature in the vicinity of the lower side (first height H1) is close to the target temperature, the temperature in the vicinity of the upper side (second height H2) is lower than the target temperature. In a configuration in a comparative example in which the

denitration agent is always blown in the horizontal direction, the denitration on the upper side (the second height H2) does not proceed, and it becomes difficult to lower NOx. In contrast, as in the present embodiment, the discharge angle of the nozzle 80 on the upper side is adjusted downward, and the reaction temperature on the upper side (second height H2) is brought close to the target temperature. In this manner, the denitration proceeds, and the NOx can be lowered.

[0083]

<10. Modification Example>

Next, a modification example of the first embodiment will be described.

Fig. 10 is a sectional view showing the nozzle 80 of the modification example. In the present modification example, the furnace 43 includes protection equipment 410 for protecting the nozzle 80. The protection equipment 410 includes a wind box 411, an air supply line 412, and a blower 413.

[0084]

The wind box 411 is inserted into the hole portion 70h provided on the furnace wall 70. The wind box 411 is made of metal, and accommodates at least a portion of the nozzle 80. For example, the wind box 411 accommodates a connection portion (pivoting portion) between the stationary portion 86 and the movable portion 87 of the nozzle 80. The wind box 411 includes a discharge port 411h for discharging the air supplied into the wind box 411 through the air supply line 412 (to be described later) to the inside of the furnace 43.

[0085]

The air supply line 412 is connected to the inside of the wind box 411. The blower 413 is connected to the inside of the wind box 411 through the air supply line 412. The blower 413 pumps the air into the wind box 411 through the air supply line

412. Since the air is pumped into the wind box 411 through the air supply line 412, a backflow of the exhaust gas into the wind box 411 from the inside of the furnace 43 is suppressed. In this manner, components accommodated inside the wind box 411 are protected from a high-temperature state and dust contained in the exhaust gas. In this manner, for example, fixing the connection portion (pivoting portion) between the stationary portion 86 and the movable portion 87 of the nozzle 80 is suppressed.

[0086]

In the present modification example, for example, the adjustment mechanism 88 includes a drive device 421 and a power transmission mechanism 422. The drive device 421 is a motor, for example. The power transmission mechanism 422 is a mechanism that transmits power, such as a link or a gear, and connects the drive device 421 and the movable portion 87 of the nozzle 80. In this manner, the nozzle angle control unit 110 can cause the movable portion 87 to pivot with respect to the stationary portion 86 by driving the drive device 421. In the present modification example, the power transmission mechanism 422 is accommodated and protected inside the wind box 411.

[0087]

According to this configuration, it is possible to provide the denitration agent supply unit 210 that can be more stably operated even in an environment where the denitration agent supply unit 210 comes into contact with a high-temperature and high-dust concentration combustion gas.

[0088]

(Second Embodiment)

Next, a second embodiment will be described. The second embodiment is different from the first embodiment in that a supply ratio (for example, a distribution

ratio) of the denitration agent in the front and the rear of the furnace 43 is changed when flow rates of the exhaust gas are different between the front space FS and the rear space BS of the furnace 43. The second embodiment is the same as the first embodiment except for configurations described below.

[0089]

Specifically, in some cases, flow rates of the exhaust gases may be different between the front space FS and the rear space BS of the furnace 43. For example, when a flow path folded back downward is present on the downstream side of the furnace 43 as shown in Fig. 1, the flow speed is low on the front side in the furnace 43. On the other hand, the flow is likely to be faster on the rear side of the furnace. In this case, in a region where the flow speed on the front side of the furnace is low, the amount of the denitration agent required for the denitration is small. On the other hand, in a region where the flow speed on the rear side of the furnace is high, the amount of the denitration agent required for the denitration is large.

[0090]

Here, since a large amount of combustion gas is generated as the combustion is more active, it is conceivable that the temperature is likely to be higher at a place where the flow speed is high. In the present embodiment, this idea is utilized to estimate a flow rate distribution on the front side of the furnace / rear side of the furnace, based on information on a temperature distribution inside the furnace (temperature difference between the front side of the furnace and the rear side of the furnace), and a loading amount of the denitration agent is distributed to be proportional to each flow rate on the front side and the rear side of the furnace.

[0091]

(Nozzle)

Fig. 11 is a perspective view showing the furnace 43 of the present embodiment. In Fig. 11, in order to facilitate understanding of the drawing, the denitration agent supply line 211, the pressure feeder 212, and the like are omitted in the drawing.

[0092]

In the present embodiment, the denitration agent flowing through one denitration agent supply line 211 is distributed and supplied to the nozzles 81A to 81D. Similarly, the denitration agent flowing through one denitration agent supply line 211 is distributed and supplied to the nozzles 82A to 82D. In the present embodiment, each of the nozzles 81A, 81C, 82A, and 82C is the nozzle 80 disposed corresponding to the front space FS (front region FR to be described later), and is an example of a “first nozzle”. On the other hand, each of the nozzles 81B, 81D, 82B, and 82D is the nozzle 80 disposed corresponding to the rear space BS (rear region BR to be described later), and is an example of a “second nozzle”.

[0093]

(Temperature Measurement Unit)

In the present embodiment, the furnace 43 includes the front region FR and the rear region BR in a cross section (for example, a cross section in the horizontal direction) along a direction intersecting with the flow direction of the exhaust gas. The front region FR is a region overlapping the front space FS when viewed from above. The front region FR is an example of a “first region”. The rear region BR is a region overlapping the rear space BS when viewed from above. The rear region BR is an example of a “second region”.

[0094]

The first temperature measurement unit 91 includes a plurality of (for example, two) temperature sensors 91A and 91B (front temperature sensor 91A and rear

temperature sensor 91B) provided at the first height H1. For example, each of the temperature sensors 91A and 91B is a thermocouple, and measures the temperature of the exhaust gas at the first height H1. The front temperature sensor 91A is disposed corresponding to the front region FR, and measures the exhaust gas temperature relating to the front region FR. The rear temperature sensor 91B is disposed corresponding to the rear region BR, and measures the exhaust gas temperature relating to the rear region BR.

[0095]

The second temperature measurement unit 92 includes a plurality of (for example, two) temperature sensors 92A and 92B (front temperature sensor 92A and rear temperature sensor 92B) provided at the second height H2. For example, each of the temperature sensors 92A and 92B is a thermocouple, and measures the temperature of the exhaust gas at the second height H2. The front temperature sensor 92A is disposed corresponding to the front region FR, and measures the exhaust gas temperature relating to the front region FR. The rear temperature sensor 92B is disposed corresponding to the rear region BR and measures the exhaust gas temperature relating to the rear region BR.

[0096]

Fig. 12 is a view for describing another aspect of the temperature measurement unit 90 of the present embodiment. The temperature measurement unit 90 in another aspect includes a third temperature measurement unit 94 including a camera 94a installed at a furnace top portion of the furnace 43. For example, the camera 94a is an infrared camera, and images the inside of the furnace 43 from above to acquire an infrared image of the inside of the furnace 43.

[0097]

Fig. 13 is a view for describing an infrared image IM captured by the camera 94a. In the infrared image IM, the front region FR corresponding to the front space FS of the furnace 43 and the rear region BR corresponding to the rear space BS of the furnace 43 are set. The third temperature measurement unit 94 calculates the temperature (for example, an average temperature) of the front region FR and the temperature (for example, an average temperature) of the rear region BR, based on a brightness value included in the front region FR and a brightness value included in the rear region BR in the infrared image IM. The temperature measurement unit 90 of the above-described another aspect shown in Figs. 12 and 13 may be provided instead of/in addition to the temperature measurement unit 90 shown in Fig. 11.

[0098]

(Denitration Agent Supply Unit)

Fig. 14 is a block diagram showing a functional configuration relating to the denitration in the second embodiment. In the present embodiment, the denitration agent supply line 211 of the denitration agent supply unit 210 includes a first front nozzle flow rate adjustment unit 231, a first rear nozzle flow rate adjustment unit 232, a second front nozzle flow rate adjustment unit 233, and a second rear nozzle flow rate adjustment unit 234.

[0099]

The first front nozzle flow rate adjustment unit 231 is an adjustment unit that adjusts a flow rate of the denitration agent supplied to the nozzles 81A and 81C included in the first group G1, and is a throttle valve, for example. The first rear nozzle flow rate adjustment unit 232 is an adjustment unit that adjusts a flow rate of the denitration agent supplied to the nozzles 81B and 81D included in the first group G1, and is a throttle valve, for example.

[0100]

The second front nozzle flow rate adjustment unit 233 is an adjustment unit that adjusts a flow rate of the denitration agent supplied to the nozzles 82A and 82C included in the second group G2, and is a throttle valve, for example. The second rear nozzle flow rate adjustment unit 234 is an adjustment unit that adjusts a flow rate of the denitration agent supplied to the nozzle 82B and the nozzle 82D included in the second group G2, and is a throttle valve, for example.

[0101]

(Front and Rear Supply Amount Adjustment Unit)

In the present embodiment, the control device 100 includes a front and rear supply amount adjustment unit 120. The front and rear supply amount adjustment unit 120 determines a supply ratio (for example, a distribution ratio) of the denitration agent in the front and the rear of the furnace 43, based on a temperature difference between the temperatures measured by the two temperature sensors 91A and 91B disposed at the same height (first height H1). For example, when the temperature difference exists between the temperatures measured by the two temperature sensors 91A and 91B, the front and rear supply amount adjustment unit 120 controls at least one of the first front nozzle flow rate adjustment unit 231 and the first rear nozzle flow rate adjustment unit 232. In this manner, the front and rear supply amount adjustment unit 120 changes the supply ratio between a discharge amount of the denitration agent to be discharged from the nozzle 81A and the nozzle 81C to the front space FS of the furnace 43 and a discharge amount of the denitration agent to be discharged from the nozzle 81B and the nozzle 81D to the rear space BS of the furnace 43.

[0102]

For example, when the temperature measured by the front temperature sensor

91A is higher than the temperature measured by the rear temperature sensor 91B, the front and rear supply amount adjustment unit 120 determines the supply ratio of the denitration agent in the front and the rear of the furnace 43 such that the discharge amount of the denitration agent to be discharged to the front space FS is larger than the discharge amount of the denitration agent to be discharged to the rear space BS. On the other hand, when the temperature measured by the rear temperature sensor 91B is higher than the temperature measured by the front temperature sensor 91A, the front and rear supply amount adjustment unit 120 determines the supply ratio of the denitration agent in the front and the rear of the furnace 43 such that the discharge amount of the denitration agent to be discharged to the rear space BS is larger than the discharge amount of the denitration agent to be discharged to the front space FS.

[0103]

Hereinafter, an example in which the discharge amount of the nozzles 81A to 81D included in the first group G1 is controlled based on the measurement result of the front temperature sensor 91A and the rear temperature sensor 91B of the first temperature measurement unit 91 will be described in detail. In the following description, in controlling the discharge amount of the nozzles 82A to 82D included in the second group G2, based on the measurement result of the front temperature sensor 92A and the rear temperature sensor 92B of the second temperature measurement unit 92, “the first temperature measurement unit 91” may be read as “the second temperature measurement unit 92”, “the front temperature sensor 91A” may be read as “the front temperature sensor 92A”, “the rear temperature sensor 91B” may be read as “the rear temperature sensor 92B”, “the first front nozzle flow rate adjustment unit 231” may be read as “the second front nozzle flow rate adjustment unit 233”, “the first rear nozzle flow rate adjustment unit 232” may be read as “the second rear nozzle flow rate

adjustment unit 234", "the first group G1" may be read as "the second group G2", and "the nozzles 81A to 81D" may be read as "the nozzles 82A to 82D".

[0104]

Fig. 15 is a view for describing control of the discharge amount. In the present embodiment, when the temperature difference obtained by subtracting the temperature measured by the front temperature sensor 91A from the temperature measured by the rear temperature sensor 91B falls within the predetermined temperature difference range TDR, the front and rear supply amount adjustment unit 120 sets the discharge amount of the denitration agent to be discharged from the nozzle 81A and the nozzle 81C to the front space FS of the furnace 43 and the discharge amount of the denitration agent to be discharged from the nozzle 81B and the nozzle 81D to the rear space BS of the furnace 43 to be equal to each other.

[0105]

When the temperature difference is greater than the predetermined temperature difference range TDR, the front and rear supply amount adjustment unit 120 increases an opening degree of a throttle valve of the first rear nozzle flow rate adjustment unit 232, and decreases an opening degree of a throttle valve of the first front nozzle flow rate adjustment unit 231. In this manner, the discharge amount of the denitration agent to be discharged from the nozzle 81B and the nozzle 81D to the rear space BS of the furnace 43 is increased, compared to the discharge amount of the denitration agent to be discharged from the nozzle 81A and the nozzle 81C to the front space FS of the furnace 43. For example, when the above-described temperature difference is greater than the predetermined temperature difference range TDR, the front and rear supply amount adjustment unit 120 determines the supply ratio to increase a difference in the supply ratios of the denitration agents in the front and the rear of the furnace 43 as the

temperature difference increases.

[0106]

For example, when the above-described temperature difference is greater than the predetermined temperature difference range TDR, the supply ratio of the denitration agent in the front and the rear of the furnace 43 is determined in accordance with a magnitude of the difference between the above-described temperature difference and the upper limit value of the predetermined temperature difference range TDR. The description "determined in accordance with the magnitude of the difference between the temperature difference and the upper limit value of the predetermined temperature difference range TDR" is not limited to a case where the supply ratio is adjusted to be linearly proportional to the magnitude of the difference as illustrated in Fig. 15, and means a case where the supply ratio is adjusted in stages (for example, in a stepwise manner of one stage or two stages) in accordance with the magnitude of the difference.

[0107]

When the above-described temperature difference is smaller than the predetermined temperature difference range TDR, the front and rear supply amount adjustment unit 120 increases the opening degree of the throttle valve of the first front nozzle flow rate adjustment unit 231, and decreases the opening degree of the throttle valve of the first rear nozzle flow rate adjustment unit 232. In this manner, the discharge amount of the denitration agent to be discharged from the nozzle 81A and the nozzle 81C to the front space FS of the furnace 43 increases, compared to the discharge amount of the denitration agent to be discharged from the nozzle 81B and the nozzle 81D to the rear space BS of the furnace 43. For example, when the above-described temperature difference is smaller than the predetermined temperature difference range TDR, the front and rear supply amount adjustment unit 120 determines the supply ratio

to increase the difference in the supply ratios of the denitration agents in the front and the rear of the furnace 43 as an absolute value of the above-described temperature difference becomes greater.

[0108]

For example, when the above-described temperature difference is smaller than the predetermined temperature difference range TDR, the supply ratio of the denitration agent in the front and the rear of the furnace 43 is determined in accordance with the magnitude of the difference between the above-described temperature difference and the lower limit value of the predetermined temperature difference range TDR. The description "determined in accordance with the magnitude of the difference between the temperature difference and the lower limit value of the predetermined temperature difference range TDR" is not limited to a case where the supply ratio is adjusted to be linearly proportional to the magnitude of the difference as illustrated in Fig. 15, and means a case where the supply ratio is adjusted in stages (for example, in a stepwise manner of one stage or two stages) in accordance with the magnitude of the difference.

[0109]

Hitherto, the example in which the discharge amount of the nozzles 81A to 81D included in the first group G1 is controlled, based on the measurement result of the front temperature sensor 91A and the rear temperature sensor 91B has been described. This control is independently performed on the nozzles 81A to 81D included in the first group G1 and the nozzles 82A to 82D included in the second group G2. That is, the discharge amount of the nozzles 82A to 82D included in the second group G2 is controlled, based on the measurement result of the front temperature sensor 92A and the rear temperature sensor 92B.

[0110]

The predetermined temperature difference range TDR described above is an example of a “predetermined reference” from another viewpoint. The "predetermined reference" is not limited to a certain temperature difference range, and the temperature difference may be zero. That is, the "predetermined temperature difference range TDR" in the description of the present disclosure may be appropriately read as "the temperature difference is zero".

[0111]

In the present embodiment, in order to reflect the difference in the exhaust gas flow rate between the front region FR and the rear region BR of the furnace 43, the discharge amount of the denitration agent is controlled by directly using the measurement result of the temperature relating to the front region FR and the measurement result of the temperature relating to the rear region BR. Alternatively, the front and rear supply amount adjustment unit 120 may estimate a difference (flow rate distribution) in the exhaust gas flow rate between the front region FR and the rear region BR of the furnace 43, based on the measurement result of the front temperature sensor 92A and the rear temperature sensor 92B, and may control the discharge amount of the denitration agent, based on an estimated difference in the exhaust gas flow rate.

[0112]

(Control Flow)

Next, a control flow will be described.

Fig. 16 is a flowchart showing a control flow relating to the adjustment of the discharge amount of the nozzles 81A to 81D included in the first group G1. First, the front temperature sensor 91A and the rear temperature sensor 91B of the first temperature measurement unit 91 measure the temperature of the exhaust gas at the first height H1 (S201).

[0113]

Next, the front and rear supply amount adjustment unit 120 calculates the temperature difference between the front and the rear of the furnace 43 by subtracting the temperature measured by the front temperature sensor 91A from the temperature measured by the rear temperature sensor 91B (S202).

[0114]

Next, the front and rear supply amount adjustment unit 120 determines whether or not the calculated temperature difference falls within the predetermined temperature difference range TDR (S203). When the temperature difference falls within the predetermined temperature difference range TDR (S203: YES), the front and rear supply amount adjustment unit 120 adjusts the discharge amount of the denitration agent to be discharged to the front space FS of the furnace 43 and the discharge amount of the denitration agent to be discharged to the rear space BS of the furnace 43 to be equal to each other (S204), and completes a series of processes.

[0115]

On the other hand, when the temperature difference does not fall within the predetermined temperature difference range TDR (S203: NO), the front and rear supply amount adjustment unit 120 determines whether or not the temperature difference is greater than the predetermined temperature difference range TDR (S205).

[0116]

When the temperature difference is greater than the predetermined temperature difference range TDR (S205: YES), the front and rear supply amount adjustment unit 120 reduces the discharge amount of the denitration agent to be discharged to the front space FS of the furnace 43, increases the discharge amount of the denitration agent to be discharged to the rear space BS of the furnace 43 (S206), and completes a series of

the processes.

[0117]

On the other hand, when the temperature difference is smaller than the predetermined temperature difference range TDR (S205: NO), the front and rear supply amount adjustment unit 120 increases the discharge amount of the denitration agent to be discharged to the front space FS of the furnace 43, and decreases the discharge amount of the denitration agent to be discharged to the rear space BS of the furnace 43 (S207), and completes a series of the processes.

[0118]

The processes in S201 to S207 described above are repeatedly performed at a predetermined cycle.

[0119]

(Operational Effects)

As described above, in many cases, the flow of the combustion gas in the combustion equipment is biased to either the front side of the furnace or the rear side of the furnace depending on a combustion state and an air blowing condition. It is conceivable that a side where the flow is fast has a high exhaust gas flow rate has a large amount of the denitration agent required for the denitration, and a side where the flow is slow has a small amount of the denitration agent required for the denitration. Therefore, in a horizontal plane at the same height, a large amount of the denitration agent is blown to the side where the exhaust gas flow rate is high. In this manner, a concentration ratio of NOx and the denitration agent inside the furnace can be close to uniformity, and the denitration rate can be improved.

[0120]

Fig. 17 is a view for describing an operational effect of adjusting the supply

ratio of the denitration agent in the front and the rear of the furnace 43, and shows a simulation result indicating a comparison between a case where the supply ratio is adjusted and a case where the supply ratio is not adjusted. As shown in Fig. 17, it can be understood that the denitration rate is improved when the supply ratio of the denitration agent in the front and the rear of the furnace 43 is adjusted, compared to a case where the distribution ratio is not adjusted.

[0121]

(Other Embodiments)

Hitherto, the embodiments of the present disclosure have been described in detail with reference to the drawings. However, specific configurations are not limited to the above-described embodiments, and design changes within the scope not departing from the concept of the present disclosure are also included. For example, the plurality of nozzles 80 may be provided on the front wall 71 instead of the left wall 73 and the right wall 74. In the present disclosure, the "information relating to the temperature of the combustion gas" is not limited to the measurement result of the thermocouple, and may be information detected by a camera or another measurement means.

[0122]

Fig. 18 is a hardware configuration diagram showing a configuration of a computer 1100 according to the present embodiment. For example, the computer 1100 includes a processor 1110, a main memory 1120, a storage 1130, and an interface 1140.

[0123]

Each functional unit of the control device 100 is installed in the computer 1100. An operation of each functional unit described above is stored in the storage 1130 in a form of a program. The processor 1110 reads the program from the storage 1130, develops the read program in the main memory 1120, and executes the above-described

process in accordance with the program. In addition, the processor 1110 secures a storage region used by each of the above-described functional units in the main memory 1120 in accordance with the program.

[0124]

The program may be intended to realize some of functions fulfilled by the computer 1100. For example, the program may fulfill a function in combination with another program previously stored in the storage 1130, or in combination with another program installed in another device. In addition, the computer 1100 may include a custom large scale integrated circuit (LSI) such as a programmable logic device (PLD) in addition to or in place of the above configuration. Examples of the PLD include a programmable array logic (PAL), a generic array logic (GAL), a complex programmable logic device (CPLD), and a field programmable gate array (FPGA). In this case, functions that are realized by the processor 1110 may be partially or entirely realized by the integrated circuit.

[0125]

As an example of the storage 1130, a magnetic disk, a magneto-optical disk, or a semiconductor memory can be used. The storage 1130 may be an internal medium directly connected to a bus of the computer 1100 or may be an external medium connected to the computer 1100 through the interface 1140 or a communication line. In addition, when this program is distributed to the computer 1100 via the communication line, the computer 1100 receiving the distributed program may develop the program in the main memory 1120 to execute the above-described process. In addition, the program may be used to partially realize the above-described functions. In addition, the program may be a so-called difference file (difference program) that realizes the above-described functions in combination with another program previously

stored in the storage 1130.

[0126]

<Additional Notes>

The noncatalytic denitration system, the combustion equipment, the denitration method, and the expansion nozzle which are described in each embodiment are understood as follows, for example.

[0127]

(1) The noncatalytic denitration system 200 according to a first aspect includes the denitration agent supply unit 210 installed in the flow path (for example, the furnace 43) through which the combustion gas flows in the combustion equipment 1 and including the first nozzle (for example, the nozzle 80) configured to adjust the discharge angle of the denitration agent with respect to the flow direction of the combustion gas, and the control unit (for example, the control device 100) that controls the discharge angle of the first nozzle, based on the information relating to the temperature of the combustion gas. According to this configuration, the discharge angle of the nozzle 80 is changed. In this manner, the denitration agent can be loaded such that the denitration agent can react at a temperature close to the target temperature. Therefore, it is possible to cope with temperature fluctuations inside the furnace without installing the plurality of nozzles in the height direction, and constructability can be improved.

[0128]

(2) In the noncatalytic denitration system 200 of a second aspect, in the noncatalytic denitration system 200 according to (1), when the temperature of the combustion gas is lower than the predetermined reference, the control unit (for example, control device 100) controls the discharge angle of the first nozzle (for example, the nozzle 80) to discharge the denitration agent toward the upstream side in the flow

direction of the combustion gas, and when the temperature of the combustion gas is higher than the predetermined reference, the control unit (for example, control device 100) controls the discharge angle of the first nozzle (for example, the nozzle 80) to discharge the denitration agent toward the downstream side in the flow direction of the combustion gas. According to this configuration, the denitration agent can be loaded such that the denitration agent can react at a temperature close to the target temperature in a wide range.

[0129]

(3) In the noncatalytic denitration system 200 of a third aspect, in the noncatalytic denitration system 200 according to (1) or (2), the flow path (for example, the furnace 43) includes the first region (for example, the front region FR) and the second region (for example, the rear region BR) in a cross section along the direction intersecting with the flow direction of the combustion gas. The denitration agent supply unit 210 includes the first nozzle (for example, the nozzles 81A, 81C, 82A, and 82C) disposed corresponding to the first region and the second nozzle (for example, the nozzles 81B, 81D, 82B, and 82D) disposed corresponding to the second region. The control unit (for example, the control device 100) controls at least one of the amount of the denitration agent to be discharged from the first nozzle and the amount of the denitration agent to be discharged from the second nozzle, based on the temperature difference between the temperature of the combustion gas which is measured with regard to the first region and the temperature of the combustion gas which is measured with regard to the second region. According to this configuration, when the flow rate of the combustion gas is biased, a large amount of the denitration agent can be blown to the side having more combustion gases. Therefore, the denitration rate can be improved.

[0130]

(4) The combustion equipment 1 of a fourth aspect includes the flow path (for example, the furnace 43) and the noncatalytic denitration system 200 according to any one of (1) to (3). According to this configuration, it is possible to cope with temperature fluctuations inside the furnace without installing the plurality of nozzles in the height direction, and constructability can be improved.

[0131]

(5) A denitration method of a fifth aspect is the denitration method of discharging the denitration agent into the flow path through which the combustion gas flows in the combustion equipment, in which the discharge angle at which the denitration agent is discharged from the nozzle 80 with respect to the flow direction of the combustion gas is changed, based on the information relating to the temperature of the combustion gas. According to this configuration, it is possible to cope with temperature fluctuations inside the furnace without installing the plurality of nozzles in the height direction, and constructability can be improved.

[0132]

(6) The expansion nozzle 300 of a sixth aspect includes the stationary portion 86 connectable to the pipe portion 85 to which the denitration agent is supplied in the combustion equipment 1, the movable portion 87 connected to the stationary portion 86 to be pivotable and including the discharge port 87h through which the denitration agent flowing from the pipe portion 85 to the stationary portion 86 can be discharged to the outside, and the adjustment mechanism 88 capable of adjusting the angle of the movable portion 87 with respect to the stationary portion 86. According to this configuration, the nozzle 80 capable of adjusting the discharge angle of the denitration agent can be provided by attaching the expansion nozzle 300 to the existing combustion equipment.

[Industrial Applicability]

[0133]

According to the noncatalytic denitration system, the combustion equipment, the denitration method, and the expansion nozzle in the present disclosure, constructability can be improved.

[Reference Signs List]

[0134]

1: Combustion equipment

43: Furnace (flow path)

80: Nozzle

81A, 81C, 82A, 82C: Nozzle (first nozzle)

81B, 81D, 82B, 82D: Nozzle (second nozzle)

85: Pipe portion

86: Stationary portion

87: Movable portion

88: Adjustment mechanism

91: First temperature measurement unit

91A: Front temperature sensor

91B: Rear temperature sensor

92: Second temperature measurement unit

92A: Front temperature sensor

92B: Rear temperature sensor

100: Control device (control unit)

200: Noncatalytic denitration system

210: Denitration agent supply unit

300: Expansion nozzle

FR: Front region (first region)

BR: Rear region (second region)

Claims

[Claim 1]

A noncatalytic denitration system in combustion equipment including a fire grate that transports a combustion target material during combustion and a flow path disposed above the fire grate and through which a combustion gas flows upward, the system comprising:

a denitration agent supply unit installed in the flow path and including a first nozzle configured to adjust a discharge angle of a denitration agent with respect to a flow direction of the combustion gas; and

a control unit that controls the discharge angle of the first nozzle, based on information relating to a temperature of the combustion gas,

wherein in a horizontal cross section along a direction intersecting with the flow direction of the combustion gas, when viewed from above, the flow path includes a first region and a second region located on a downstream side of the first region in a transport direction of the combustion target material,

the denitration agent supply unit includes the first nozzle disposed corresponding to the first region, and a second nozzle disposed corresponding to the second region, and

the control unit controls at least one of the amount of the denitration agent to be discharged from the first nozzle and the amount of the denitration agent to be discharged from the second nozzle, based on a temperature difference between a temperature of the combustion gas which is measured with regard to the first region and a temperature of the combustion gas which is measured with regard to the second region.

[Claim 2]

The noncatalytic denitration system according to Claim 1,

wherein when the temperature of the combustion gas is lower than a predetermined reference, the control unit controls the discharge angle of the first nozzle to discharge the denitration agent toward an upstream side in the flow direction of the combustion gas, and

when the temperature of the combustion gas is higher than the predetermined reference, the control unit controls the discharge angle of the first nozzle to discharge the denitration agent toward a downstream side in the flow direction of the combustion gas.

[Claim 3]

Combustion equipment comprising:

the fire grate;

the flow path; and

the noncatalytic denitration system according to Claim 1 or 2.

[Claim 4]

A denitration method of discharging a denitration agent into a flow path through which a combustion gas flows in combustion equipment including a fire grate that transports a combustion target material during combustion and the flow path disposed above the fire grate and through which the combustion gas flows upward, in a horizontal cross section along a direction intersecting with a flow direction of the combustion gas, when viewed from above, the flow path including a first region and a second region located on a downstream side of the first region in a transport direction of the

combustion target material, the denitration method comprising:

changing a discharge angle with respect to the flow direction of the combustion gas, the discharge angle at which the denitration agent is discharged from a first nozzle, based on information relating to a temperature of the combustion gas; and

controlling at least one of the amount of the denitration agent to be discharged from the first nozzle disposed corresponding to the first region and the amount of the denitration agent to be discharged from a second nozzle disposed corresponding to the second region, based on a temperature difference between a temperature of the combustion gas which is measured with regard to the first region and a temperature of the combustion gas which is measured with regard to the second region.