

## DESCRIPTION

### Title of Invention

#### COMBUSTION FACILITY AND CONTROL DEVICE

##### [Technical Field]

[0001]

The present disclosure relates to a combustion facility and a control device.

This application claims priority to Japanese Patent Application No. 2022-056371, filed in Japan on March 30, 2022, the content of which is incorporated herein by reference.

##### [Background Art]

[0002]

For example, Patent Document 1 discloses a refuse incinerator in which a secondary air supply nozzle is disposed at a position facing in a refuse feeding direction in a primary combustion chamber, and a nozzle hole of the secondary air supply nozzle is directed to jet secondary air along an upper surface of refuse on a fire grate. As the secondary air as a free jet is jetted along the upper surface of the refuse, a combustion gas is mixed and stirred at a base portion of a flame. Therefore, an effect of promoting combustion is increased. Accordingly, by suppressing an occurrence of incomplete combustion, an occurrence of unburned content is suppressed. Meanwhile, in a technique described in Patent Document 1, a gas in the primary combustion chamber is swept away by the secondary air. Therefore, there is a possibility that a retention time of the gas in the primary combustion chamber is reduced.

[0003]

In addition, for example, Patent Document 2 discloses a combustion operating method of a combustion furnace that supplies an exhaust gas discharged from an incinerator as a free jet from a ceiling wall of a furnace positioned above a drying fire grate among a plurality of fire grates provided at a bottom portion in the incinerator and from a rear wall of the furnace on a downstream side with respect to a refuse supply direction in the furnace not to directly hit a fire grate of a furnace bottom and to attract a gas generated by combustion. A recirculation exhaust gas is supplied to an inside of the furnace, so that an entire primary combustion chamber in the furnace is utilized as a combustion space, and nitrogen oxide at a furnace outlet is reduced. In a technique described in Patent Document 2, a supply angle of the recirculation exhaust gas is set such that the recirculation exhaust gas is not affected by the ceiling wall and is not attenuated.

[0004]

In addition, for example, Patent Document 3 discloses an incinerator that causes an unburned gas generated in a combustion stage to be attracted to a rear wall side via a gas flow serving as a free jet supplied from a rear supply nozzle and that causes an unburned gas generated in a drying stage to be attracted to a front side via a gas flow serving as a free jet supplied from a front supply nozzle, in a primary combustion chamber of a combustion furnace, and then that causes the unburned gases to flow into a secondary combustion chamber. The nozzles contribute to the same thermal NO<sub>x</sub> reduction as in the related art in which a recirculation exhaust gas is supplied from a ceiling wall on the front side in the primary combustion chamber.

[0005]

In addition, for example, Patent Document 4 discloses a stoker furnace in

which a central axis of a furnace for discharging an exhaust gas generated in a treatment space (inside a furnace body) is disposed to be shifted at a position different from a combustion stage, and a first gas port jets an exhaust gas as a free jet into the treatment space from a side opposite to a displacement direction of the furnace. Accordingly, a secondary flow directed to the side opposite to the displacement direction of the furnace is formed in the treatment space, and thus a flame grows in a direction away from the furnace. Drying of a material to be incinerated in a drying stage or post-combustion in a post-combustion stage is promoted by heat of the flame, and as a result, reduction of NO<sub>x</sub> and unburned gas is realized.

[0006]

In addition, for example, Patent Document 5 discloses a stoker type incineration facility including a nozzle that sends at least one type of gas of a part of combustion air and a part of a combustion gas into a furnace as a mixing gas of a free jet. The nozzle is provided to be capable of heading for the top portion of a flame formed by the mixing gas combusting a material to be incinerated on the stoker. Accordingly, the mixing gas jetted from the nozzle can reach the top portion of the flame or a position above the top portion of the flame. As a result, a mixing ratio of the mixing gas to the combustion gas can be increased, and combustion efficiency of an unburned content contained in the combustion gas can be improved.

[Citation List]

[Patent Document]

[0007]

[Patent Document 1] Japanese Patent No. 2662746

[Patent Document 2] Japanese Patent No. 6116545

[Patent Document 3] International Publication No. WO2020/189394

[Patent Document 4] International Publication No. WO2021/106645

[Patent Document 5] International Publication No. WO2020/071142

[Summary of Invention]

[Technical Subject]

[0008]

In the field of a combustion facility that performs incineration treatment on refuse, a technique for increasing a retention time of an exhaust gas in a furnace body is required.

[0009]

The present disclosure has been made to solve the above subjects, and an object thereof is to provide a combustion facility and a control device capable of increasing a retention time of an exhaust gas in a furnace body.

[Subject to be solved]

[0010]

In order to solve the above subjects, a combustion facility according to the present disclosure includes a furnace body that transfers a material to be incinerated while combusting the material to be incinerated inside, and a nozzle that supplies a part of an exhaust gas discharged from the furnace body to the inside of the furnace body, in which the nozzle is disposed at a furnace back end of the furnace body in a direction in which the exhaust gas supplied to the inside of the furnace body forms a wall jet along a ceiling portion of the furnace body, the nozzle supplies the exhaust gas such that the exhaust gas spreads in a conical shape from an opening of the nozzle, so that a part of the exhaust gas collides with the ceiling portion of the furnace body from a lower side to form the wall jet, a plurality of the nozzles are disposed at the furnace back end at intervals in a furnace width direction, and the intervals between the

plurality of nozzles are set such that the wall jet in which the exhaust gases supplied from each of the nozzles are combined with each other is formed.

[0011]

A control device according to the present disclosure is a control device of the above-described combustion facility, in which the combustion facility further includes a fan that supplies a part of the exhaust gas to the nozzle through an exhaust gas recirculation line, the control device includes a detecting unit that detects a CO concentration and a NO<sub>x</sub> concentration in the exhaust gas, and an adjustment unit that increases or decreases a rotation speed of the fan when one or both of the CO concentration and the NO<sub>x</sub> concentration in the exhaust gas are increased or decreased, based on a detection result of the detecting unit.

[Advantageous Effects of Invention]

[0012]

According to the present disclosure, it is possible to provide a combustion facility and a control device capable of increasing a retention time of an exhaust gas in a furnace body.

[Brief Description of Drawings]

[0013]

Fig. 1 is a diagram illustrating the configuration of a combustion facility according to an embodiment of the present disclosure.

Fig. 2 is an enlarged diagram of a main part of the combustion facility according to the embodiment of the present disclosure.

Fig. 3 is a diagram illustrating a configuration of a nozzle according to the embodiment of the present disclosure.

Fig. 4 is a functional block diagram of a control device according to the

embodiment of the present disclosure.

Fig. 5 is a flowchart illustrating an example of an operation of the control device according to the embodiment of the present disclosure.

Fig. 6 is a flowchart illustrating an example of the operation of the control device according to the embodiment of the present disclosure.

Fig. 7 is a hardware configuration diagram illustrating a configuration of a computer according to the embodiment of the present disclosure.

[Description of Embodiments]

[0014]

Hereinafter, an embodiment of a combustion facility according to the present disclosure will be described with reference to the accompanying drawings.

[0015]

(Combustion Facility)

The combustion facility is, for example, a stoker type combustion furnace that performs incineration treatment on municipal refuse, industrial waste, biomass, or the like as materials to be incinerated. Hereinafter, for convenience of description, the "material to be incinerated" is referred to as "refuse". The refuse is fuel for generating a combustion reaction in the combustion furnace.

[0016]

As illustrated in Fig. 1, a combustion facility 100 includes a combustion furnace 1, a heat recovery steam generator 12, a temperature reduction tower 13, a dust collection device 14, an outlet flow path 15, a chimney 16, an induced draft fan 17, a refuse pit 18, an ash extrusion device 19, an ash pit 20, an exhaust gas recirculation system 21, an exhaust gas concentration acquisition unit 25, and a control device 30.

[0017]

(Combustion Furnace)

The combustion furnace 1 is a furnace that combusts refuse W while transferring the refuse W inside. As the refuse W is combusted by the combustion furnace 1, an exhaust gas is generated from the combustion furnace 1. The generated exhaust gas is sent to the heat recovery steam generator 12 connected to the upper portion of the combustion furnace 1.

[0018]

The heat recovery steam generator 12 performs heat exchange between the exhaust gas and water to heat the water and generate steam. The generated steam is used in, for example, a device (not illustrated) such as a steam turbine outside the combustion facility 100. The exhaust gas that has passed through the heat recovery steam generator 12 is cooled by the temperature reduction tower 13 and then sent to the dust collection device 14. The exhaust gas from which soot and dust are removed at the dust collection device 14 is discharged into the atmosphere through the outlet flow path 15 and the chimney 16.

[0019]

Here, the induced draft fan 17 (IDF) capable of inducing the exhaust gas generated in the combustion furnace 1 toward the chimney 16 is disposed in the middle of the outlet flow path 15. The induced draft fan 17 induces the exhaust gas from the inside of the combustion furnace 1 to maintain the inside of the combustion furnace 1 in a negative pressure state.

[0020]

The combustion furnace 1 includes a furnace body 2, a fuel supply mechanism 3, a stoker 4, a wind box 5, a discharge chute 6, a furnace 7, a forced draft fan 8, a primary air line 9, an air preheater 10, and a secondary air line 11.

[0021]

(Furnace Body)

The furnace body 2 is configured with a plurality of partition walls. A treatment space V for transferring the refuse W while combusting the refuse W is defined in the furnace body 2. In the treatment space V, the refuse W is transferred in a transfer direction Da (left-right direction in Figs. 1 and 2) while being combusted. The refuse W incinerated in the treatment space V is discharged to the outside of the furnace body 2 through the discharge chute 6.

[0022]

Hereinafter, for convenience of description, a side (left side in Figs. 1 and 2) from the discharge chute 6 toward the fuel supply mechanism 3 in the transfer direction Da will be referred to as “one side Dal”. Further, a side (right side in Figs. 1 and 2) to which the refuse W is transferred on a side opposite to the one side Dal is referred to as “the other side Dar”.

A configuration of the furnace body 2 will be described later.

[0023]

(Fuel Supply Mechanism)

The fuel supply mechanism 3 is a mechanism that receives the refuse W from the outside of the combustion furnace 1 and that supplies the received refuse W to the treatment space V inside the furnace body 2. The fuel supply mechanism 3 in the present embodiment has a hopper 300 and a feeder 310.

[0024]

The hopper 300 is an inlet of the combustion furnace 1 for supplying the refuse W into the furnace body 2. The refuse W is put into the hopper 300 from the outside of the combustion furnace 1 via a crane 182. The hopper 300 has an inlet

portion 301 and an outlet portion 302.

[0025]

The inlet portion 301 is an inlet portion of the hopper 300 in which the refuse W enters from the outside. The inlet portion 301 guides the refuse W supplied from the upper side in a vertical direction Dv (up-down direction in Figs. 1 and 2) which is a direction perpendicular to the horizontal plane, to the lower side outlet portion 302. The inlet portion 301 has a tubular shape extending in the vertical direction Dv. The outlet portion 302 is connected to a lower portion of the inlet portion 301. Therefore, the refuse W that is put into the inlet portion 301 falls downward on the lower side due to gravity.

[0026]

Hereinafter, for convenience of description, an upper side (upper side in Figs. 1 and 2) in the vertical direction Dv will be simply referred to as an "upper side Dvu". In addition, a side (lower side in Figs. 1 and 2) opposite to the upper side Dvu is simply referred to as a "lower side Dvd".

[0027]

The outlet portion 302 is an outlet portion of the hopper 300 that guides the refuse W put into the inlet portion 301 to the treatment space V inside the furnace body 2. The outlet portion 302 internally forms a storage space R for temporarily storing the refuse W before supplying the refuse W to the treatment space V in the furnace body 2. The outlet portion 302 in the present embodiment has a box shape extending in the transfer direction Da.

[0028]

The feeder 310 is a device that supplies the refuse W in the hopper 300 to the treatment space V inside the furnace body 2. The feeder 310 is disposed to be

movable back and forth in the transfer direction Da with respect to a floor surface 302a of the inner surface of the outlet portion 302 facing the upper side Dvu.

[0029]

An end portion of the feeder 310 on the one side Dal is connected to a feeder driving mechanism (not illustrated) that causes the feeder 310 to move back and forth by using hydraulic pressure or the like. The feeder 310 is capable of moving back and forth in the storage space R in the transfer direction Da via the feeder driving mechanism. That is, the feeder 310 is capable of advancing and retreating on the floor surface 302a of the outlet portion 302 from the one side Dal toward the other side Dar.

[0030]

The feeder 310 has a plate shape extending in the transfer direction Da and in the furnace width direction and having a predetermined thickness. The feeder 310 has an upper surface 311 facing the upper side Dvu and an extrusion surface 312 connected to the upper surface 311 and facing the other side Dar. Hereinafter, for convenience of description, a width direction of the furnace body 2, which is a direction perpendicular to each of the transfer direction Da and the vertical direction Dv, will be referred to as a “furnace width direction Dw”.

[0031]

The upper surface 311 is a surface on which the refuse W supplied from the inlet portion 301 is accumulated. The extrusion surface 312 is a surface that extrudes the refuse W accumulated on the floor surface 302a to the other side Dar. That is, the feeder 310 moves back and forth in the transfer direction Da at a predetermined time, and thus the feeder 310 intermittently extrudes the refuse W in the storage space R toward the treatment space V.

[0032]

That is, the refuse W on the upper surface 311 of the feeder 310 and the refuse W on the floor surface 302a of the outlet portion 302 are integrated with each other in the storage space R. Therefore, the extrusion surface 312 of the feeder 310 extrudes the refuse W to the treatment space V side, so that the refuse W accumulated on the upper surface 311 is also moved to the treatment space V side in conjunction with the extrusion.

[0033]

(Stoker)

The stoker 4 is configured with a plurality of fire grates (not illustrated), and the plurality of fire grates form a stoker surface 4a to which the refuse W is supplied in a layered manner by the fuel supply mechanism 3. The fire grate has a fixed fire grate and a movable fire grate.

[0034]

The fixed fire grate is fixed to a surface of the wind box 5 facing the upper side Dvu of the wind box 5. The movable fire grate moves to the one side Dal (upstream side) and the other side Dar (downstream side) at a constant speed, so that the movable fire grate transfers the refuse W on the movable fire grate and on the fixed fire grate (on the stoker surface 4a) to the downstream side while stirring and mixing the refuse W. The stoker 4 transfers the refuse W supplied in a layered manner to the stoker surface 4a to the discharge chute 6 while combusting the refuse W.

[0035]

Here, the furnace body 2 has a drying stage 50, a combustion stage 51, and a post-combustion stage 52 in order from the one side Dal. The drying stage 50, the combustion stage 51, and the post-combustion stage 52 partition the treatment space V

in the transfer direction Da. The drying stage 50 is a region for drying the refuse W supplied from the hopper 300 prior to combustion on the stoker 4. That is, in the drying stage 50, moisture is volatilized, and thus the steam is mainly generated from the drying stage 50.

[0036]

The combustion stage 51 and the post-combustion stage 52 are regions where the refuse W in a dried state is combusted on the stoker 4. In the combustion stage 51, diffusion combustion occurs due to the pyrolysis gas generated from the refuse W, and a bright flame F is generated. In the post-combustion stage 52, the fixed carbon combustion of the refuse W occurs after the diffusion combustion, and thus the bright flame F does not occur. Therefore, the bright flame F resulting from combustion is mainly formed in the combustion stage 51.

[0037]

(Wind Box)

The wind box 5 supplies combustion air (primary air A1) from below the stoker 4 toward the treatment space V. A plurality of the wind boxes 5 are arranged in the transfer direction Da. In the present embodiment, the drying stage 50, the combustion stage 51, and the post-combustion stage 52 in the furnace body 2 are partitioned by the wind box 5.

[0038]

(Discharge Chute)

The discharge chute 6 is a device that causes the refuse W, which has completed combustion and has turned into ash, to fall to the ash extrusion device 19 positioned on the lower side Dvd with respect to the furnace body 2. The discharge chute 6 is provided at an end portion of the post-combustion stage 52 on the other side

Dar.

[0039]

Here, as illustrated in Fig. 2, the furnace body 2 has a furnace back end 203 and a ceiling portion 200. The furnace back end 203 is a part of the partition wall in the furnace body 2. The furnace back end 203 is formed of a refractory material or the like. The furnace back end 203 is disposed on the other side Dar with respect to the post-combustion stage 52 partitioned by the wind box 5. The furnace back end 203 is connected to the discharge chute 6 from the upper side Dvu. The furnace back end 203 has a furnace back end surface 204 facing the one side Dal. The furnace back end surface 204 in the present embodiment has a planar shape extending in the vertical direction Dv and in the furnace width direction Dw.

[0040]

The ceiling portion 200 is a part of the partition wall in the furnace body 2. The ceiling portion 200 is formed of a refractory material or the like. The ceiling portion 200 is disposed on the upper side Dvu with respect to the furnace back end 203. The ceiling portion 200 is inclined in a direction in which the height in the vertical direction Dv decreases toward the other side Dar. The end portion of the ceiling portion 200 on the other side Dar is connected to the furnace back end 203. Hereinafter, for convenience of description, the connection point with the furnace back end 203 in the ceiling portion 200 will be referred to as a “rear end 201a”. In addition, an end portion of the ceiling portion 200 on the one side Dal opposite to the rear end 201a is referred to as a “front end 201b”.

[0041]

The ceiling portion 200 has a ceiling surface 201 that has a planar shape, and a curved surface 202 that is connected to the ceiling surface 201 from the one side Dal

and that has a convex curved surface shape that faces the upper side Dvu toward the one side Dal. The ceiling surface 201 is connected to the furnace back end surface 204 of the furnace back end 203 from the one side Dal. Therefore, the end portion of the ceiling surface 201 on the other side Dar is the rear end 201a. The ceiling surface 201 in the present embodiment is disposed to face the post-combustion stage 52 in the vertical direction Dv.

[0042]

The curved surface 202 is connected to the ceiling surface 201 from the one side Dal. The curved surface 202 when viewed from the furnace width direction Dw is formed in an arc shape having a predetermined radius of curvature. Hereinafter, the length of the curved surface 202 when viewed from the furnace width direction Dw is defined as "X<sub>R</sub>".

[0043]

(Furnace)

The furnace 7 extends from the furnace body 2 toward the upper side Dvu. An exhaust gas G generated by the combustion of the refuse W in the treatment space V is sent to the heat recovery steam generator 12 through the furnace 7. The furnace 7 has a tubular shape extending in the vertical direction Dv and having an inner surface 70. The furnace 7 in the present embodiment has a rectangular cross section.

[0044]

The furnace 7 is connected to the ceiling portion 200 from the one side Dal. One surface 70a of the inner surface 70 of the furnace 7 facing the one side Dal is connected to the curved surface 202 in the ceiling portion 200 from the upper side Dvu. Therefore, the connecting portion between the end portion of the one surface 70a of the inner surface 70 on the lower side Dvd and the end portion of the curved surface

202 on the one side Dal is the front end 201b. The one surface 70a extends upward from the front end 201b toward the upper side Dvu. In addition, the furnace 7 is connected to the outlet portion 302 in the hopper 300 from the other side Dar. Therefore, the furnace 7 is disposed between the ceiling portion 200 and the outlet portion 302. The furnace 7 in the present embodiment is disposed directly above the combustion stage 51.

[0045]

(Forced Draft Fan)

As illustrated in Fig. 1, the forced draft fan 8 is a device that pumps air for combustion of the refuse W in the treatment space V toward the inside of the combustion furnace 1. The forced draft fan 8 has a first forced draft fan 81 and a second forced draft fan 82. The first forced draft fan 81 pumps the combustion air toward the wind box 5 through the primary air line 9. The second forced draft fan 82 pumps the combustion air toward the furnace 7 through the secondary air line 11.

[0046]

(Primary Air Line)

The primary air line 9 is a pipe that connects the first forced draft fan 81 and the wind box 5. The first forced draft fan 81 is driven, so that the air necessary for the combustion of the refuse W is supplied to the wind box 5 through the primary air line 9. The primary air line 9 is connected to the wind box 5 from the lower side Dvd. The air supplied to the wind box 5 goes toward the refuse W from below the stoker 4. Hereinafter, for convenience of description, the air supplied to the inside of the furnace body 2 through the primary air line 9 will be referred to as the “primary air A1”.

[0047]

The primary air line 9 has a primary air damper 90. The primary air damper

90 is disposed in the middle of the primary air line 9, and regulates the flow rate of the primary air A1 in the primary air line 9 via the opening degree of the damper of the primary air damper 90.

[0048]

(Air Preheater)

The air preheater 10 is a heat exchanger that preheats the air pumped from the first forced draft fan 81. The air preheater 10 is provided in the middle of the primary air line 9, and preheats the combustion air flowing from the first forced draft fan 81 toward the wind box 5.

[0049]

The combustion air preheated by the air preheater 10 is supplied into the treatment space V, and is used for combustion of the refuse W and is heat-exchanged with the exhaust gas G generated in association with the combustion of the refuse W. Therefore, the air preheater 10 is capable of adjusting the temperature of the exhaust gas G by adjusting the temperature of the combustion air.

[0050]

(Secondary Air Line)

The secondary air line 11 is a pipe that connects the second forced draft fan 82 and the furnace 7. The second forced draft fan 82 is driven, so that the air necessary for the combustion of the refuse W is supplied to the furnace 7 through the secondary air line 11. The secondary air line 11 penetrates the furnace 7 from the outer side. As illustrated in Fig. 2, the tip of the secondary air line 11 is disposed inside the inner surface 70 of the furnace 7. The air supplied to the furnace 7 goes toward the refuse W from above the stoker 4. Hereinafter, for convenience of description, the air supplied to the inside of the furnace body 2 through the secondary air line 11 will be

referred to as the “secondary air A2”.

[0051]

As illustrated in Fig. 1, the secondary air line 11 has a secondary air damper 110. The secondary air damper 110 is provided in the middle of the secondary air line 11, and regulates the flow rate of the secondary air A2 via the opening degree of the damper of the secondary air damper 110.

[0052]

(Refuse Pit)

The refuse pit 18 stores the refuse W and supplies the refuse W to the hopper 300. The refuse pit 18 includes a refuse pit body 180, a platform 181, the crane 182, and a crane control device 189.

[0053]

The refuse pit body 180 is a chamber that stores the refuse W on the one side Dal with respect to the combustion furnace 1. The refuse pit body 180 is connected to the inlet portion 301 of the hopper 300. That is, the inside of the hopper 300 and the inside of the refuse pit body 180 communicate with each other, and the refuse W can be supplied from the inside of the refuse pit body 180 to the inside of the hopper 300.

[0054]

The platform 181 is a carry-in port for carrying the refuse W into the refuse pit body 180. The platform 181 is connected to a carry-in opening portion formed on the one side Dal of the refuse pit body 180. A refuse collecting vehicle T is carried into the platform 181 from the outside of the combustion facility 100. The refuse collecting vehicle T puts the carried-in refuse W into the inside of the refuse pit body 180.

[0055]

The crane 182 grips a part of the refuse W stored in the refuse pit body 180 and transfers the gripped refuse W from the refuse pit body 180 to the inlet portion 301 of the hopper 300. The crane 182 is provided on the ceiling portion of the refuse pit body 180 on the upper side Dvu.

[0056]

The crane 182 includes a rail 183 provided on the ceiling, a girder 184 running along the rail 183, a trolley 185 traversing on the girder 184, a wire 186 suspended from the trolley 185, a winch 187 that winds up and winds down the wire 186, and a grapple 188 attached to a tip of the wire 186.

[0057]

The crane control device 189 is a device that controls the running of the girder 184, the traverse of the trolley 185, the winding up and the winding down of the wire 186 via the winch 187, and the gripping operation of the grapple 188.

[0058]

(Ash Extrusion Device)

The ash extrusion device 19 is a device that receives the refuse W (ash) fallen from the furnace body 2 to the lower side Dvd through the discharge chute 6 and that extrudes the refuse W (ash) to the subsequent ash pit 20. The ash extrusion device 19 has an extrusion device body 190 and an extrusion mechanism (not illustrated).

[0059]

The extrusion device body 190 receives the refuse W that has been combusted in the treatment space V and that has turned into ash, and temporarily accumulates the refuse W. The extrusion device body 190 is disposed on the lower side Dvd with respect to the furnace body 2. The extrusion device body 190 is connected to the

discharge chute 6 from the lower side Dvd. The extrusion mechanism extrudes the refuse W (ash) fallen into the extrusion device body 190 toward the ash pit 20.

[0060]

(Ash Pit)

The ash pit 20 is a chamber that receives the refuse W in the extrusion device body 190 and that stores the refuse W therein. The ash pit 20 in the present embodiment is connected to the extrusion device body 190 from the other side Dar. The refuse W stored in the ash pit 20 is transferred to the outside of the combustion facility 100 by, for example, an ash crane or the like (not illustrated).

[0061]

(Exhaust Gas Recirculation System)

The exhaust gas recirculation system 21 is exhaust gas recirculation (EGR) that recirculates a part of the post-combustion exhaust gas G flowing inside the outlet flow path 15 into the furnace body 2. The exhaust gas recirculation system 21 has an exhaust gas recirculation line 22, a nozzle 23, and a fan 24.

[0062]

(Exhaust Gas Recirculation Line)

The exhaust gas recirculation line 22 connects the outlet flow path 15 and the furnace body 2. One end of the exhaust gas recirculation line 22 in the present embodiment is connected to the vicinity of the dust collection device 14 in the outlet flow path 15, and the other end of the exhaust gas recirculation line 22 is connected to the furnace back end 203 in the furnace body 2 via the nozzle 23.

[0063]

(Nozzle)

The nozzle 23 is a circular nozzle that supplies (releases) the exhaust gas G

supplied through the exhaust gas recirculation line 22 into the furnace body 2. The nozzle 23 is connected to the other end of the exhaust gas recirculation line 22. As illustrated in Figs. 2 and 3, the nozzle 23 in the present embodiment has a cylindrical shape extending around a center line O. The nozzle 23 is fixed to the furnace back end 203 in a state of penetrating the furnace back end 203.

[0064]

A plurality of the nozzles 23 are disposed at the furnace back end 203 at intervals in the furnace width direction Dw in a state where the nozzles 23 have the same height in the vertical direction Dv. In the present embodiment, two nozzles 23 are disposed at the furnace back end 203 at an interval in the furnace width direction Dw. In Fig. 2, for convenience of illustration, only one nozzle 23 is illustrated.

[0065]

The nozzle 23 is open to the inside of the furnace body 2 in a state of facing the inside of the furnace body 2. The nozzle 23 is fixed to the furnace back end 203 such that the center of the opening is aligned with the furnace back end surface 204. In the present embodiment, the exhaust gas G released from the nozzle 23 spreads in a conical shape around the opening of the nozzle 23. Hereinafter, the opening diameter of the nozzle 23 in the present embodiment is defined as "D".

[0066]

Here, a horizontal distance between the rear end 201a and the front end 201b is defined as "X", a vertical distance between the front end 201b and the center of the opening of the nozzle 23 is defined as "H", an angle formed by the ceiling portion 200 and a horizontal plane Hp is defined as " $\alpha$ ", and an angle formed by the center line O of the nozzle 23 and the horizontal plane Hp is defined as " $\beta$ ". In this case, the nozzle 23 is disposed at the furnace back end 203 to satisfy the following Expression

(I).

$$\text{atan}((H/X) + \tan(\alpha)) - \beta < 10 \dots (I)$$

[0067]

The horizontal distance referred to herein means a two-dimensional geometric distance in a horizontal direction. In addition, the vertical distance means a one-dimensional geometric distance in the vertical direction  $D_v$ . In addition, " $\text{atan}((H/X) + \tan(\alpha)) - \beta$ " on the left-hand side of Expression (I) is larger than 0.

[0068]

Hereinafter, the derivation process of Expression (I) will be described. When a vertical distance between the front end 201b and the rear end 201a is defined as "H1", a vertical distance between the rear end 201a and the center of the opening of the nozzle 23 is defined as "H2", and a release angle of the exhaust gas G with respect to the center line O of the nozzle 23 is defined as " $\gamma$ ", the following Expression (II) is established.  $\gamma$  is larger than 0.

$$\text{atan}((H1 + H2)/X) < \beta + \gamma \dots (II)$$

[0069]

When Expression (II) is transformed, the following Expression (III) is obtained.

$$\text{atan}((H1/X) + (H2/X)) < \beta + \text{atan}(0.172) \dots (III)$$

[0070]

Here, 0.172 on the right-hand side of Expression (III) is an experimental constant. That is, as illustrated in Fig. 3, when a predetermined distance from the center of the opening of the nozzle 23 on the center line O is defined as "D1" and a distance that the exhaust gas G spreads from the center line O at a position separated from the center of the opening of the nozzle 23 by the predetermined distance is

defined as "D2", in the relation to the above  $\gamma$ , the above Expression (III) is established by substituting the following Equation (IV) into the above Expression (II).

$$\gamma = \text{atan}(D2/D1) = \text{atan}(0.172) \dots \text{(IV)}$$

[0071]

When the above Expression (III) is transformed, the following Expression (V), that is, the above Expression (I) is derived.

$$\text{atan}((H/X) + \tan(\alpha)) - \beta < 9.759 \dots \approx 10 \dots \text{(V)}$$

[0072]

Here, in the relation of D, which is the opening diameter of the nozzle 23, and  $X_R$ , which is the length of the curved surface 202 when viewed from the furnace width direction Dw, the opening diameter of the nozzle 23 is set such that the following Expression (VI) is satisfied.

$$X_R/D < 52 \dots \text{(VI)}$$

[0073]

In addition, in the present embodiment, it is desirable that  $u_m$  obtained from the following Equation (VII) satisfies the following Expression (VIII) in relation to the left-hand side portion ( $X_R/D$ ) in Expression (VI).

$$u_m = 3.5(D/D1)^{0.5}u_0 \dots \text{(VII)}$$

$$u_m > 1.5\exp(0.0768X_R/D) \dots \text{(VIII)}$$

[0074]

$u_0$  in Equation (VII) is a nozzle flow speed determined by the type of the nozzle 23, or the like. In addition, the source of Equation (VII) is Toshihiko Shakouchi, "Journal of Jet Flow Engineering", Morikita Publishing Co., Ltd. (2004). Further, Expression (VIII) is a prediction expression established by the present inventors based on test data quoted from Toshihiko Shakouchi, "Transactions of the

Japan Society of Mechanical Engineers (B)", Vol. 56, No. 532 (1990).

[0075]

(Fan)

The fan 24 supplies the exhaust gas G to the nozzle 23 through the exhaust gas recirculation line 22. As illustrated in Fig. 1, the fan 24 is disposed in the middle of the exhaust gas recirculation line 22. The fan 24 is driven to pump a part of the exhaust gas G in the outlet flow path 15 to the nozzle 23. The fan 24 is controlled by the control device 30 disposed outside the combustion furnace 1.

[0076]

Specifically, the fan 24 receives a signal indicating the rotation speed from the control device 30 via wired or wireless communication. That is, the fan 24 rotates based on the rotation speed indicated by the signal, draws a part of the exhaust gas G in the outlet flow path 15 from the outlet flow path 15, and sends the exhaust gas G toward the nozzle 23. In addition, the fan 24 transmits a signal indicating the output rotation speed of the fan 24 to the control device 30 at a predetermined time interval via wired or wireless communication.

[0077]

(Movement of Exhaust Gas Released from Nozzle)

Hereinafter, the movement of the exhaust gas G released into the furnace body 2 by the nozzle 23 will be described. As illustrated in Fig. 2, a part of the exhaust gas G released from the nozzle 23 that satisfies the relationship shown in the above Expression (I) collides with the ceiling surface 201 in the ceiling portion 200 from the lower side Dvd. Hereinafter, for convenience of description, the exhaust gas G released from the nozzle 23 will be referred to as a "nozzle gas".

[0078]

The nozzle gas that has collided with the ceiling surface 201 forms a wall jet Jw that spreads along the ceiling surface 201 in a flattened state. The nozzle gas flows to the one side Dal along the ceiling surface 201 while forming the wall jet Jw. That is, the wall jet Jw forms a sheet shape spreading along the ceiling surface 201. In this case, the nozzle gases released from the two nozzles 23 each are along the ceiling surface 201 to form the wall jet Jw that the nozzle gases are combined with each other.

[0079]

A part of the wall jet Jw that has reached the curved surface 202 disposed on the one side Dal with respect to the ceiling surface 201 straightly travels in the spreading direction of the ceiling surface 201. Hereinafter, for convenience of description, the wall jet Jw that passes through the curved surface 202 and that straightly travels to the other side Dar in the spreading direction of the ceiling surface 201 will be referred to as a “first jet Jw1”. The first jet Jw1 flows to cover a portion of the combustion stage 51 on the upper side Dvu from the lower side Dvd, of opening portions of the furnace 7 facing the lower side Dvd.

[0080]

Meanwhile, a part of the wall jet Jw different from the first jet Jw1, of the wall jets Jw that have reached the curved surface 202, flows into the furnace 7 along the curved surface shape of the curved surface 202. That is, the wall jet Jw flows toward the upper side Dvu inside the furnace 7 on the upper side Dvu from the first jet Jw1 due to the Coanda effect. Hereinafter, for convenience of description, the wall jet Jw that advances into the inside of the furnace 7 along the curved surface shape of the curved surface 202 will be referred to as a “second jet Jw2”. In Fig. 2, for the sake of simplifying the description, only the flows of the first jet Jw1 and the second jet Jw2

of the wall jets  $J_w$  passing through the curved surface 202 are illustrated by hatching.

[0081]

(Exhaust Gas Concentration Acquisition Unit)

The exhaust gas concentration acquisition unit 25 acquires the concentrations of CO and NO<sub>x</sub> contained in the exhaust gas G generated from the combustion furnace 1. The exhaust gas concentration acquisition unit 25 is disposed in the outlet flow path 15. The exhaust gas concentration acquisition unit 25 has a CO sensor 25a and a NO<sub>x</sub> sensor 25b. Hereinafter, the concentration of CO contained in the exhaust gas G is referred to as a "CO concentration", and the concentration of NO<sub>x</sub> contained in the exhaust gas G is referred to as a "NO<sub>x</sub> concentration".

[0082]

The CO sensor 25a acquires the CO concentration of the exhaust gas G flowing inside the outlet flow path 15 at a predetermined time interval, and transmits a signal indicating the CO concentration to the control device 30 via wired or wireless communication. The NO<sub>x</sub> sensor 25b acquires the NO<sub>x</sub> concentration of the exhaust gas G flowing inside the outlet flow path 15 at a predetermined time interval, and transmits a signal indicating the NO<sub>x</sub> concentration to the control device 30 via wired or wireless communication. The CO sensor 25a and the NO<sub>x</sub> sensor 25b in the present embodiment acquire, for example, the CO concentration and the NO<sub>x</sub> concentration in the exhaust gas G per unit flow rate.

[0083]

(Control Device)

The control device 30 adjusts the flow rate of the exhaust gas G released from the nozzle 23 by transmitting and receiving a signal between the various devices described above. As illustrated in Fig. 4, the control device 30 in the present

embodiment includes a detecting unit 31, a determination unit 32, an adjustment unit 33, and a storage unit 34.

[0084]

(Detecting Unit)

The detecting unit 31 detects the CO concentration and the NO<sub>x</sub> concentration of the exhaust gas G flowing inside the outlet flow path 15 by receiving a signal indicating the CO concentration acquired by the CO sensor 25a of the exhaust gas concentration acquisition unit 25 and the NO<sub>x</sub> concentration acquired by the NO<sub>x</sub> sensor 25b. The detecting unit 31 transmits a signal indicating the detection result (CO concentration and NO<sub>x</sub> concentration) to the determination unit 32 and the adjustment unit 33.

[0085]

(Determination Unit)

The determination unit 32 determines whether or not each of the CO concentration and the NO<sub>x</sub> concentration detected by the detecting unit 31 is an appropriate concentration. Specifically, the determination unit 32 compares the CO concentration detected by the detecting unit 31 with the CO concentration threshold value stored in the storage unit 34.

[0086]

The determination unit 32 determines that "the CO concentration is appropriate" in a case where the CO concentration detected by the detecting unit 31 is equal to or lower than the CO concentration threshold value. On the other hand, the determination unit 32 determines that "the CO concentration is not appropriate" in a case where the CO concentration detected by the detecting unit 31 is higher than the CO concentration threshold value.

[0087]

In addition, the determination unit 32 determines that "the NO<sub>x</sub> concentration is appropriate" in a case where the NO<sub>x</sub> concentration detected by the detecting unit 31 is equal to or lower than the NO<sub>x</sub> concentration threshold value. On the other hand, the determination unit 32 determines that "the NO<sub>x</sub> concentration is not appropriate" in a case where the NO<sub>x</sub> concentration detected by the detecting unit 31 is higher than the NO<sub>x</sub> concentration threshold value. The determination unit 32 transmits a signal indicating the determination result to the adjustment unit 33.

[0088]

(Adjustment Unit)

The adjustment unit 33 adjusts the flow rate of the exhaust gas G supplied into the furnace body 2 by the nozzle 23 in a case where the signal indicating the CO concentration and the NO<sub>x</sub> concentration transmitted from the detecting unit 31 is received. In addition, the adjustment unit 33 adjusts the flow rate of the exhaust gas G supplied into the furnace body 2 by the nozzle 23, based on the determination result of the determination unit 32.

[0089]

In a case where the adjustment unit 33 receives the signal indicating the CO concentration from the detecting unit 31, the adjustment unit 33 transmits a signal indicating the increase in the rotation speed to the fan 24. Meanwhile, in a case where the adjustment unit 33 receives the signal indicating the NO<sub>x</sub> concentration from the detecting unit 31, the adjustment unit 33 transmits the signal indicating the increase in the rotation speed to the fan 24.

[0090]

In addition, in a case where the determination unit 32 determines that "the CO

concentration is appropriate", the adjustment unit 33 transmits a signal indicating the decrease in the rotation speed to the fan 24. On the other hand, in a case where the determination unit 32 determines that "the CO concentration is not appropriate", the adjustment unit 33 transmits the signal indicating the increase in the rotation speed to the fan 24.

[0091]

In addition, in a case where the determination unit 32 determines that "the NO<sub>x</sub> concentration is appropriate", the adjustment unit 33 transmits the signal indicating the decrease in the rotation speed to the fan 24. On the other hand, in a case where the determination unit 32 determines that "the NO<sub>x</sub> concentration is not appropriate", the adjustment unit 33 transmits the signal indicating the increase in the rotation speed to the fan 24.

[0092]

(Operation of Control Device)

Subsequently, an operation of the control device 30 will be described. Hereinafter, an example of the operation of the control device 30 in a case where the detecting unit 31 receives the signal indicating the CO concentration from the exhaust gas concentration acquisition unit 25 will be described with reference to Fig. 5.

[0093]

The detecting unit 31 detects the CO concentration contained in the exhaust gas G in the outlet flow path 15 by receiving the signal indicating the CO concentration from the exhaust gas concentration acquisition unit 25 (step S0). Next, when the adjustment unit 33 receives the detection result from the detecting unit 31, the adjustment unit 33 transmits the signal indicating the increase in the rotation speed to the fan 24 and increases the flow rate of the exhaust gas G supplied to the inside of

the furnace body 2 (step S1).

[0094]

Next, when the determination unit 32 receives the detection result from the detecting unit 31, the determination unit 32 determines whether or not the CO concentration detected by the detecting unit 31 is an appropriate concentration (step S2). In a case where the determination unit 32 determines that "the CO concentration is appropriate" (step S2: YES), the adjustment unit 33 transmits the signal indicating the decrease in the rotation speed to the fan 24 and decreases the flow rate of the exhaust gas G supplied to the inside of the furnace body 2 (step S3). When the process of step S3 is completed, the process of step S0 is performed again.

[0095]

In a case where the determination unit 32 determines that "the CO concentration is not appropriate" (step S2: NO), the adjustment unit 33 receives the determination result from the determination unit 32, transmits the signal indicating the increase in the rotation speed to the fan 24, and increases the flow rate of the exhaust gas G supplied to the inside of the furnace body 2 (step S1'). When the process of step S1' is completed, the process of step S2 is performed again.

[0096]

The processes of step S0 to step S3 described above are repeatedly executed in the operation stage of the combustion facility 100.

[0097]

Subsequently, an example of the operation of the control device 30 in a case where the detecting unit 31 receives the signal indicating the NO<sub>x</sub> concentration from the exhaust gas concentration acquisition unit 25 will be described with reference to Fig. 6.

[0098]

The detecting unit 31 detects the NO<sub>x</sub> concentration contained in the exhaust gas G in the outlet flow path 15 by receiving the signal indicating the NO<sub>x</sub> concentration from the exhaust gas concentration acquisition unit 25 (step S10). Next, when the adjustment unit 33 receives the detection result from the detecting unit 31, the adjustment unit 33 transmits the signal indicating the increase in the rotation speed to the fan 24 and increases the flow rate of the exhaust gas G supplied to the inside of the furnace body 2 (step S11).

[0099]

Next, when the determination unit 32 receives the detection result from the detecting unit 31, the determination unit 32 determines whether or not the NO<sub>x</sub> concentration detected by the detecting unit 31 is an appropriate concentration (step S12). In a case where the determination unit 32 determines that "the NO<sub>x</sub> concentration is appropriate" (step S12: YES), the adjustment unit 33 transmits the signal indicating the decrease in the rotation speed to the fan 24 and decreases the flow rate of the exhaust gas G supplied to the inside of the furnace body 2 (step S13). When the process of step S13 is completed, the process of step S10 is performed again.

[0100]

In a case where the determination unit 32 determines that "the NO<sub>x</sub> concentration is not appropriate" (step S12: NO), the adjustment unit 33 receives the determination result from the determination unit 32, transmits the signal indicating the increase in the rotation speed to the fan 24, and increases the flow rate of the exhaust gas G supplied to the inside of the furnace body 2 (step S11'). When the process of step S11' is completed, the process of step S12 is performed again.

[0101]

The processes of step S10 to step S13 described above are repeatedly executed in the operation stage of the combustion facility 100.

[0102]

(Operations and Effects)

According to the combustion facility 100 of the above embodiment, the nozzle 23 is disposed at the furnace back end 203 in a direction in which the nozzle gas forms the wall jet  $J_w$  along the ceiling portion 200 of the furnace body 2. Accordingly, a part of the exhaust gas  $G$  that rises due to the combustion of the refuse  $W$  on the lower side  $Dvd$  with respect to the wall jet  $J_w$  collides with the wall jet  $J_w$  from the lower side  $Dvd$ . A part of the exhaust gas  $G$  colliding with the wall jet  $J_w$  is bounded back to the lower side  $Dvd$  and is retained inside the furnace body 2. Therefore, the direct flow-out of the exhaust gas  $G$  into the furnace 7 is prevented, and the mixing with the unburned gas such as  $CO$  inside the furnace body 2 is enhanced. Accordingly, the retention time of the exhaust gas  $G$  inside the furnace body 2 can be increased. As a result, an increase in the  $CO$  concentration and the  $NO_x$  concentration in the exhaust gas  $G$  in the furnace body 2 can be reduced.

[0103]

Here, in a case where the nozzle gases released from the plurality of nozzles 23 form a free jet that is not along the ceiling portion 200, a gap may be formed between the free jets released from the respective nozzles 23. In this case, the exhaust gas  $G$  generated by the combustion of the refuse  $W$  may slip to the upper side  $Dvu$  through the gap between the free jets. According to the combustion facility 100 of the above-described embodiment, the nozzle gases released from the plurality of nozzles 23 become the wall jet  $J_w$  in which the nozzle gases are along the ceiling surface 201 in the ceiling portion 200 to combine with each other. Therefore, a gap is

less likely to be generated between the wall jets  $J_w$  formed by the nozzle gases released from the respective nozzles 23. Therefore, it is possible to suppress the exhaust gas  $G$  generated with the combustion of the refuse  $W$  from slipping to the upper side  $D_{vu}$  with respect to the wall jet  $J_w$ . As a result, the retention time of the exhaust gas  $G$  inside the furnace body 2 can be further increased. In addition, it is possible to suppress that the volatile matter content generated from the refuse  $W$  is present in a lower portion (lower side  $D_{vd}$  with respect to a connecting portion between the furnace 7 and the secondary air line 11) in the furnace 7 at a locally high concentration.

[0104]

In addition, since the flattened wall jet  $J_w$  is formed along the ceiling surface 201 by the nozzle gas, for example, the jet width of the nozzle gas in the vertical direction  $D_v$  can be reduced compared to a case where the nozzle gas forms a free jet. Accordingly, a position where the exhaust gas  $G$  is accelerated by colliding with the nozzle gas is on the upper side  $D_{vu}$  compared to a case where the nozzle gas forms the free jet. That is, the retention time of the exhaust gas  $G$  inside the furnace body 2 can be increased. Therefore, the exhaust gas  $G$  can be retained for a longer time inside the furnace body 2 as compared with a case where the nozzle gas forms the free jet.

[0105]

In addition, according to the combustion facility 100 of the above embodiment, the nozzle 23 is disposed at the furnace back end 203 to satisfy the above Expression (I). Accordingly, the wall jet  $J_w$  along the ceiling portion 200 can be effectively formed inside the furnace body 2. In addition, the above-described operations and effects can be realized in specific settings.

[0106]

In addition, according to the combustion facility 100 of the above embodiment, the ceiling portion 200 has the curved surface 202 that connects the ceiling surface 201 and the inner surface 70 of the furnace 7. Accordingly, the curved surface 202 exhibits the Coanda effect with respect to the wall jet  $J_w$ . That is, a part of the wall jet  $J_w$  flowing along the ceiling surface 201, that is, the second jet  $J_{w2}$ , flows along the curved surface 202 and flows to the upper side Dvu inside the furnace 7. The second jet  $J_{w2}$  flowing to the upper side Dvu spreads and flows inside the furnace 7, and is mixed with the exhaust gas G generated due to the combustion of the refuse W and flowing into the furnace 7. As a result, a bias in distribution of the CO and the  $NO_x$  in the exhaust gas G in the furnace 7 can be reduced.

[0107]

In addition, according to the control device 30 of the embodiment, the adjustment unit 33 increases or decreases the rotation speed of the fan 24 when one or both of the CO concentration and the  $NO_x$  concentration in the exhaust gas G flowing in the outlet flow path 15 are increased or decreased, based on the detection result of the detecting unit 31. Accordingly, the CO concentration and the  $NO_x$  concentration in the exhaust gas G inside the furnace body 2 and in the exhaust gas G discharged to the outside of the furnace body 2 can be optimized. For example, when CO or  $NO_x$  is detected by the detecting unit 31, the adjustment unit 33 can increase the rotation speed of the fan 24 to enhance the above-described operations and effects. As a result, the CO concentration and the  $NO_x$  concentration in the exhaust gas G can be reduced.

[0108]

(Other Embodiments)

While the embodiments of the present disclosure have been described above in

detail with reference to the drawings, specific configurations are not limited to the configurations of each embodiment, and additions, omissions, and substitutions of the configurations and other changes can be made without departing from the concept of the present disclosure.

[0109]

Fig. 7 is a hardware configuration diagram illustrating a configuration of a computer 1100 according to the present embodiment. The computer 1100 includes a processor 1110, a main memory 1120, a storage 1130, and an interface 1140.

[0110]

The above-described control device 30 is mounted on the computer 1100. An operation of each of the processing units described above is stored in the storage 1130 in a form of a program. The processor 1110 reads the program from the storage 1130, deploys the read program in the main memory 1120, and executes the above-described process in accordance with the program. Further, the processor 1110 ensures a storage area corresponding to each storage unit 34 described above in the main memory 1120 in accordance with the program.

[0111]

The program may be a program for realizing 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 PLDs 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.

[0112]

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 in the computer 1100 or may be an external medium connected to the computer 1100 via the interface 1140 or via 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 deploy the program in the main memory 1120 to execute the above-described process. In the above-described embodiment, the storage 1130 is a non-transitory tangible storage medium.

[0113]

In addition, the program may be a program for realizing some of 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.

[0114]

In addition, in the embodiment, the configuration in which the two nozzles 23 are disposed at the furnace back end 203 at an interval in the furnace width direction  $D_w$  has been described. However, the present disclosure is not limited to this configuration. One nozzle 23 may be disposed at the furnace back end 203. In addition, three or more nozzles 23 may be disposed at the furnace back end 203 at intervals in the furnace width direction  $D_w$ .

[0115]

In addition, the ceiling portion 200 described in the embodiment may be formed of a material having higher wear resistance than the furnace back end 203. Examples of a material having high wear resistance adopted for the ceiling portion 200 include SiC (silicon carbide). Accordingly, even in a case where the fly ash (ash) contained in the wall jet Jw collides with the ceiling portion 200, the wear of the ceiling portion 200 can be suppressed. In addition to the above configuration, the furnace 7 may be formed of a material having higher wear resistance than the furnace back end 203.

[0116]

In addition, in the embodiment, the configuration in which the nozzle 23 is a circular nozzle has been described. However, the nozzle is not limited to the circular nozzle.

[0117]

In addition, in the embodiment, the combustion facility 100 is a stoker type combustion furnace. However, the combustion facility is not limited to the stoker type combustion furnace. The combustion facility 100 may be, for example, a kiln stoker furnace, a biomass fluidized bed boiler, a sludge combustion furnace, or the like. Therefore, the control device 30 described above may be a control device of the combustion facility 100 such as the kiln stoker furnace, the biomass fluidized bed boiler, and the sludge combustion furnace.

[0118]

[Supplementary Notes]

The combustion facility 100 and the control device 30 described in the embodiment are, for example, understood as follows.

[0119]

(1) A combustion facility 100 according to a first aspect includes a furnace body 2 that transfers a material W to be incinerated while combusting the material W to be incinerated inside, and a nozzle 23 that supplies a part of an exhaust gas G discharged from the furnace body 2 to the inside of the furnace body 2, in which the nozzle 23 is disposed at a furnace back end 203 of the furnace body 2 in a direction in which the exhaust gas G supplied to the inside of the furnace body 2 forms a wall jet Jw along a ceiling portion 200 of the furnace body 2.

[0120]

Accordingly, a part of the exhaust gas G that rises due to the combustion of the material W to be incinerated on the lower side Dvd with respect to the wall jet Jw collides with the wall jet Jw from the lower side Dvd. A part of the nozzle gas colliding with the wall jet Jw is bounded back to the lower side Dvd and is retained inside the furnace body 2.

[0121]

(2) A combustion facility 100 according to a second aspect is the combustion facility 100 of the first aspect, in which a plurality of the nozzles 23 may be disposed at the furnace back end 203, and the plurality of nozzles 23 may be disposed such that the exhaust gases G are along the ceiling portion 200 to form the wall jet Jw in which the exhaust gases G are combined with each other.

[0122]

Accordingly, a gap is less likely to be generated between the wall jets Jw formed by the exhaust gas G released from each nozzle 23. Therefore, it is possible to suppress the exhaust gas G generated with the combustion of the material W to be incinerated from slipping to the upper side Dvu with respect to the wall jet Jw.

[0123]

(3) A combustion facility 100 according to a third aspect is the combustion facility 100 of the first aspect or the second aspect, in which the ceiling portion 200 may be inclined in a direction in which a height in a vertical direction  $D_v$  decreases toward a direction in which the material  $W$  to be incinerated is transferred, in a state of being connected to the furnace back end 203, and in a case where a horizontal distance between a rear end 201a, which is a connection point with the furnace back end 203 in the ceiling portion 200, and a front end 201b, which is on a side opposite to the rear end 201a in the ceiling portion 200, is defined as  $X$ , a vertical distance between the front end 201b and a center of the opening of the nozzle 23 is defined as  $H$ , an angle formed by the ceiling portion 200 and a horizontal plane  $H_p$  is defined as  $\alpha$ , and an angle formed by a center line  $O$  of the nozzle 23 and the horizontal plane  $H_p$  is defined as  $\beta$ , the nozzle 23 may be disposed at the furnace back end 203 such that a relationship  $\tan((H/X) + \tan(\alpha)) - \beta < 10$  is satisfied.

[0124]

Accordingly, the above operations can be realized with a specific setting.

[0125]

(4) A combustion facility 100 according to a fourth aspect is the combustion facility 100 of the third aspect, and may further include a furnace 7 which extends upward from the furnace body 2 and of which an inner surface 70 is connected to the ceiling portion 200, in which the ceiling portion 200 may include a ceiling surface 201 that has a planar shape, and a curved surface 202 that connects the inner surface 70 and the ceiling surface 201 and that has a curved surface shape that faces upward from the ceiling surface 201 toward the inner surface 70.

[0126]

Accordingly, the curved surface 202 exhibits the Coanda effect with respect to

the wall jet Jw. That is, a part of the wall jet Jw flowing along the ceiling surface 201 flows along the curved surface 202 and flows to the upper side Dvu inside the furnace 7.

[0127]

(5) A control device 30 according to a fifth aspect is a control device 30 of the combustion facility 100 of any one of the first aspect to the fourth aspect, in which the combustion facility 100 further includes a fan 24 that supplies a part of the exhaust gas G to the nozzle 23 through an exhaust gas recirculation line 22, the control device 30 includes a detecting unit 31 that detects a CO concentration and a NO<sub>x</sub> concentration in the exhaust gas G, and an adjustment unit 33 that increases or decreases a rotation speed of the fan 24 when one or both of the CO concentration and the NO<sub>x</sub> concentration in the exhaust gas G are increased or decreased, based on a detection result of the detecting unit 31.

[0128]

Accordingly, the CO concentration and the NO<sub>x</sub> concentration in the exhaust gas G inside the furnace body 2 and in the exhaust gas G discharged to the outside of the furnace body 2 can be optimized.

[Industrial Applicability]

[0129]

According to the present disclosure, it is possible to provide a combustion facility and a control device capable of increasing a retention time of an exhaust gas in a furnace body.

[Reference Signs List]

[0130]

1: combustion furnace

2: furnace body  
3: fuel supply mechanism  
4: stoker  
4a: stoker surface  
5: wind box  
6: discharge chute  
7: furnace  
8: forced draft fan  
9: primary air line  
10: air preheater  
11: secondary air line  
12: heat recovery steam generator  
13: temperature reduction tower  
14: dust collection device  
15: outlet flow path  
16: chimney  
17: induced draft fan  
18: refuse pit  
19: ash extrusion device  
20: ash pit  
21: exhaust gas recirculation system  
22: exhaust gas recirculation line  
23: nozzle  
24: fan  
25: exhaust gas concentration acquisition unit

25a: CO sensor  
25b: NO<sub>x</sub> sensor  
30: control device  
31: detecting unit  
32: determination unit  
33: adjustment unit  
34: storage unit  
50: drying stage  
51: combustion stage  
52: post-combustion stage  
70: inner surface  
70a: one surface  
81: first forced draft fan  
82: second forced draft fan  
90: primary air damper  
100: combustion facility  
110: secondary air damper  
180: refuse pit body  
181: platform  
182: crane  
183: rail  
184: girder  
185: trolley  
186: wire  
187: winch

188: grapple  
189: crane control device  
190: extrusion device body  
200: ceiling portion  
201: ceiling surface  
201a: rear end  
201b: front end  
202: curved surface  
203: furnace back end  
204: furnace back end surface  
300: hopper  
301: inlet portion  
302: outlet portion  
302a: floor surface  
310: feeder  
311: upper surface  
312: extrusion surface  
1100: computer  
1110: processor  
1120: main memory  
1130: storage  
1140: interface  
A1: primary air  
A2: secondary air  
Da: transfer direction

Dal: one side  
Dar: the other side  
Dv: vertical direction  
Dvd: lower side  
Dvu: upper side  
Dw: furnace width direction  
F: bright flame  
G: exhaust gas  
Hp: horizontal plane  
Jw: wall jet  
Jw1: first jet  
Jw2: second jet  
O: center line  
R: storage space  
R1: primary combustion region  
R2: secondary combustion region  
T: refuse collecting vehicle  
V: treatment space  
W: material to be incinerated, refuse

## Claims

### [Claim 1]

A combustion facility comprising:

a furnace body that transfers a material to be incinerated while combusting the material to be incinerated inside; and

a nozzle that supplies a part of an exhaust gas discharged from the furnace body to the inside of the furnace body,

wherein the nozzle is disposed at a furnace back end of the furnace body in a direction in which the exhaust gas supplied to the inside of the furnace body forms a wall jet along a ceiling portion of the furnace body,

the nozzle supplies the exhaust gas such that the exhaust gas spreads in a conical shape from an opening of the nozzle, so that a part of the exhaust gas collides with the ceiling portion of the furnace body from a lower side to form the wall jet,

a plurality of the nozzles are disposed at the furnace back end at intervals in a furnace width direction, and

the intervals between the plurality of nozzles are set such that the wall jet in which the exhaust gases supplied from each of the nozzles are combined with each other is formed.

### [Claim 2]

The combustion facility according to Claim 1,

wherein the ceiling portion is inclined in a direction in which a height in a vertical direction decreases toward a direction in which the material to be incinerated is transferred, in a state of being connected to the furnace back end, and

in a case where a horizontal distance between a rear end, which is a connection point with the furnace back end in the ceiling portion, and a front end, which is on a side opposite to the rear end in the ceiling portion, is defined as X, a vertical distance between the front end and a center of the opening of the nozzle is defined as H, an angle formed by the ceiling portion and a horizontal plane is defined as  $\alpha$ , and an angle formed by a center line of the nozzle and the horizontal plane is defined as  $\beta$ , the nozzle is disposed at the furnace back end such that a relationship  $\tan((H/X) + \tan(\alpha)) - \beta < 10$  is satisfied.

[Claim 3]

The combustion facility according to Claim 2, further comprising:

a furnace which extends upward from the furnace body and of which an inner surface is connected to the ceiling portion,

wherein the ceiling portion includes

a ceiling surface that has a planar shape, and

a curved surface that connects the inner surface and the ceiling surface and that has a curved surface shape that faces upward from the ceiling surface toward the inner surface.

[Claim 4]

A control device of the combustion facility according to any one of Claims 1 to 3, in which the combustion facility further includes a fan that supplies a part of the exhaust gas to the nozzle through an exhaust gas recirculation line, the control device comprising:

a detecting unit that detects a CO concentration and a NO<sub>x</sub> concentration in

the exhaust gas; and

an adjustment unit that increases or decreases a rotation speed of the fan when one or both of the CO concentration and the NO<sub>x</sub> concentration in the exhaust gas are increased or decreased, based on a detection result of the detecting unit.