

## 5 CONTROL DEVICE OF COMBUSTION FURNACE FACILITY

### Technical Field

[0001]

10 The present disclosure relates to a control device of a combustion furnace facility.

### Background Art

[0002]

15 Patent Document 1 discloses a technique for adjusting the amount of waste supply in waste incineration facilities by controlling the stroke length of a pusher-type refuse feeding device based on specific gravity information obtained from the weight and volume of waste to be fed.

20 Municipal waste, which is the main object to be burned in waste incineration facilities, varies greatly in properties, and has high moisture content. Accordingly, when a large amount of municipal waste is supplied into the combustion furnace, the gas temperature and steam flow rate related to combustion temporarily decrease.

### Citation List

25 Patent Literature

[0003]

Patent Document 1: JP 6779779 B

### Summary of Invention

30 Technical Problem

[0004]

35 Incidentally, in the pusher-type refuse feeding device (feeder) described in Patent Document 1 described above, excessive waste may be supplied at a time or waste may be merely compressed and thus not appropriately supplied in the course of supplying waste (object to be burned) into the furnace. In all of these cases, the gas temperature and steam flow rate related to combustion decrease, and thus there is a possibility that the supply state of waste by the feeder may not be accurately grasped, and that the combustion state of waste may not be stabilized.

40 [0005]

The present disclosure has been made to solve the above-described problems. An object of the present disclosure is to provide a control device of a

- 5 combustion furnace facility that can accurately grasp the supply state of waste by the feeder and that can stabilize the combustion state of waste.

### Solution to Problem

[0006]

- 10 In order to solve the above-described problems, the control device of the combustion furnace facility according to the present disclosure is a control device of a combustion furnace facility including a furnace body that transports an object to be burned while burning the same, and a feeder that supplies the object to be burned to the furnace body, and the control device includes: an  
15 image acquisition unit configured to chronologically acquire a feeder image that is an image of a region including the feeder; a luminance change identification unit configured to identify a change in luminance of the feeder image; a feeder operation acquisition unit configured to acquire operation information of the feeder; and a supply state determination unit configured to  
20 determine whether a supply amount of the object to be burned is sufficient based on identification of the change in luminance of the feeder image and the operation information of the feeder.

### Advantageous Effects of Invention

25 [0007]

According to the present disclosure, it is possible to provide a control device of a combustion furnace facility that can accurately grasp the supply state of waste by the feeder and stabilize the combustion state of waste.

30

### Brief Description of Drawings

[0008]

FIG. 1 is a diagram illustrating a configuration of a stoker furnace according to an embodiment of the present disclosure.

- 35 FIG. 2 is a function block diagram illustrating a configuration of a control device according to an embodiment of the present disclosure.

FIGS. 3A, 3B, and 3C are diagrams schematically illustrating an operation of a feeder according to an embodiment of the present disclosure.

FIG. 4 is a diagram schematically illustrating a feeder image generated by a camera according to an embodiment of the present disclosure.

- 40 FIGS. 5A and 5B are flowcharts illustrating an operation of an exhaust gas concentration acquisition unit of a control device according to an embodiment of the present disclosure.

5           FIGS. 6A, 6B, and 6C are diagrams illustrating a degree of opening of secondary air dampers determined by a secondary air volume control unit of a control device according to an embodiment of the present disclosure.

FIG. 7 is a flowchart illustrating an operation of a control device according to an embodiment of the present disclosure.

10           FIG. 8 is a hardware configuration diagram illustrating a configuration of a computer according to an embodiment of the present disclosure.

### Description of Embodiments

[0009]

#### 15 Combustion Furnace Facility

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

The combustion furnace facility according to the present embodiment is  
20 a waste incineration stoker furnace that incinerates waste such as municipal waste as the object to be burned.

[0010]

FIG. 1 is a diagram illustrating a configuration of a combustion furnace facility according to the present embodiment. A combustion furnace facility  
25 100 includes a stoker furnace 1, a waste heat recovery boiler 8, a temperature reduction column 9, a precipitator 11, an outlet flow path 12, and a stack 13.

[0011]

#### Stoker Furnace

The stoker furnace 1 is a furnace that burns the object to be burned 400  
30 while transporting the same. As the object to be burned 400 is burned by the stoker furnace 1, exhaust gas is generated from the stoker furnace 1. This exhaust gas is sent to the waste heat recovery boiler 8 provided at an upper portion of the stoker furnace 1.

[0012]

35           The waste heat recovery boiler 8 performs heat exchange between exhaust gas and water to heat the water and generate steam. This steam is utilized in external equipment not illustrated. The exhaust gas that passes through the waste heat recovery boiler 8 is cooled in the temperature reduction column 9, and then sent to the precipitator 11. After soot and dust are removed  
40 by the precipitator 11, the exhaust gas is discharged to the atmosphere through the outlet flow path 12 and the stack 13.

[0013]

5           The stoker furnace 1 includes a furnace body 10, a hopper 3, a feeder 31, a stocker 6, wind boxes 2, a discharge chute 14, a forced draft fan B, an air preheater H, a furnace 7, a primary air line L1, a secondary air line L2, a camera 220, and a control device 300.

[0014]

#### 10   Furnace Body

          A processing space V for burning the object to be burned 400 is formed inside the furnace body 10. In this processing space V, the object to be burned 400 is transported to a first side of a transport direction Da while burning. The incinerated object to be burned 400 is discharged to the outside through the  
15   discharge chute 14.

          In the present specification, the first side of the transport direction Da is a direction in which the object to be burned 400 travels from the hopper 3 toward the discharge chute 14. Furthermore, a second side of the transport direction Da is a direction opposite to the first side of the transport direction  
20   Da.

[0015]

#### Hopper

          The hopper 3 is an inlet for the object to be burned 400 to be fed into the furnace body 10. In the present embodiment, the object to be burned 400 is fed  
25   into the hopper 3 from a waste crane (not illustrated) provided outside the stoker furnace 1.

[0016]

#### Feeder

          The feeder 31 is a device that supplies the object to be burned 400 fed  
30   into the hopper 3 to the processing space V of the furnace body 10. In the present embodiment, the feeder 31 has a plate shape. Since the feeder 31 itself reciprocates in the transport direction Da, the feeder 31 pushes out the object to be burned 400 accumulated on the upper surface of the feeder 31 into the processing space V at a predetermined timing. The feeder 31 pushes out the  
35   object to be burned 400 into the processing space V to supply the object to be burned 400 on the stoker 6.

[0017]

#### Stoker

          The stoker 6 is constituted by a plurality of fire grates. The plurality of  
40   fire grates form an upper surface on which the object to be burned 400 is supplied in a layered manner from the feeder 31. The fire grates include fixed fire grates and movable fire grates. The fixed fire grates are fixed to the upper

5 surface of the wind boxes 2. The movable fire grates move to the first side  
 (downstream side) of the transport direction Da and to the second side  
 (upstream side) of the transport direction Da at a constant speed, thereby  
 transporting downstream the object to be burned 400 on the movable fire grates  
 and the fixed fire grates while stirring and mixing the same. The stoker 6  
 10 transports the object to be burned 400 supplied on the upper surface in a  
 layered manner in a horizontal direction toward the discharge chute 14 while  
 burning the same.

[0018]

The furnace body 10 includes a drying stage 21, a combustion stage 22,  
 15 and a post-combustion stage 23 in the order from the second side of the  
 transport direction Da. The drying stage 21, the combustion stage 22, and the  
 post-combustion stage 23 divide the processing space V in the transport  
 direction Da. The drying stage 21 is a region for drying the object to be burned  
 400 supplied from the hopper 3 prior to combustion on the stoker 6.

20 [0019]

The combustion stage 22 and the post-combustion stage 23 are regions  
 for burning the object to be burned 400 in a dry state on the stoker 6. In the  
 combustion stage 22, diffusion combustion caused by pyrolysis gas generated  
 from the object to be burned 400 occurs, causing luminous flame F. In the post-  
 25 combustion stage 23, combustion of fixed carbon occurs after the diffusion  
 combustion of the object to be burned 400, and thus the luminous flame F is not  
 generated. Accordingly, the luminous flame F generated by combustion is  
 mainly formed in the combustion stage 22.

[0020]

30 The luminous flame F has a burnout length Z at an end portion on the  
 first side of the transport direction Da of the luminous flame F. The burnout  
 length Z is a point on the stoker 6 indicating that the diffusion combustion of  
 the object to be burned 400 in the combustion stage 22 has ended. The burnout  
 length Z is one of the indicators used for control to achieve suitable combustion  
 35 in the stoker furnace 1.

[0021]

#### Wind Boxes

Wind boxes 2 supply air from below the stoker 6. A plurality of wind  
 boxes 2 are arranged in the transport direction Da. In the present embodiment,  
 40 the drying stage 21, the combustion stage 22, and the post-combustion stage 23  
 are divided by the wind boxes 2.

[0022]

## 5 Discharge Chute

A discharge chute 14 is provided at an end portion on the first side in the transport direction Da of the post-combustion stage 23. The discharge chute 14 is a device that causes the object to be burned 400 that turned into ash after completion of combustion to fall into an ash discharger (not illustrated) located at a lower portion of the furnace body 10.

[0023]

## Forced draft fan

The forced draft fan B pumps air toward the inside of the furnace body 10. In the forced draft fan B, the pressure of air to be pumped is determined in accordance with the rotational speed of the fan.

The forced draft fan B includes a first forced draft fan B1 and a second forced draft fan B2. The first forced draft fan B1 pumps air toward the wind boxes 2 through the primary air line L1 to be described later. The second forced draft fan B2 pumps air toward the furnace 7 through the secondary air line L2 to be described later.

[0024]

## Air Preheater

The air preheater H preheats the air pumped from the first forced draft fan B1.

[0025]

## Furnace

The furnace 7 extends upwardly from an upper portion of the furnace body 10. The exhaust gas generated in the processing space V is sent to the waste heat recovery boiler 8 through the furnace 7.

[0026]

## Primary Air Line

The primary air line L1 connects the first forced draft fan B1 and the wind boxes 2. The first forced draft fan B1 is driven to cause air required for combustion of the object to be burned 400 (hereinafter referred to as the primary air) to be supplied to the wind boxes 2 through the primary air line L1. The primary air line L1 includes primary air dampers L1a. The primary air dampers L1a are provided in the middle of the primary air line L1, and regulate the flow rate of the primary air in the primary air line L1 by the degree of opening of the dampers.

[0027]

## Secondary Air Line

5           The secondary air line L2 connects the second forced draft fan B2 and  
the furnace 7. The second forced draft fan B2 is driven to cause the air required  
for combustion of the object to be burned 400 (hereinafter referred to as the  
secondary air) to be supplied into the furnace 7 through the secondary air line  
L2. The secondary air travels from above the stoker 6 toward the object to be  
10   burned 400. The secondary air line L2 includes secondary air dampers L2a. The  
secondary air dampers L2a are provided in the middle of the secondary air line  
L2, and regulate the flow rate of the secondary air by the degree of opening of  
the dampers.

[0028]

15   Camera

          The camera 220 includes an infrared camera and a visible camera, and is  
provided at a ceiling portion inside the furnace body 10. In processed images  
generated by the camera 220 that takes pictures of the inside of the furnace  
body 10, the regions in which the feeder 31, the drying stage 21, the  
20   combustion stage 22, and the post-combustion stage 23 are displayed are  
identified in advance, respectively.

[0029]

          The infrared camera takes pictures of the inside of the furnace body 10  
in a wavelength band of 3.5 to 4.5  $\mu\text{m}$  to generate a processed image.  
25   Hereinafter, processed images generated by the infrared camera that takes  
pictures of the inside of the furnace body 10 are referred to as feeder images  
315a. The imaging range of the camera 220 encompasses at least a region  
including the feeder 31. Since the infrared camera takes pictures in the above-  
described wavelength band, the luminous flame F can be penetrated and is  
30   almost never displayed in generated feeder images 315a.

[0030]

          The visible camera takes pictures of the inside of the furnace body 10 in  
a wavelength band in the visible wavelength range, and generates processed  
images. Hereinafter, a processed image generated by the visible camera that  
35   takes pictures of the inside of the furnace body 10 is referred to as an intra-  
furnace image. The imaging range of the camera 220 encompasses at least the  
luminous flame F. Since the visible camera takes pictures in the above-  
described wavelength band, the luminous flame F cannot be penetrated and is  
mainly displayed in the generated intra-furnace image. Since the luminous  
40   flame F mainly occurs in the combustion stage 22, the luminous flame F is  
mainly displayed in the upper half of the intra-furnace image.

[0031]

## 5 Control Device

Next, the configuration of the control device 300 of the present embodiment will be described with reference to FIGS. 2 to 7.

As illustrated in FIG. 2, the control device 300 includes a feeder operation acquisition unit 310, an image acquisition unit 315, a luminance change identification unit 320, a feeder operation restriction unit 325, a feeder speed control unit 330, a supply state determination unit 335, an oversupply determination unit 340, an exhaust gas concentration acquisition unit 345, a secondary air volume control unit 350, a combustion state acquisition unit 355, a combustion state determination unit 360, and a combustion control unit 365.

The control device 300 is connected to the combustion furnace facility 100 in a wired or wireless manner.

[0032]

### Feeder Operation Acquisition Unit

The feeder operation acquisition unit 310 acquires operation information related to the reciprocation state of the feeder 31.

Specifically, the feeder operation acquisition unit 310 acquires the operation information of the feeder 31 by the operations described below.

[0033]

The feeder operation acquisition unit 310 chronologically checks the reciprocation state of the feeder 31 and acquires the amount of reciprocation in the transport direction Da. An example of the reciprocation state of the feeder 31 checked by the feeder operation acquisition unit 310 is illustrated in FIGS. 3A, 3B, and 3C.

With the position illustrated in FIG. 3A as the initial position, for example, the feeder 31 continuously transitions to the state illustrated in FIG. 3B at a predetermined timing, and continuously transitions to the state illustrated in FIG. 3C. In this way, the object to be burned 400 stacked inside the hopper 3 is pushed into the furnace body 10 by the feeder 31. When the object to be burned 400 is completely pushed into the furnace body 10, the feeder 31 returns to the initial position illustrated in FIG. 3A via the state illustrated in FIG. 3B.

[0034]

The feeder operation acquisition unit 310 judges the reciprocation state of the feeder 31 by chronologically checking the above-described transition state of the feeder 31.

5           When it is confirmed that the feeder 31 is transitioning from FIG. 3A to FIG. 3C, the feeder operation acquisition unit 310 judges that "the feeder 31 is advancing."

          When it is confirmed that the feeder 31 is transitioning from FIG. 3C to FIG. 3A, the feeder operation acquisition unit 310 judges that "the feeder 31 is  
10   retracting."

          When it is confirmed that the feeder 31 maintains the state illustrated in FIG. 3A, the feeder operation acquisition unit 310 judges that "the feeder 31 is stopped."

[0035]

#### 15   Image Acquisition Unit

          The image acquisition unit 315 chronologically acquires feeder images 315a taken by the camera 220. In the present embodiment, the image acquisition unit 315 acquires feeder images 315a at an interval of one second, for example.

20   [0036]

#### Luminance Change Identification Unit

          The luminance change identification unit 320 receives feeder images 315a acquired by the image acquisition unit 315, and identifies a change in luminance of the region including the feeder 31 based on received feeder  
25   images 315a.

          Specifically, the luminance change identification unit 320 identifies luminance by the operations described below.

[0037]

          The luminance change identification unit 320 sequentially receives  
30   feeder images 315a chronologically acquired by the image acquisition unit 315 from the image acquisition unit 315. An example of feeder images 315a received by the luminance change identification unit 320 is illustrated in FIG. 4. In feeder images 315a taken by the camera 220, the region including the feeder 31 (referred to as the specific region 320a in the present embodiment) is  
35   specified in advance.

[0038]

          The luminance change identification unit 320 calculates the average luminance (average value of luminance) of each pixel of the specific region 320a that is displayed in sequentially-received feeder images 315a. In the  
40   present embodiment, an example is illustrated in FIG. 4 in which the specific region 320a is divided into 20 meshes with imaginary lines (two-dot-dash lines). In other words, the luminance change identification unit 320 calculates

5 the average luminance, which is calculated from all the pixels included in a mesh, for each mesh and by extension for each feeder image 315a.  
[0039]

Upon finishing calculating the average luminance in each mesh of one feeder image 315a, the luminance change identification unit 320 calculates the  
10 average luminance in each mesh of the feeder image 315a received next after the one feeder image 315a (hereinafter referred to as the next feeder image 315a). The luminance change identification unit 320 compares the average luminance in each mesh of the one feeder image 315a and the average luminance in each mesh of the next feeder image 315a.  
15 [0040]

The luminance change identification unit 320 determines whether there is a change in average luminance that is greater than or equal to a predetermined threshold between each mesh of the one feeder image 315a and each mesh of the next feeder image 315a. In the present embodiment, the image  
20 acquisition unit 315 acquires feeder images 315a at an interval of one second. Accordingly, the time difference between the acquisition time of the one feeder image 315a and the acquisition time of the next feeder image 315a is one second.  
[0041]

25 When it is determined that there is a change in average luminance in one or more meshes, the luminance change identification unit 320 identifies that "there is a change in luminance distribution." When it is determined that there is only a change in average luminance that is less than the predetermined threshold between each mesh of the one feeder image 315a and each mesh of  
30 the next feeder image 315a, the luminance change identification unit 320 identifies that "there is no change in luminance distribution." Accordingly, the luminance change identification unit 320 identifies a change in luminance of each of the plurality of meshes in the feeder image 315a.  
[0042]

35 In the present embodiment, the object to be burned 400 present in the region including the feeder 31 exhibits a relatively high luminance when the surface is dry, and exhibits a relatively low luminance when the surface is not dry. Accordingly, when a portion of the object to be burned 400 including a dry surface is pushed into the furnace body 10 by the feeder 31, the object to be  
40 burned 400 at an inner side that is not dry is exposed. For this reason, a change in average luminance occurs between one mesh of the one feeder image 315a and the mesh of the next feeder image 315a corresponding to the one mesh.

5 [0043]

#### Supply State Determination Unit

The supply state determination unit 335 determines whether the supply amount of the object to be burned 400 is sufficient based on the identification of the change in luminance of feeder images 315a and the operation

10 information of the feeder 31.

When the feeder operation acquisition unit 310 judges that "the feeder 31 is retracting" or "the feeder 31 is stopped," or when the luminance change identification unit 320 identifies that "there is no change in luminance distribution," the supply state determination unit 335 determines that "the

15 supply amount of the object to be burned 400 is not sufficient."

[0044]

When the feeder operation acquisition unit 310 judges that "the feeder 31 is advancing" and the luminance change identification unit 320 identifies that "there is a change in luminance distribution," the supply state determination unit 335 determines that "the supply amount of the object to be

20 burned 400 is sufficient."

[0045]

#### Feeder Speed Control Unit

When the supply state determination unit 335 determines that "the

25 supply amount of the object to be burned 400 is not sufficient," the feeder speed control unit 330 increases the operating speed of the feeder 31. The operating speed of the feeder 31 is the speed at which the feeder 31 advances (the speed of transitioning from FIG. 3A to FIG. 3C) and the speed at which the feeder 31 retracts (the speed of transitioning from FIG. 3C to FIG. 3A).

30 [0046]

#### Oversupply Determination Unit

When the supply state determination unit 335 determines that "the supply amount of the object to be burned 400 is sufficient," the oversupply determination unit 340 determines whether the supply amount of the object to

35 be burned 400 is excessive based on the number of regions (meshes) in which a change in luminance has been identified.

The oversupply determination unit 340 receives the one feeder image 315a and the next feeder image 315a handled by the luminance change identification unit 320, and checks the number of meshes in which a change in

40 luminance distribution has occurred between the one feeder image 315a and the next feeder image 315a that have been received.

[0047]

5           After checking the number of meshes, when the number of meshes in which a change in luminance distribution has occurred is greater than or equal to a predetermined number, the oversupply determination unit 340 determines that "the object to be burned 400 is oversupplied."

10           After checking the number of meshes, when the number of meshes in which a change in luminance distribution has occurred is less than the predetermined number, the oversupply determination unit 340 determines that "the object to be burned 400 is not oversupplied."

15           In the oversupply determination unit 340 of the present embodiment, for the number of meshes greater than or equal to a predetermined number, a number of two or more is suitably employed, for example.

[0048]

#### Feeder Operation Restriction Unit

20           The feeder operation restriction unit 325 restricts the amount of operation per unit time of the feeder 31. In the present embodiment, the amount of operation per unit time of the feeder 31 is, for example, the integrated value of a reciprocation distance A of the feeder 31 per 10 minutes. The feeder operation restriction unit 325 controls the integrated value per unit time to provide an upper limit for the supply amount of the object to be burned 400, thereby performing regulation such that a certain amount or more of the object

25           to be burned 400 is not supplied.

[0049]

#### Exhaust Gas Concentration Acquisition Unit

30           When the oversupply determination unit 340 determines that "the object to be burned 400 is oversupplied," the exhaust gas concentration acquisition unit 345 chronologically acquires the CO concentration and the NO<sub>x</sub> concentration in the exhaust gas discharged from the furnace body 10 at a predetermined timing.

35           The exhaust gas concentration acquisition unit 345 includes an exhaust gas concentration detection sensor 346. The exhaust gas concentration detection sensor 346 is provided in the outlet flow path 12. The exhaust gas concentration detection sensor 346 includes a CO sensor 345a capable of detecting the CO concentration and an NO<sub>x</sub> sensor 345b capable of detecting the NO<sub>x</sub> concentration.

[0050]

#### 40           Secondary Air Volume Control Unit

          The secondary air volume control unit 350 receives the CO concentration and the NO<sub>x</sub> concentration acquired by the exhaust gas

5 concentration acquisition unit 345, and controls the flow rate of the secondary air flowing through the secondary air line L2 based on each of the received concentrations. The secondary air volume control unit 350 controls the flow rate of the secondary air by the degree of opening of the secondary air dampers L2a provided in the secondary air line L2.

10 [0051]

As illustrated in FIGS. 5A and 5B, the secondary air volume control unit 350 sets a CO index corresponding to the CO concentration acquired by the exhaust gas concentration acquisition unit 345, and an NO<sub>x</sub> index corresponding to the NO<sub>x</sub> concentration acquired by the exhaust gas concentration acquisition unit 345. The CO index and the NO<sub>x</sub> index are indicators corresponding to the CO concentration and the NO<sub>x</sub> concentration for determining the degree of opening of the secondary air dampers L2a, respectively.

[0052]

20 Hereinafter, a procedure (flowchart) by which the secondary air volume control unit 350 sets the CO index will be described with reference to FIG. 5A.

First, the secondary air volume control unit 350 determines whether the one-hour average of the CO concentration received from the exhaust gas concentration acquisition unit 345 is less than 3 ppm (step S61a). When it is determined that the one-hour average of the CO concentration is less than 3 ppm (step S61a; Yes), the secondary air volume control unit 350 sets the CO index to "5" (step S65a).

[0053]

When it is determined that the CO concentration is not less than 3 ppm (step S6a; No), the secondary air volume control unit 350 determines whether the one-hour average of the CO concentration is 3 ppm or more and less than 6 ppm (step S62a). When it is determined that the one-hour average of the CO concentration is 3 ppm or more and less than 6 ppm (step S62a; Yes), the secondary air volume control unit 350 sets the CO index to "4" (step S66a).

35 [0054]

When it is determined that the CO concentration is neither 3 ppm or more nor less than 6 ppm (step S62a; No), the secondary air volume control unit 350 determines whether the one-hour average of the CO concentration is 6 ppm or more and less than 9 ppm (step S63a). When it is determined that the one-hour average of the CO concentration is 6 ppm or more and less than 9 ppm (step S63a; Yes), the secondary air volume control unit 350 sets the CO index to "3" (step S67a).

5 [0055]

When it is determined that the CO concentration is neither 6 ppm or more nor less than 9 ppm (step S63a; No), the secondary air volume control unit 350 determines whether the one-hour average of the CO concentration is 9 ppm or more and less than 12 ppm (step S64a). When it is determined that the  
10 one-hour average of the CO concentration is 9 ppm or more and less than 12 ppm (step S64a; Yes), the secondary air volume control unit 350 sets the CO index to "2" (step S68a).

[0056]

When it is determined that the CO concentration is neither 9 ppm or  
15 more nor less than 12 ppm (step S64a; No), the secondary air volume control unit 350 sets the CO index to "1" (step S69a).

[0057]

Hereinafter, a procedure (flowchart) by which the secondary air volume control unit 350 sets the NO<sub>x</sub> index will be described with reference to FIG.  
20 5B.

First, the secondary air volume control unit 350 determines whether the one-hour average of the NO<sub>x</sub> concentration received from the exhaust gas concentration acquisition unit 345 is less than 95 ppm (step S61b). When it is determined that the one-hour average of the NO<sub>x</sub> concentration is less than 95  
25 ppm (step S61b; Yes), the secondary air volume control unit 350 sets the NO<sub>x</sub> index to "5" (step S65b).

[0058]

When it is determined that the NO<sub>x</sub> concentration is not less than 95 ppm (step S61b; No), the secondary air volume control unit 350 determines  
30 whether the one-hour average of the NO<sub>x</sub> concentration is 95 ppm or more and less than 100 ppm (step S62b). When it is determined that the one-hour average of the NO<sub>x</sub> concentration is 95 ppm or more and less than 100 ppm (step S62b; Yes), the secondary air volume control unit 350 sets the NO<sub>x</sub> index to "4" (step S66b).

35 [0059]

When it is determined that the NO<sub>x</sub> concentration is neither 95 ppm or more nor less than 100 ppm (step S62b; No), the secondary air volume control unit 350 determines whether the one-hour average of the NO<sub>x</sub> concentration is 100 ppm or more and less than 105 ppm (step S63b). When it is determined that  
40 the one-hour average of the NO<sub>x</sub> concentration is 100 ppm or more and less than 105 ppm (step S63b; Yes), the secondary air volume control unit 350 sets the NO<sub>x</sub> index to "3" (step S67b).

5 [0060]

When it is determined that the NO<sub>x</sub> concentration is neither 100 ppm or more nor less than 105 ppm (step S63b; No), the secondary air volume control unit 350 determines whether the one-hour average of the NO<sub>x</sub> concentration is 105 ppm or more and less than 110 ppm (step S64b). When it is determined that  
 10 one-hour average of the NO<sub>x</sub> concentration is 105 ppm or more and less than 110 ppm (step S64b; Yes), the secondary air volume control unit 350 sets the NO<sub>x</sub> index to "2" (step S68b).

[0061]

When it is determined that the NO<sub>x</sub> concentration is neither 105 ppm or  
 15 more nor less than 110 ppm (step S64b; No), the secondary air volume control unit 350 sets the NO<sub>x</sub> index to "1" (step S69b).

[0062]

Upon finishing setting the CO index and the NO<sub>x</sub> index, the secondary air volume control unit 350 controls the flow rate of the secondary air based on  
 20 the CO index and the NO<sub>x</sub> index as well as the number of meshes in which a change in luminance distribution has occurred as confirmed by the oversupply determination unit 340.

The secondary air volume control unit 350 controls the degree of opening of the secondary air dampers L2a to control the flow rate of the  
 25 secondary air.

[0063]

FIGS. 6A, 6B, and 6C show tables of degree-of-opening conditions of the dampers corresponding to the number of meshes in which a change in luminance distribution has occurred as confirmed by the oversupply  
 30 determination unit 340, that is, the degree of supply of the object to be burned 400.

FIG. 6A illustrates base degree-of-opening conditions of the secondary air dampers L2a employed by the secondary air volume control unit 350 under normal operation (when the oversupply determination unit 340 determines that  
 35 "the supply amount of the object to be burned 400 is not excessive"). The degree of opening of the secondary air dampers L2a is determined based on the CO index and the NO<sub>x</sub> index set by the secondary air volume control unit 350. In the present embodiment, the degree of opening of the dampers shown in FIGS. 6A, 6B, and 6C is shown as a ratio (%), with the fully open state being  
 40 100 (%).

[0064]

5           FIGS. 6B and 6C illustrate degree-of-opening conditions of the  
secondary air dampers L2a employed by the secondary air volume control unit  
350 when the oversupply determination unit 340 determines that "the supply  
amount of the object to be burned 400 is excessive." FIG. 6B illustrates  
intermediate degree-of-opening conditions of the secondary air dampers L2a.  
10   FIG. 6C illustrates maximum degree-of-opening conditions of the secondary air  
dampers L2a.  
[0065]

          In the maximum conditions illustrated in FIG. 6C, the degree of opening  
is set to be greater than that of the intermediate conditions illustrated in FIG.  
15   6B regardless of the value of the CO index and the NO<sub>x</sub> index. That is, the  
maximum conditions are conditions employed in a state in which the object to  
be burned 400 does not burn easily in the combustion furnace, with the object  
to be burned 400 being in an oversupply state. Whether the degree of opening  
of the secondary air dampers L2a is to be set to intermediate conditions or  
20   maximum conditions is suitably selected in accordance with the degree of  
supply of the object to be burned 400.  
[0066]

          In the present embodiment, the degree-of-opening condition of the  
secondary air dampers L2a is selected based on the number of meshes in which  
25   a change in luminance distribution has occurred as confirmed by the oversupply  
determination unit 340. Accordingly, if the number of meshes in which a  
change in luminance distribution has occurred as confirmed by the oversupply  
determination unit 340 falls within a predetermined range, the intermediate  
condition is selected; if it is greater than or equal to the predetermined number,  
30   the maximum condition is selected.  
[0067]

#### Combustion State Acquisition Unit

          The combustion state acquisition unit 355 acquires the combustion state  
of the object to be burned 400 inside the furnace body 10. In the present  
35   embodiment, the combustion state of the object to be burned 400 is, for  
example, the temperature of the exhaust gas generated by combustion of the  
object to be burned 400 inside the furnace body 10.

          The combustion state acquisition unit 355 includes an exhaust gas  
thermometer 355a. The exhaust gas thermometer 355a is provided inside the  
40   waste heat recovery boiler 8. The exhaust gas thermometer 355a measures the  
temperature of the exhaust gas that is generated from inside the furnace body  
10 and that is sent to the waste heat recovery boiler 8 via the furnace 7.

5 [0068]

#### Combustion State Determination Unit

The combustion state determination unit 360 determines whether there is combustion failure of the object to be burned 400 based on the combustion state acquired by the combustion state acquisition unit 355.

10 The combustion state determination unit 360 receives the exhaust gas temperature acquired by the combustion state acquisition unit 355.

[0069]

The combustion state determination unit 360 compares the received exhaust gas temperature to a predetermined temperature that is preset for comparison. When it is confirmed that the exhaust gas temperature is greater  
15 than or equal to the predetermined temperature, the combustion state determination unit 360 determines that "there is no combustion failure."

The combustion state determination unit 360 compares the received exhaust gas temperature to the predetermined temperature for comparison.  
20 When it is confirmed that the exhaust gas temperature is lower than the predetermined temperature, the combustion state determination unit 360 determines that "there is combustion failure."

[0070]

#### Combustion Control Unit

25 When the supply state determination unit 335 determines that "the supply amount of the object to be burned 400 is sufficient" and the combustion state determination unit 360 determines that "there is combustion failure," the combustion control unit 365 performs control to promote combustion inside the furnace body 10.

30 The combustion control unit 365 calculates the control amount based on the combustion state acquired by the combustion state acquisition unit 355.

After calculating the control amount, the combustion control unit 365 controls any one or more of (a) to (d) described below as appropriate.

[0071]

35 (a) Increase Primary Air Volume

The combustion control unit 365 transmits a command to increase the rotational speed of the first forced draft fan B1 to the first forced draft fan B1. Upon receiving the command transmitted from the combustion control unit 365, the first forced draft fan B1 increases the rotational speed by the control  
40 amount described above. In other words, the combustion control unit 365 increases the flow rate of the primary air that is blown from the first forced draft fan B1 through the primary air line L1 to the wind boxes 2.

5 [0072]

(b) Increase Degree of Opening of Dampers

The combustion control unit 365 transmits a command to increase the degree of opening of the primary air dampers L1a to the primary air dampers L1a provided in the primary air line L1. Upon receiving the command  
 10 transmitted from the combustion control unit 365, the primary air dampers L1a increase the degree of opening of the dampers by the control amount described above. In other words, the combustion control unit 365 increases the flow rate of the primary air that is blown from the first forced draft fan B1 through the primary air line L1 to the wind boxes 2.

15 [0073]

(c) Raise Primary Air Temperature

The combustion control unit 365 transmits a command to raise the preheating temperature to the air preheater H. Upon receiving the command transmitted from the combustion control unit 365, the air preheater H raises the  
 20 preheating temperature by the control amount described above. In other words, the combustion control unit 365 raises the temperature of the primary air that is blown from the first forced draft fan B1 through the primary air line L1 to the wind boxes 2.

[0074]

25 (d) Increase Speed of Fire Grates

The combustion control unit 365 transmits a command to increase the speed of the movable fire grates to the stoker 6. Upon receiving the command transmitted from the combustion control unit 365, the stoker 6 increases the movable speed of the movable fire grates by the control amount described  
 30 above. In other words, the combustion control unit 365 causes the agitation of the object to be burned 400 in the combustion furnace to proceed.

[0075]

Operation of Control Device

Next, an operation of the control device 300 will be described with  
 35 reference to FIG. 7. FIG. 7 is a flowchart illustrating an operation of the control device 300.

[0076]

The feeder operation acquisition unit 310 acquires the operation information of the feeder 31.

40 The image acquisition unit 315 chronologically acquires feeder images 315a (step S1).

[0077]

5           The luminance change identification unit 320 identifies a change in luminance based on feeder images 315a chronologically acquired by the image acquisition unit 315.

          The supply state determination unit 335 determines whether the supply amount of the object to be burned 400 is sufficient based on the change in  
10   luminance identified by the luminance change identification unit 320, and the operation information of the feeder 31 acquired by the feeder operation acquisition unit 310 (step S2).

[0078]

          When the supply state determination unit 335 determines that the supply  
15   amount of the object to be burned 400 is not sufficient (step S2; No), the feeder speed control unit 330 increases the operating speed of the feeder 31 (step S3).

          After the feeder speed control unit 330 increases the operating speed of the feeder 31, the processing of the control device 300 returns to step S2.

[0079]

20           When the supply state determination unit 335 determines that the supply amount of the object to be burned 400 is sufficient (step S2; Yes), the oversupply determination unit 340 determines whether the object to be burned 400 is oversupplied (step S4).

[0080]

25           When the oversupply determination unit 340 determines that the supply amount of the object to be burned 400 is excessive (step S4; Yes), the exhaust gas concentration acquisition unit 345 acquires the CO concentration and the NO<sub>x</sub> concentration in the exhaust gas discharged from the furnace body 10 (step S5).

30   [0081]

          The secondary air volume control unit 350 receives the CO concentration and the NO<sub>x</sub> concentration acquired by the exhaust gas concentration acquisition unit 345, and controls the flow rate of the secondary air flowing through the secondary air line L2 based on each of the  
35   concentrations (step S6).

[0082]

          When the oversupply determination unit 340 determines that the supply amount of the object to be burned 400 is not excessive (step S4; No), the combustion state acquisition unit 355 acquires the combustion state of the  
40   object to be burned 400.

5           The combustion state determination unit 360 determines whether there is combustion failure of the object to be burned 400 based on the combustion state acquired by the combustion state acquisition unit 355 (step S7).

[0083]

10           When the combustion state determination unit 360 determines that there is no combustion failure (step S2; No), the control device 300 ends the operation.

[0084]

15           When the combustion state determination unit 360 determines that there is combustion failure (step S2; Yes), the combustion control unit 365 calculates the control amount based on the combustion state acquired by the combustion state acquisition unit 355 (step S8).

[0085]

20           After calculating the control amount, the combustion control unit 365 performs control to promote combustion inside the furnace body 10 (step S9).

[0086]

          After the combustion control unit 365 performed control to promote combustion, the combustion state acquisition unit 355 acquires again the combustion state of the object to be burned 400.

25           The combustion state determination unit 360 determines again whether there is combustion failure of the object to be burned 400 based on the combustion state acquired again by the combustion state acquisition unit 355 (step S10).

[0087]

30           When the combustion state determination unit 360 determines that there is combustion failure (step S10; Yes), the feeder operation restriction unit 325 restricts the amount of operation per unit time of the feeder 31 (step S11). After the feeder operation restriction unit 325 restricted the amount of operation per unit time of the feeder 31, the processing of the control device 300 returns to step S8.

35           When the combustion state determination unit 360 determines that there is no combustion failure (step S10; No), the control device 300 ends the operation.

[0088]

40           The control device 300 repeats the series of operations described above during operation of the combustion furnace facility 100.

[0089]

Operational Effects

5           The control device 300 of the combustion furnace facility 100 according to the present embodiment is the control device 300 of the combustion furnace facility 100 including the furnace body 10 that transports the object to be burned 400 while burning the same and the feeder 31 that supplies the object to be burned 400 to the furnace body 10, and the control device 300 includes: the  
 10 image acquisition unit 315 configured to chronologically acquire a feeder image 315a that is an image of a region including the feeder 31; the luminance change identification unit 320 configured to identify a change in luminance of the feeder image 315a; the feeder operation acquisition unit 310 configured to acquire operation information of the feeder 31; and the supply state  
 15 determination unit 335 configured to determine whether a supply amount of the object to be burned 400 is sufficient based on identification of the change in luminance of the feeder image 315a and the operation information of the feeder 31.

[0090]

20           According to the configuration described above, it is possible to identify a change in luminance and acquire the operation information of the feeder 31 at the same time. Thus, whether the supply amount of the object to be burned 400 by the feeder 31 is sufficient can be accurately grasped. Accordingly, it is possible to take appropriate measures to stabilize the combustion state of the  
 25 object to be burned 400 in accordance with whether the supply amount of the object to be burned 400 is sufficient.

[0091]

          Incidentally, ash of the object to be burned 400 floating inside the furnace body 10 may be displayed within the imaging range of the camera 220.  
 30 When ash is displayed in the specific region 320a, the luminance of the region in which ash is displayed tends to decrease. For this reason, even though the object to be burned 400 is not supplied into the furnace body 10, the luminance decreases just like when the object to be burned 400 that is not dry is exposed. Thus, there is a possibility that the luminance change identification unit 320  
 35 can erroneously determine that "there is a change in luminance distribution" between one feeder image 315a and the next feeder image 315a.

          According to the configuration described above, the reciprocation state of the feeder 31 can be grasped by the feeder operation acquisition unit 310. Thus, even when the luminance change identification unit 320 has made an  
 40 erroneous identification under the influence of the ash of the object to be burned 400, it is possible to avoid malfunction of the control device 300 by

5 combining the identification by the luminance change identification unit 320  
and the reciprocation state information of the feeder 31.  
[0092]

Furthermore, the control device 300 of the combustion furnace facility  
100 according to the present embodiment further includes: the combustion state  
10 acquisition unit 355 configured to acquire a combustion state of the object to be  
burned 400; the combustion state determination unit 360 configured to  
determine whether there is combustion failure of the object to be burned 400  
based on the combustion state; and the combustion control unit 365 configured  
15 to perform control to promote combustion of the furnace body 10 when it is  
determined that the supply amount of the object to be burned 400 is sufficient  
and it is determined that there is combustion failure.  
[0093]

According to the configuration described above, it is possible to perform  
suitable control to promote combustion in accordance with the combustion state  
20 of the object to be burned 400. In this way, the combustion state of the object to  
be burned 400 can be stabilized.  
[0094]

Furthermore, the control device 300 of the combustion furnace facility  
100 according to the present embodiment further includes the feeder operation  
25 restriction unit 325 configured to restrict an amount of operation per unit time  
of the feeder 31.  
[0095]

According to the configuration described above, the supply amount of  
the object to be burned 400 on the feeder 31 and around the feeder 31 into the  
30 furnace body 10 can be adjusted. Accordingly, even when a large amount of the  
object to be burned 400 has been supplied into the furnace body 10, the  
subsequent supply amount of the object to be burned 400 into the furnace body  
10 can be adjusted by the amount of operation per unit time of the feeder 31.  
Accordingly, the combustion state of the object to be burned 400 can be  
35 stabilized.  
[0096]

Furthermore, the control device 300 of the combustion furnace facility  
100 according to the present embodiment further includes the feeder speed  
control unit 330 configured to increase an operating speed of the feeder 31  
40 when it is determined that the supply amount of the object to be burned 400 is  
not sufficient.  
[0097]

5           According to the configuration described above, the supply amount of  
the object to be burned 400 on the feeder 31 and around the feeder 31 into the  
furnace body 10 can be adjusted. Accordingly, even when the object to be  
burned 400 is not supplied into the furnace body 10 well, it is possible to  
increase the supply amount of the object to be burned 400 into the furnace body  
10 10 by an increase in the operating speed of the feeder 31. Accordingly, the  
combustion state of the object to be burned 400 can be promoted.  
[0098]

          Furthermore, in the control device 300 of the combustion furnace  
facility 100 according to the present embodiment, the luminance change  
15 identification unit 320 identifies a change in luminance of each of a plurality of  
image regions in the feeder image 315a, the supply state determination unit 335  
determines whether the supply amount of the object to be burned 400 is  
sufficient based on identification of the change in luminance of at least one of  
the image regions and the operation information of the feeder 31, and the  
20 control device 300 further includes the oversupply determination unit 340  
configured to determine whether the supply amount of the object to be burned  
400 is excessive based on the number of image regions in which the change in  
luminance is identified when it is determined that the supply amount of the  
object to be burned 400 is sufficient.  
25 [0099]

          According to the configuration described above, it is possible to take  
appropriate measures to stabilize the combustion state of the object to be  
burned 400 in accordance with whether the supply amount of the object to be  
burned 400 is excessive.  
30 [0100]

          Furthermore, the control device 300 of the combustion furnace facility  
100 according to the present embodiment further includes the secondary air  
volume control unit 350 configured to perform control so as to increase a  
secondary air volume additionally supplied to the furnace body 10 when it is  
35 determined that the supply amount of the object to be burned 400 is excessive.  
[0101]

          According to the configuration described above, combustion of the  
object to be burned 400 can be promoted. Accordingly, when the supply amount  
of the object to be burned 400 is excessive, the combustion state of the object  
40 to be burned 400 can be stabilized.  
[0102]

5           Furthermore, the control device 300 of the combustion furnace facility  
100 according to the present embodiment further includes: the exhaust gas  
concentration acquisition unit 345 configured to acquire a CO concentration  
and an NO<sub>x</sub> concentration in exhaust gas discharged from the furnace body 10;  
wherein the secondary air volume control unit 350 controls the secondary air  
10 volume based on the CO concentration and the NO<sub>x</sub> concentration.  
[0103]

          According to the configuration described above, even when the exhaust  
gas concentration has risen, the exhaust gas concentration can be stabilized by  
controlling the secondary air volume.  
15 [0104]

#### Other Embodiments

          Embodiments of the present disclosure have been described above in  
detail with reference to the drawings. However, specific configurations are not  
limited to these embodiments. Any configuration can be added, omitted,  
20 substituted, or otherwise modified as long as such addition, omission,  
substitution, or modification does not depart from the scope of the present  
disclosure. The present disclosure is not limited by the embodiments.  
[0105]

          Note that FIG. 8 is a hardware configuration diagram illustrating a  
25 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.  
[0106]

          The above-described control device 300 is implemented in the computer  
30 1100. In addition, operation of each of the above-described processing units is  
stored in the storage 1130 in the form of a program. The processor 1110 reads  
the program from the storage 1130, expands the same in the main memory  
1120, and executes the processing described above according to the program.  
Furthermore, the processor 1110 secures a storage area corresponding to each  
35 of the above-described storage units in the main memory 1120 according to the  
program.  
[0107]

          The program may be for achieving some of the functions that the  
computer 1100 is caused to perform. For example, the program may be one that  
40 achieves a function in combination with another program already stored in the  
storage 1130, or in combination with another program implemented in another  
device. Furthermore, the computer 1100 may include a custom large scale

5 integrated circuit (LSI) such as a programmable logic device (PLD) in addition to or in place of the configuration described above. 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, some or all of the functions achieved by the  
 10 processor 1110 may be achieved by the integrated circuit.  
 [0108]

Examples of the storage 1130 include a magnetic disk, a magneto-optic disk, and a semiconductor memory. The storage 1130 may be an internal medium directly connected to a bus of the computer 1100, or may be an  
 15 external medium connected to the computer 1100 through the interface 1140 or a communication line. Furthermore, when this program is delivered to the computer 1100 via a communication line, the computer 1100 that received the delivery may expand the program in the main memory 1120 and execute the processing described above. In the embodiment, the storage 1130 is a non-  
 20 temporary tangible storage medium.  
 [0109]

Furthermore, the program may be for achieving some of the functions described above. Further, the program may be a so-called differential file (differential program) that achieves the functions described above in  
 25 combination with another program already stored in the storage 1130.  
 [0110]

Furthermore, the control device 300 may further include an O<sub>2</sub> concentration acquisition unit configured to acquire the O<sub>2</sub> concentration in the exhaust gas discharged from the furnace body 10. Further, in place of the  
 30 configuration described in the above-described embodiment, the feeder speed control unit 330 may determine the operating speed of the feeder 31 based on the amount of heat input to the object to be burned 400 as estimated based on the temperature and the O<sub>2</sub> concentration of the exhaust gas.  
 [0111]

35 In this configuration, the temperature of the exhaust gas is measured, for example, by the exhaust gas thermometer 355a included in the combustion state acquisition unit 355. For the temperature of the primary air, for example, the set temperature of the air preheater H that preheats the primary air flowing through the primary air line L1 is employed.

40 The O<sub>2</sub> concentration acquisition unit is provided in the outlet flow path 12. For the O<sub>2</sub> concentration acquisition unit, for example, a zirconia oxygen sensor is employed.

5 [0112]

The amount of heat input to the object to be burned 400 inside the furnace body 10 can be estimated based on the measured temperature of the exhaust gas and the O<sub>2</sub> concentration in the exhaust gas. In this configuration, an ideal amount of heat input to the object to be burned 400 that serves as a target during operation of the combustion furnace facility 100 (hereinafter referred to as the ideal amount of heat input) is set. In addition, whether the amount of heat input to the object to be burned 400, which is estimated based on the temperature of the exhaust gas measured during operation of the combustion furnace facility 100 and the O<sub>2</sub> concentration in the exhaust gas (hereinafter referred to as the estimated amount of heat input), is greater than or less than the ideal amount of heat input is checked in real time by finding a difference between the two.

[0113]

When the estimated amount of heat input is smaller than the ideal amount of heat input, the feeder speed control unit 330 increases the operating speed of the feeder 31 by an amount corresponding to the magnitude of the difference described above.

When the estimated amount of heat input is larger than the ideal amount of heat input, the feeder speed control unit 330 decreases the operating speed of the feeder 31 by an amount corresponding to the magnitude of the difference described above.

[0114]

The operating speed of the feeder 31 is controlled by these operations. Thus, the supply amount of the object to be burned 400 as fuel into the furnace body 10 is optimized, and the estimated amount of heat input can be brought closer to the ideal amount of heat input. Accordingly, the supply amount of the object to be burned 400 can be promptly optimized, and the exhaust gas concentration and the steam flow rate can be stabilized.

[0115]

Hereinafter, an estimation method for the amount of heat input in the configuration described above will be outlined.

The estimated amount of heat input (Q) into the furnace body 10 is obtained in a relationship among the exhaust gas mass flow rate determined based on the O<sub>2</sub> concentration (m<sub>g</sub>), the temperature of the exhaust gas (T<sub>g</sub>), and the temperature of the primary air (T<sub>a</sub>) by the following equation (1):

$$Q = Cp \times m_g \times (T_g - T_a) + H \quad (1)$$

[0116]

5           Here,  $C_p$  represents molar heat at constant pressure, and  $H$  represents  
heat loss. Molar heat at constant pressure ( $C_p$ ) is a uniquely obtained numerical  
value in an environment of isobaric change. Heat loss ( $H$ ) is the amount of loss  
heat obtained by combining heat radiation, unburnt loss, and sensible heat  
released by ash. Heat loss is a variable that is directly proportional to the  
10   estimated amount of heat input  $Q$ .  
[0117]

          Furthermore, the feeder 31 described in the above-described  
embodiments is configured to continuously transition from the state illustrated  
in FIG. 3A to the state illustrated in FIG. 3C, and then return to the state  
15   illustrated in FIG. 3A. However, the feeder 31 is not limited to this  
configuration. The feeder 31 may be configured to continuously transition from  
the state illustrated in FIG. 3A to the state illustrated in FIG. 3B, and then  
return to the state illustrated in FIG. 3A.  
[0118]

20           Furthermore, the CO index and the  $\text{NO}_x$  index in the secondary air  
volume control unit 350 described in the above-described embodiments are  
classified in five stages. However, they are not limited to the five-stage  
classification. Furthermore, in evaluating the CO concentration and the  $\text{NO}_x$   
concentration in setting the CO index and the  $\text{NO}_x$  index, numerical values of  
25   ratio (ppm) indicated in the above-described embodiments vary depending on  
the plant in which the combustion furnace facility 100 operates. The numerical  
values of ratio indicated above are examples, and the ratio is not limited to the  
numerical values of ratio indicated above.  
[0119]

30           Furthermore, the tables (FIGS. 6A, 6B, and 6C) of degree-of-opening  
conditions of the dampers referenced by the secondary air volume control unit  
350 as described in the above-described embodiments are illustrated in three  
stages in accordance with the degree of supply of the object to be burned 400.  
However, the number of stages is not limited to three. Furthermore, the degree  
35   of opening indicated in the tables is an example. The degree of opening is not  
limited to the degree of opening illustrated in each of the tables of FIGS. 6A,  
6B, and 6C.  
[0120]

          Furthermore, in the embodiments described above, the combustion  
40   furnace facility 100 is a waste incineration stoker furnace. However, the  
combustion furnace facility 100 is not limited to a waste incineration stoker

5 furnace. The combustion furnace facility 100 may be a kiln stoker furnace, a biomass fluidized bed boiler, a sludge incinerator, or the like.

[0121]

#### Supplementary Notes

For example, the control device of the combustion furnace facility  
10 according to each of the embodiments can be grasped as follows.

[0122]

(1) The control device 300 of the combustion furnace facility 100 according to a first aspect is the control device 300 of the combustion furnace facility 100 including the furnace body 10 that transports the object to be  
15 burned 400 while burning the same, and the feeder 31 that supplies the object to be burned 400 to the furnace body 10, and the control device 300 includes: the image acquisition unit 315 configured to chronologically acquire a feeder image 315a that is an image of a region including the feeder 31; the luminance change identification unit 320 configured to identify a change in luminance of  
20 the feeder image 315a; the feeder operation acquisition unit 310 configured to acquire operation information of the feeder 31; and the supply state determination unit 335 configured to determine whether a supply amount of the object to be burned 400 is sufficient based on identification of the change in luminance of the feeder image 315a and the operation information of the feeder  
25 31.

[0123]

In this way, it is possible to identify a change in luminance and acquire the operation information of the feeder 31 at the same time. Thus, whether the supply amount of the object to be burned 400 by the feeder 31 is sufficient can  
30 be accurately grasped. Accordingly, it is possible to take appropriate measures to stabilize the combustion state of the object to be burned 400 in accordance with whether the supply amount of the object to be burned 400 is sufficient.

[0124]

(2) The control device 300 of the combustion furnace facility 100 according to a second aspect is the control device 300 of the combustion  
35 furnace facility 100 of (1), and may further include: the combustion state acquisition unit 355 configured to acquire a combustion state of the object to be burned 400; the combustion state determination unit 360 configured to determine whether there is combustion failure of the object to be burned 400  
40 based on the combustion state; and the combustion control unit 365 configured to perform control to promote combustion of the furnace body 10 when it is

5 determined that the supply amount of the object to be burned 400 is sufficient  
and it is determined that there is combustion failure.

[0125]

In this way, it is possible to perform suitable control to promote  
combustion in accordance with the combustion state of the object to be burned  
10 400. Accordingly, the combustion state of the object to be burned 400 can be  
stabilized.

[0126]

(3) The control device 300 of the combustion furnace facility 100  
according to a third aspect is the control device 300 of the combustion furnace  
15 facility 100 of (2), and may further include the feeder operation restriction unit  
325 configured to restrict an amount of operation per unit time of the feeder 31.

[0127]

In this way, the supply amount of the object to be burned 400 on the  
feeder 31 and around the feeder 31 into the furnace body 10 can be adjusted.  
20 Accordingly, even when a large amount of the object to be burned 400 has been  
supplied into the furnace body 10, the subsequent supply amount of the object  
to be burned 400 into the furnace body 10 can be adjusted by the amount of  
operation per unit time of the feeder 31.

[0128]

25 (4) The control device 300 of the combustion furnace facility 100  
according to a fourth aspect is the control device 300 of the combustion furnace  
facility 100 of any of (1) to (3), and may further include the feeder speed  
control unit 330 configured to increase an operating speed of the feeder 31  
when it is determined that the supply amount of the object to be burned 400 is  
30 not sufficient.

[0129]

In this way, the supply amount of the object to be burned 400 on the  
feeder 31 and around the feeder 31 into the furnace body 10 can be adjusted.  
Accordingly, even when the object to be burned 400 is not supplied into the  
35 furnace body 10 well, it is possible to increase the supply amount of the object  
to be burned 400 into the furnace body 10 by an increase in the operating speed  
of the feeder 31.

[0130]

(5) The control device 300 of the combustion furnace facility 100  
40 according to a fifth aspect is the control device 300 of the combustion furnace  
facility 100 of any of (1) to (3), and may further include: an O<sub>2</sub> concentration  
acquisition unit configured to acquire an O<sub>2</sub> concentration in exhaust gas

5 discharged from the furnace body 10; and the feeder speed control unit 330 configured to change an operating speed of the feeder 31 based on an amount of heat input to the object to be burned 400 as estimated based on a temperature and the O<sub>2</sub> concentration of the exhaust gas.

[0131]

10 In this way, by controlling the operating speed of the feeder 31, the supply amount of the object to be burned 400 into the furnace body 10 is optimized, and the estimated amount of heat input can be brought closer to the target amount of heat input. Accordingly, the supply amount of the object to be burned 400 can be promptly optimized, and the exhaust gas concentration and  
15 the steam flow rate can be stabilized.

[0132]

(6) The control device 300 of the combustion furnace facility 100 according to a sixth aspect is the control device 300 of the combustion furnace facility 100 of any of (1) to (5), wherein the luminance change identification  
20 unit 320 identifies a change in luminance of each of a plurality of image regions in the feeder image 315a, the supply state determination unit 335 determines whether the supply amount of the object to be burned 400 is sufficient based on identification of the change in luminance of at least one of the image regions and the operation information of the feeder 31, and the  
25 control device 300 may further include the oversupply determination unit 340 configured to, when it is determined that the supply amount of the object to be burned 400 is sufficient, determine whether the supply amount of the object to be burned 400 is excessive based on the number of image regions in which the change in luminance is identified.

30 [0133]

In this way, it is possible to take appropriate measures to stabilize the combustion state of the object to be burned 400 in accordance with whether the supply amount of the object to be burned 400 is excessive.

[0134]

35 (7) The control device 300 of the combustion furnace facility 100 according to a seventh aspect is the control device 300 of the combustion furnace facility 100 of (6), and may further include the secondary air volume control unit 350 configured to perform control so as to increase a secondary air volume additionally supplied to the furnace body 10 when it is determined that  
40 the supply amount of the object to be burned 400 is excessive.

[0135]

5           In this way, combustion of the object to be burned 400 can be promoted. Accordingly, when the supply amount of the object to be burned 400 is excessive, the combustion state of the object to be burned 400 can be stabilized.

[0136]

10           (8) The control device 300 of the combustion furnace facility 100 according to an eighth aspect is the control device 300 of the combustion furnace facility 100 of (7), and may further include: the exhaust gas concentration acquisition unit 345 configured to acquire a CO concentration and an NO<sub>x</sub> concentration in exhaust gas discharged from the furnace body 10;  
15           wherein the secondary air volume control unit 350 may control the secondary air volume based on the CO concentration and the NO<sub>x</sub> concentration.

[0137]

            In this way, even when the exhaust gas concentration has risen, the exhaust gas concentration can be stabilized by controlling the secondary air  
20           volume.

[0138]

            (9) The control device 300 of the combustion furnace facility 100 according to a ninth aspect is the control device 300 of the combustion furnace facility 100 of any of (1) to (8), wherein the feeder image 315a may be  
25           generated by a camera 220 capable of taking a picture in a wavelength band of 3.5 to 4.5 μm.

#### Reference Signs List

[0139]

30    1 Stoker furnace  
      2 Wind box  
      3 Hopper  
      6 Stoker  
      7 Furnace  
35    8 Waste heat recovery boiler  
      9 Temperature reduction column  
      10 Furnace body  
      11 Precipitator  
      12 Outlet flow path  
40    13 Stack  
      14 Discharge chute  
      21 Drying stage

- 5 22 Combustion stage
  - 23 Post-combustion stage
  - 31 Feeder
  - 100 Combustion furnace facility
  - 220 Camera
- 10 300 Control device
  - 310 Feeder operation acquisition unit
  - 315 Image acquisition unit
  - 315a Feeder image
  - 320 Luminance change identification unit
- 15 320a Specific region
  - 325 Feeder operation restriction unit
  - 330 Feeder speed control unit
  - 335 Supply state determination unit
  - 340 Oversupply determination unit
- 20 345 Exhaust gas concentration acquisition unit
  - 345a CO sensor
  - 345b NO<sub>x</sub> sensor
  - 346 Exhaust gas concentration detection sensor
  - 350 Secondary air volume control unit
- 25 355 Combustion state acquisition unit
  - 355a Exhaust gas thermometer
  - 360 Combustion state determination unit
  - 365 Combustion control unit
  - 400 Object to be burned
- 30 1100 Computer
  - 1110 Processor
  - 1120 Main memory
  - 1130 Storage
  - 1140 Interface
- 35 A Reciprocation distance
  - B Forced draft fan
  - B1 First forced draft fan
  - B2 Second forced draft fan
  - Da Transport direction
- 40 F Luminous flame
  - H Air Preheater
  - L1 Primary air line

- 5 L1a Primary air damper
- L2 Secondary air line
- L2a Secondary air damper
- V Processing space
- Z Burnout length

## 5 Claims

## [Claim 1]

A control device of a combustion furnace facility including a furnace body that transports an object to be burned while burning the same, and a  
10 feeder that supplies the object to be burned to the furnace body, the control device comprising:  
an image acquisition unit configured to chronologically acquire a feeder image that is an image of a region including the feeder;  
a luminance change identification unit configured to identify a change in  
15 luminance of the feeder image;  
a feeder operation acquisition unit configured to acquire operation information of the feeder; and  
a supply state determination unit configured to determine whether a supply amount of the object to be burned is sufficient based on identification of  
20 the change in luminance of the feeder image and the operation information of the feeder.

## [Claim 2]

The control device of the combustion furnace facility according to claim  
25 1, further comprising:  
a combustion state acquisition unit configured to acquire a combustion state of the object to be burned;  
a combustion state determination unit configured to determine whether there is combustion failure of the object to be burned based on the combustion  
30 state; and  
a combustion control unit configured to perform control to promote combustion of the furnace body when it is determined that the supply amount of the object to be burned is sufficient and it is determined that there is combustion failure.

35

## [Claim 3]

The control device of the combustion furnace facility according to claim  
2, further comprising a feeder operation restriction unit configured to restrict  
40 an amount of operation per unit time of the feeder.

40

## [Claim 4]

5           The control device of the combustion furnace facility according to any one of claims 1 to 3, further comprising a feeder speed control unit configured to increase an operating speed of the feeder when it is determined that the supply amount of the object to be burned is not sufficient.

10   [Claim 5]

          The control device of the combustion furnace facility according to any one of claims 1 to 3, further comprising:

          an O<sub>2</sub> concentration acquisition unit configured to acquire an O<sub>2</sub> concentration in exhaust gas discharged from the furnace body; and

15           a feeder speed control unit configured to change an operating speed of the feeder based on an amount of heat input to the object to be burned as estimated based on a temperature and the O<sub>2</sub> concentration of the exhaust gas.

[Claim 6]

20           The control device of the combustion furnace facility according to any one of claims 1 to 5, wherein:

          the luminance change identification unit identifies a change in luminance of each of a plurality of image regions in the feeder image,

          the supply state determination unit determines whether the supply  
25           amount of the object to be burned is sufficient based on identification of the change in luminance of at least one of the image regions and the operation information of the feeder, and

          the control device further includes an oversupply determination unit configured to, when it is determined that the supply amount of the object to be  
30           burned is sufficient, determine whether the supply amount of the object to be burned is excessive based on the number of image regions in which the change in luminance is identified.

[Claim 7]

35           The control device of the combustion furnace facility according to claim 6, further comprising a secondary air volume control unit configured to perform control so as to increase a secondary air volume additionally supplied to the furnace body when it is determined that the supply amount of the object to be burned is excessive.

40

[Claim 8]

5           The control device of the combustion furnace facility according to claim  
7, further comprising:

          an exhaust gas concentration acquisition unit configured to acquire a CO  
concentration and an NO<sub>x</sub> concentration in exhaust gas discharged from the  
furnace body; wherein

10           the secondary air volume control unit controls the secondary air volume  
based on the CO concentration and the NO<sub>x</sub> concentration.

[Claim 9]

          The control device of the combustion furnace facility according to any  
15 one of claims 1 to 8, wherein the feeder image is generated by a camera capable  
of taking a picture in a wavelength band of 3.5 to 4.5 μm.