DESCRIPTION

Title of Invention

COMBUSTION FACILITY CONTROL DEVICE, COMBUSTION FACILITY CONTROL METHOD AND PROGRAM

[Technical Field]

[0001]

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

The present application claims priority with respect to Japanese Patent Application No. 2019-219250 filed in Japan on December 4, 2019, the contents of which are incorporated herein by reference.

[Background Art]

[0002]

As for the technique disclosed in Patent Document 1, the oxygen concentration of exhaust gas is detected by ignition point determination and burnout point determination based on the temperature distribution obtained from waste combustion furnace imaging data. Then, a total supply air amount at which the oxygen concentration is within a predetermined range is obtained, the amount of combustion air is obtained by subtracting

the amount of air required in drying and combustion regions from the total supply air amount, and the air is supplied to a wind box.

[Citation List]

[Patent Document]

[0003]

[Patent Document 1] Japanese Patent No. 3916450

[Summary of Invention]

[Technical Subject]

[0004]

An incineration object burned in a combustion facility (e.g. waste and biomass) has highly fluctuating combustion properties, and the combustion state fluctuations lead to fluctuations in the unburned portion of the incineration object.

The present disclosure has been made in view of the above, and an object of the present disclosure is to provide a combustion facility control device, a combustion facility control method, and a program.

[Subject to be solved]

[0005]

A control device for a combustion facility according to the present disclosure is a control device for a combustion facility including a furnace main body defining a treatment space, a fire grate transporting an

incineration object in a transport direction in the treatment space, and a wind box supplying air to the treatment space. The combustion facility control device includes: an image acquisition unit acquiring a treatment image showing sections resulting from partitioning the treatment space in the transport direction; a point identification unit identifying a burnout point as a rear end in the transport direction of a flame caused by combustion of the incineration object based on the treatment image; a first speed calculation unit calculating a first speed correction value as a correction value of a speed of the fire grate of the section based on the burnout point; and a speed control unit controlling the speed of the fire grate of the section based on the first speed correction value.

[0006]

A method for controlling a combustion facility according to the present disclosure is a method for controlling a control device for a combustion facility including a furnace main body defining a treatment space, a fire grate transporting an incineration object in a transport direction in the treatment space, and a wind box supplying air to the treatment space. The combustion facility control method includes: a step of acquiring a treatment image showing sections resulting from

partitioning the treatment space in the transport direction; a step of identifying a burnout point as a rear end in the transport direction of a flame caused by combustion of the incineration object based on the treatment image; a step of calculating a first speed correction value as a correction value of a speed of the fire grate of the section based on the burnout point; and a step of controlling the speed of the fire grate of the section based on the first speed correction value.

[0007]

A program according to the present disclosure is a program for causing a computer of a control device for a combustion facility including a furnace main body defining a treatment space, a fire grate transporting an incineration object in a transport direction in the treatment space, and a wind box supplying air to the treatment space to execute: a step of acquiring a treatment image showing sections resulting from partitioning the treatment space in the transport direction; a step of identifying a burnout point as a rear end in the transport direction of a flame caused by combustion of the incineration object based on the treatment image; a step of calculating a first speed correction value as a correction value of a speed of the fire grate of the section based on the burnout point; and

a step of controlling the speed of the fire grate of the section based on the first speed correction value.

[Advantageous Effects of Invention]

[0008]

According to the combustion facility control device, the combustion facility control method, and the program of the present disclosure, it is possible to stably incinerate an incineration object in a combustion facility.

[Brief Description of Drawings]

[0009]

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

Fig. 2 is a diagram illustrating a stoker according to an embodiment of the present disclosure.

Fig. 3 is a schematic block diagram illustrating the configuration of a control device according to an embodiment of the present disclosure.

Fig. 4 is a flowchart illustrating an operation related to fire grate speed control according to an embodiment of the present disclosure.

Fig. 5 is a reference diagram illustrating the fire grate speed control according to an embodiment of the present disclosure.

Fig. 6 is a flowchart illustrating an operation related to air amount control according to an embodiment of the present disclosure.

Fig. 7 is a reference diagram illustrating wind box control according to an embodiment of the present disclosure.

Fig. 8 is a schematic block diagram illustrating the configuration of the control device according to an embodiment of the present disclosure.

Fig. 9 is a schematic block diagram illustrating the configuration of the control device according to an embodiment of the present disclosure.

Fig. 10 is a flowchart illustrating an operation related to controlling a secondary air control unit according to an embodiment of the present disclosure.

Fig. 11 is a block diagram illustrating the configuration of the control device according to an embodiment of the present disclosure.

Fig. 12 is a block diagram illustrating the configuration of the control device according to an embodiment of the present disclosure.

Fig. 13 is a schematic block diagram illustrating the configuration of a computer according to at least one embodiment.

[Description of Embodiments]

[0010]

<First Embodiment>

<<Configuration of Combustion Apparatus>>

Hereinafter, the configuration of a combustion facility 100 according to a first embodiment will be described. The combustion facility 100 according to the first embodiment is a facility for incinerating waste as an incineration object 400. Examples of the combustion facility 100 include a waste incinerator stoker furnace and a biomass fluidized bed boiler. The combustion facility 100 according to the first embodiment is a waste incinerator stoker furnace.

[0011]

Fig. 1 is a diagram illustrating the configuration of the combustion facility 100 according to the first embodiment. The combustion facility 100 includes a stoker furnace 1, a waste heat recovery boiler 8, a temperature reduction tower 9, a dust collector 11, a chimney 12, and a control device 300.

[0012]

The stoker furnace 1 is a furnace where the incineration object 400 is burned while being transported. Examples of the incineration object 400 include waste and biomass. The incineration object 400 in Fig. 1 is waste. Exhaust gas is generated from the stoker furnace 1 as the

incineration object 400 is burned by the stoker furnace 1. This exhaust gas is sent to the waste heat recovery boiler 8 provided in the upper portion of the stoker furnace 1.

[0013]

The waste heat recovery boiler 8 performs heat exchange between the exhaust gas and water to heat the water and generate steam. This steam is used in external equipment (not illustrated). The exhaust gas that has passed through the waste heat recovery boiler 8 is cooled by the temperature reduction tower 9 and then sent to the dust collector 11. After soot and dust removal at the dust collector 11, the exhaust gas is discharged into the atmosphere through the chimney 12.

[0014]

Next, the configuration of the stoker furnace 1 will be described. As illustrated in Fig. 1, the stoker furnace 1 has a furnace main body 10, a furnace 7 extending upward from the furnace main body 10, a hopper 3 temporarily storing the incineration object 400, a feeder 31 supplying the incineration object 400 from the hopper 3 into the furnace main body 10, and a stoker 6 provided in the bottom portion of the furnace main body 10. In addition, the stoker furnace 1 has a discharge chute 13 discharging the incineration object 400 to the outside after incineration, a wind box 2 provided below the stoker

6, a clinker roller 210 moving the incineration object 400 to the discharge chute 13, and a camera 220 taking an image of an accommodation space V of the furnace main body 10. In addition, the stoker furnace 1 has a blower B1 sending air into a primary air line L1 and a secondary air line L2, the primary air line L1 supplying the air to the wind box 2, and the secondary air line L2 supplying the air to the furnace 7.

[0015]

Fig. 2 is a diagram illustrating the stoker 6 in the combustion facility 100 according to the first embodiment. As illustrated in Fig. 2, the stoker 6 is configured by a plurality of fire grates 61. The fire grate 61 is divided into a fixed fire grate 61A and a movable fire grate 61B. The fixed fire grate 61A is the fire grate 61 that is fixed. The movable fire grate 61B is the fire grate 61 that stirs the incineration object 400 on the fire grate 61 by operating in a transport direction +Da and a transport reverse direction -Da at a constant speed. The transport direction +Da is from the hopper 3 toward the discharge chute 13. The transport reverse direction -Da is opposite to the transport direction Da. The configuration of the combination of the fixed fire grate 61A and the movable fire grate 61B illustrated in Fig. 2 is an example, and different combinations may also be used.

[0016]

The treatment space V for burning the incineration object 400 is formed in the furnace main body 10. In this treatment space V, the incineration object 400 is transported by the stoker 6 in the transport direction +Da from the feeder 31 toward the discharge chute 13. After the combustion, the incineration object 400 is discharged to the outside through the discharge chute 13. In the present embodiment, the stoker 6 is provided horizontally. The stoker 6 according to another embodiment may be provided so as to be inclined with respect to a horizontal plane.

[0017]

The furnace main body 10 is designed to be divided into a drying stage 21, a combustion stage 22, and a post-combustion stage 23 in this order from the upstream side in the transport direction +Da. The drying stage 21, the combustion stage 22, and the post-combustion stage 23 partition the treatment space V in the transport direction Da. The drying stage 21 is a section for drying the incineration object 400 supplied from the hopper 3 prior to combustion. The combustion stage 22 and the post-combustion stage 23 are sections for burning the incineration object 400 that is dry. In the combustion stage 22, a flame F is generated by the pyrolysis gas that

is generated from the incineration object 400. In the post-combustion stage 23, the fixed carbon of the incineration object 400 is burned, and thus the flame F is not generated. In other words, the flame F resulting from combustion is mainly formed above the combustion stage 22.

[0018]

The furnace 7 extends upward from the upper portion of the furnace main body 10. The exhaust gas in the treatment space V is sent to the waste heat recovery boiler 8 through the furnace 7. The primary air line L1 connects the blower B1 and the wind box 2. By driving the blower B1, air is supplied to the wind box 2 through the primary air line L1. The wind box 2 supplies air from below the fire grate 61. The secondary air line L2 connects the blower B1 and the inside of the furnace 7. Air for combustion is supplied into the furnace 7 from above the fire grate 61 through the secondary air line L2. The wind box 2 forms the bottom surface of the treatment space V. A plurality of the wind boxes 2 are arranged in the transport direction Da.

[0019]

The clinker roller 210 rotates to move the incineration object 400 from the post-combustion stage 23 to the discharge chute 13. The clinker roller 210 rotates every time set by the control device 300.

[0020]

The camera 220 captures a treatment image showing the drying stage 21, the combustion stage 22, and the post-combustion stage 23 of the treatment space V. By the camera 220 imaging the treatment space V, the treatment image generated by the camera 220 shows a bright flame generated from the incineration object 400. Examples of the camera 220 include a camera having a visible camera and a far infrared camera.

[0021]

A measuring unit 230 is a device measuring the steam flow rate and the oxygen concentration in the treatment space V. The incineration object 400 is dried in the drying stage 21, and steam is generated as a result of the moisture evaporation. The measuring unit 230 measures the steam flow rate attributable to the drying of the incineration object 400. The steam flow rate increases as the drying of the incineration object 400 becomes stronger in the drying stage 21. On the other hand, in the combustion stage 22, the incineration object 400 burns using the oxygen in the treatment space V. In other words, the oxygen concentration decreases as the combustion of the incineration object 400 becomes stronger in the combustion stage 22.

[0022]

The control device 300 controls the fire grate 61 and the wind box 2 by calculating correction values on the speed of the fire grate 61 and the amount of air supplied by the wind box 2. Fig. 3 is a schematic block diagram illustrating the configuration of the control device 300. The control device 300 includes an acquisition unit 310, a point identification unit 320, a first speed calculation unit 330, a first air amount calculation unit 340, a flow rate concentration calculation unit 350, a speed control unit 360, and an air amount control unit 370. The control device 300 is connected to the combustion facility 100 by wire or wirelessly.

[0023]

The acquisition unit 310 is an example of an image measuring unit, acquires the treatment image from the camera 220, and acquires the steam flow rate and the oxygen concentration from the measuring unit 230.

[0024]

The point identification unit 320 identifies a burnout point Z, which is the rear end in the transport direction Da of the flame F caused by the combustion of the incineration object 400, based on the treatment image acquired by the acquisition unit 310. Specifically, the point identification unit 320 identifies the burnout point Z by the following operation.

[0025]

The point identification unit 320 receives the treatment image acquired by the acquisition unit 310. Subsequently, the point identification unit 320 performs binarization with a preset threshold based on the brightness of the treatment image. The point identification unit 320 identifies the burnout point Z with the average value of the points at which the value of the binarized treatment image changes. The brightness of the image related to the place where the flame F is generated as a result of the combustion of the incineration object 400 is high, and the brightness of the image related to the place where the flame F is not generated is low. Accordingly, the point identification unit 320 is capable of identifying the burnout point Z by binarization as described above.

[0026]

The first speed calculation unit 330 calculates a first speed correction value, which is the correction value of the speed of the fire grate 61 of each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23, based on the burnout point Z identified by the point identification unit 320. Specifically, the first speed calculation unit 330

calculates the first speed correction value by the following operation.

[0027]

The first speed calculation unit 330 acquires the burnout point Z identified by the point identification unit 320. Subsequently, the first speed calculation unit 330 calculates the difference between a reference burnout point associated with the drying stage 21 and the burnout point Z and performs proportional-integral-differential (PID) calculation on the difference to calculate the first speed correction value associated with the drying stage 21. The first speed calculation unit 330 performs the above operation in relation to the combustion stage 22 and the post-combustion stage 23 to calculate the first speed correction value associated with the combustion stage 22 and the first speed correction value associated with the post-combustion stage 23.

In addition, the reference burnout point is a point set in advance in each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 so that the incineration object 400 is stably dried, burned, and post-burned in the drying stage 21, the combustion stage 22, and the post-combustion stage 23, respectively. The reference burnout point is, for example, a burnout

point set such that the ratio of the unburned portion of the incineration object 400 becomes a specific value.

[0028]

The first air amount calculation unit 340 calculates a first air amount correction value, which is the correction value of the amount of air supplied by the wind box 2 to each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23, based on the burnout point Z identified by the point identification unit 320. Specifically, the first air amount calculation unit 340 calculates the first air amount correction value by the following operation.

[0029]

The first air amount calculation unit 340 acquires the burnout point Z identified by the point identification unit 320. Subsequently, the first air amount calculation unit 340 calculates the difference between the reference burnout point associated with the drying stage 21 and the burnout point Z and performs PID calculation on the difference to calculate and the first air amount correction value associated with the drying stage 21. The first air amount calculation unit 340 performs the above operation in relation to the combustion stage 22 and the post-combustion stage 23 to calculate the first air amount correction value associated with the combustion stage 22

and the first air amount correction value associated with the post-combustion stage 23. The difference between the reference burnout point and the burnout point Z becomes a positive value when the burnout point Z is positioned upstream of the reference burnout point. The position of the reference burnout point is different in each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23. The position of the reference burnout point of the drying stage 21 is positioned most upstream in the transport direction +Da, and the position of the reference burnout point of the post-combustion stage 23 is positioned most downstream in the transport direction +Da.

[0030]

The flow rate concentration calculation unit 350 calculates a basic correction value based on the steam flow rate and the oxygen concentration acquired by the measuring unit 230. Specifically, the flow rate concentration calculation unit 350 calculates the basic correction value by the following operation.

[0031]

The flow rate concentration calculation unit 350 receives the steam flow rate and the oxygen concentration acquired by the measuring unit 230. The flow rate concentration calculation unit 350 divides the acquired

steam flow rate from a reference steam flow rate to calculate the difference. The flow rate concentration calculation unit 350 calculates a steam flow rate correction value by multiplying the difference by a weight associated with the steam flow rate. In addition, the flow rate concentration calculation unit 350 divides the acquired oxygen concentration from a reference oxygen concentration to calculate the difference. The flow rate concentration calculation unit 350 calculates an oxygen concentration correction value by multiplying the difference by a weight associated with the oxygen concentration. The flow rate concentration calculation unit 350 calculates the basic correction value by adding the steam flow rate correction value to the oxygen concentration correction value.

[0032]

The speed control unit 360 controls the speed of the fire grate 61 of each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 based on the first speed correction value calculated by the first speed calculation unit 330. Specifically, the speed control unit 360 controls the speed of the fire grate 61 by the following operation.

[0033]

The speed control unit 360 acquires the first speed correction value associated with the drying stage 21 among the first speed correction values calculated by the first speed calculation unit 330. In a case where the first speed correction value associated with the drying stage 21 is equal to or less than a preset lower limit value, the speed control unit 360 uses the lower limit value as the first speed correction value. In addition, in a case where the first speed correction value associated with the drying stage 21 is equal to or more than a preset upper limit value, the speed control unit 360 uses the upper limit value as the first speed correction value. Here, each of the upper limit value and the lower limit value of the first speed correction value is a positive value. Accordingly, in a case where the burnout point Z is positioned downstream of the reference burnout point, the first speed correction value becomes equal to the lower limit value. This is because the difference between the reference burnout point and the burnout point Z becomes a negative value in a case where the burnout point Z is positioned downstream of the reference burnout point. In other words, the first speed correction value is a value for accelerating the movement of the burnout point Z to the downstream side in a case where the burnout point Z is on the upstream side beyond a reference position.

[0034]

Subsequently, the speed control unit 360 adds the first speed correction value to a basic fire grate speed associated with the drying stage 21 to calculate a corrected speed associated with the drying stage 21. The speed control unit 360 sends an electric signal to the actuator of the movable fire grate 61B of the drying stage 21 such that the movable fire grate 61B is capable of moving at the corrected speed. The movable fire grate 61B is capable of moving at the corrected speed with the electric signal received.

The speed control unit 360 also performs the same operation as described above in relation to the fire grate 61 of the combustion stage 22 and the fire grate 61 of the post-combustion stage 23.

[0035]

The air amount control unit 370 controls the amount of air supplied by the wind box 2 to each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 based on the first air amount correction value calculated by the first air amount calculation unit 340 and the basic correction value calculated by the flow rate concentration calculation unit 350. Specifically, the air amount control unit 370 controls the wind box 2 by the following operation.

[0036]

The air amount control unit 370 acquires the first air amount correction value associated with the drying stage 21 among the first air amount correction values calculated by the first air amount calculation unit 340. In a case where the first air amount correction value associated with the drying stage 21 is equal to or less than a preset lower limit value, the air amount control unit 370 uses the lower limit value as the first air amount correction value. In addition, in a case where the first air amount correction value associated with the drying stage 21 is equal to or more than a preset upper limit value, the air amount control unit 370 uses the upper limit value as the first air amount correction value.

Here, each of the upper limit value and the lower limit value of the first air amount correction value is a positive value. Accordingly, in a case where the burnout point Z is positioned downstream of the reference burnout point, the first air amount correction value becomes equal to the lower limit value. This is because the difference between the reference burnout point and the burnout point Z becomes a negative value in a case where the burnout point Z is positioned downstream of the reference burnout point. In other words, the first air amount correction value is a value for accelerating the movement of the

burnout point Z to the downstream side in a case where the burnout point Z is on the upstream side beyond the reference position.

[0037]

Subsequently, the air amount control unit 370 acquires the basic correction value calculated by the flow rate concentration calculation unit 350. The air amount control unit 370 calculates a corrected air amount calculated by adding the basic correction value to the first air amount correction value associated with the drying stage 21. The air amount control unit 370 sends an electric signal to the wind box 2 of the drying stage 21 such that the amount of air supplied to the drying stage 21 by the wind box 2 becomes the corrected air amount. With the electric signal received, the wind box 2 changes the opening degree of the damper of the wind box 2 such that the amount of air supplied to the drying stage 21 by the wind box 2 becomes the corrected air amount.

The air amount control unit 370 also performs the same operation as described above in relation to the wind box 2 of the combustion stage 22 and the wind box 2 of the post-combustion stage 23.

[0038]

<<Operation Related to Fire Grate Speed Control>>

Hereinafter, an operation related to controlling the speed of the fire grate 61 of the combustion facility 100 will be described. Fig. 4 is a flowchart illustrating the operation related to controlling the speed of the fire grate 61.

[0039]

The first speed calculation unit 330 acquires the burnout point Z identified by the point identification unit 320 (step S1).

The first speed calculation unit 330 calculates the burnout point Z acquired in step S1 and the difference between the reference burnout point associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 and the burnout point Z and performs PID calculation on the difference to calculate the first speed correction value associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 (step S2).

[0040]

The speed control unit 360 acquires the first speed correction value associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 (step S3).

In a case where the first speed correction value associated with each of the drying stage 21, the

combustion stage 22, and the post-combustion stage 23 is equal to or more than an upper limit value associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 (step S4: YES), the speed control unit 360 uses the upper limit value as the first speed correction value (step S6).

In addition, in a case where the first speed correction value associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 is equal to or less than a lower limit value associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 (step S5: YES), the speed control unit 360 uses the lower limit value as the first speed correction value (step S7).

[0041]

The speed control unit 360 calculates the corrected speed associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 by adding the first speed correction value associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 to the basic fire grate speed associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 (step S8).

[0042]

The speed control unit 360 sends an electric signal to the actuator of the movable fire grate 61B of each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 such that the movable fire grate 61B is capable of moving at the corrected speed (step S9).

With the electric signal received as a result of step S9, the movable fire grate 61B is capable of moving at the corrected speed (step S10).

[0043]

Fig. 5 is a reference diagram illustrating the control of the speed of the fire grate 61.

The first speed calculation unit 330 performs PID calculation on the reference burnout point associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 and the burnout point Z acquired by the point identification unit 320 to calculate the first speed correction value. Subsequently, the speed control unit 360 determines the first speed correction value based on upper and lower limitations and transmits a signal to the movable fire grate 61B based on the first speed correction value and a reference fire grate speed to make the movable fire grate 61B movable at the corrected speed.

[0044]

As a result of the above operation, a user of the combustion facility 100 can control the speed of the fire grate 61 based on the identified burnout point Z, and thus the incineration object 400 can be stably dried, burned, and post-burned in the combustion facility 100. In a case where the position of the burnout point Z is close to the drying stage 21, the ratio of the unburned portion of the incineration object 400 decreases, and thus the amount per unit time of treatment of the incineration object 400 using the combustion facility 100 decreases and the efficiency of the combustion facility 100 declines. In addition, in a case where the position of the burnout point Z is close to the clinker roller 210, the ratio of the unburned portion of the incineration object 400 increases, and thus it becomes difficult to bury the incineration object 400 after post-combustion.

[0045]

In this regard, the control device 300 according to the present embodiment reduces the speed of the fire grate 61 to actively stir the incineration object 400 and increase the ratio of the unburned portion in a case where the position of the burnout point Z is close to the drying stage 21 and increases the speed of the fire grate 61 to increase the stirring of the incineration object 400 and

decrease the ratio of the unburned portion in a case where the burnout point Z is close to the clinker roller 210.

[0046]

<<Operation Related to Air Amount Control>>

Hereinafter, an operation related to controlling the air amount of the combustion facility 100 will be described. Fig. 6 is a flowchart illustrating the operation related to the air amount control.

[0047]

The first air amount calculation unit 340 acquires the burnout point Z identified by the point identification unit 320 (step S21).

The first air amount calculation unit 340 calculates the burnout point Z acquired in step S21 and the difference between the reference burnout point associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 and the burnout point Z and performs PID calculation on the difference to calculate the first air amount correction value associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 (step S22).

[0048]

The air amount control unit 370 acquires the first air amount correction value associated with each of the

drying stage 21, the combustion stage 22, and the post-combustion stage 23 (step S23).

In a case where the first air amount correction value associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 is equal to or more than an upper limit value associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 (step S24: YES), the air amount control unit 370 uses the upper limit value as the first air amount correction value (step S26).

In addition, in a case where the first air amount correction value associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 is equal to or less than a lower limit value associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 (step S25: YES), the air amount control unit 370 uses the lower limit value as the first air amount correction value (step S27).

[0049]

The air amount control unit 370 calculates the corrected air amount associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 by adding the first air amount correction value associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 to

the basic correction value calculated by the flow rate concentration calculation unit 350 (step S28).

[0050]

The air amount control unit 370 sends an electric signal to the wind box 2 of each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 such that the wind box 2 supplies the corrected amount of air to each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 (step S29).

With the electric signal received as a result of step S29, the wind box 2 changes the opening degree of the damper of the wind box 2 to supply air related to the corrected air amount (step S30).

[0051]

Fig. 7 is a reference diagram illustrating the control of the wind box 2.

The first air amount calculation unit 340 performs PID calculation on the reference burnout point associated with each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 and the burnout point Z acquired by the point identification unit 320 to calculate the first air amount correction value. Subsequently, the air amount control unit 370 determines the first air amount correction value based on upper and lower limitations and transmits a signal to the wind box 2 based

on the first air amount correction value and a reference correction value to supply the corrected amount of air.

[0052]

As a result of the above operation, a user of the combustion facility 100 can control the wind box 2 based on the identified burnout point Z, and thus the incineration object 400 can be stably dried, burned, and post-burned in the combustion facility 100.

In a case where the position of the burnout point Z is close to the drying stage 21, the ratio of the unburned portion of the incineration object 400 decreases, and thus the amount per unit time of treatment of the incineration object 400 using the combustion facility 100 decreases and the efficiency of the combustion facility 100 declines. In addition, in a case where the position of the burnout point Z is close to the clinker roller 210, the ratio of the unburned portion of the incineration object 400 increases, and thus it becomes difficult to bury the incineration object 400 after post-combustion.

[0053]

In this regard, the control device 300 according to the present embodiment reduces the opening degree of the damper of the wind box 2 to increase the ratio of the unburned portion of the incineration object 400 in a case where the position of the burnout point Z is close to the

drying stage 21 and increases the opening degree of the damper of the wind box 2 to decrease the ratio of the unburned portion in a case where the burnout point Z is close to the clinker roller 210.

[0054]

As for the control device 300 for the combustion facility 100 in the embodiment described above, the wind box 2 is controlled by the air amount control unit 370 after the fire grate 61 is controlled by the speed control unit 360. In addition, the speed control unit 360 may control the fire grate 61 after the wind box 2 is controlled by the air amount control unit 370.

[0055]

<<Actions and Effects>>

The control device 300 for the combustion facility 100 according to the present disclosure is the control device 300 for the combustion facility 100 including the furnace main body 10 defining the treatment space V, the fire grate 61 transporting the incineration object 400 in the transport direction Da in the treatment space V, and the wind box 2 supplying air to the treatment space V. The control device 300 includes the image acquisition unit acquiring the treatment image showing the sections resulting from partitioning the treatment space V in the transport direction Da, the point identification unit 320

identifying the burnout point Z, which is the rear end in the transport direction of the flame F caused by the combustion of the incineration object 400, based on the treatment image, the first speed calculation unit 330 calculating the first speed correction value, which is the correction value of the speed of the fire grate 61 of the section, based on the burnout point Z, and the speed control unit 360 controlling the speed of the fire grate 61 of the section based on the first speed correction value.

[0056]

A user of the combustion facility 100 can control the speed of the fire grate 61 based on the identified burnout point Z, and thus the incineration object 400 can be stably burned in the combustion facility 100.

[0057]

In addition, in the control device 300 for the combustion facility 100, the sections resulting from partitioning the treatment space V are the drying stage 21, the combustion stage 22, and the post-combustion stage 23 from the upstream side in the transport direction Da, the image acquisition unit acquires the treatment image showing the drying stage 21, the combustion stage 22, and the post-combustion stage 23, the first speed calculation unit 330 calculates the first speed correction value of

each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23, and the speed control unit 360 controls the speeds of the fire grates 61 of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 based on the respective first speed correction values.

[0058]

A user of the combustion facility 100 can control the speed of the fire grate 61 based on the identified burnout point Z, and thus the incineration object 400 can be stably dried, burned, and post-burned in the combustion facility 100.

[0059]

In addition, the control device 300 for the combustion facility 100 includes the first air amount calculation unit 340 calculating the first air amount correction value, which is the correction value of the amount of air supplied to each of the sections, based on the burnout point Z and the air amount control unit 370 controlling the amount of air supplied to each of the sections by the wind box 2 based on the first air amount correction value.

[0060]

A user of the combustion facility 100 can control the wind box 2 based on the identified burnout point Z,

and thus the incineration object 400 can be stably dried, burned, and post-burned in the combustion facility 100.

[0061]

<Second Embodiment>

Hereinafter, the combustion facility 100 according to a second embodiment will be described. The combustion facility 100 according to the second embodiment controls the speed of the fire grate 61 and controls the wind box 2 based on load values in the drying stage 21, the combustion stage 22, and the post-combustion stage 23.

[0062]

Fig. 8 is a schematic block diagram illustrating the configuration of the control device 300 according to the second embodiment. The control device 300 according to the second embodiment includes a determination unit 379, a load value identification unit 380, a second speed calculation unit 381, a second air amount calculation unit 382, a second speed control unit 383, and a second air amount control unit 384 in addition to the configurations of the control device 300 according to the first embodiment.

[0063]

The determination unit 379 acquires the burnout point Z from the point identification unit 320 and determines whether or not the burnout point Z is within a

preset range. The set range of the burnout point is set, for example, downstream of the reference burnout point of the post-combustion stage. In other words, the determination unit 379 determines whether or not the combustion state is a burnout defect state.

[0064]

The load value identification unit 380 identifies the load value, which is a value indicating the load state of each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23, based on at least one of the brightness of the treatment image, the moisture amount of the incineration object 400, and the lower heating value of the incineration object 400. Specifically, the load value identification unit 380 identifies the load value by the following operation. The load value increases as the combustion-related load increases. The load increases as the heating value of the incineration object increases and decreases as the moisture amount of the incineration object increases.

[0065]

The load value identification unit 380 divides the treatment image acquired by the acquisition unit 310 into the zones of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 and calculates the average brightness value of images related to the zones to

identify the load values of the drying stage 21, the combustion stage 22, and the post-combustion stage 23. This is because the flame becomes stronger as the combustion-related load increases and thus the load is estimated to increase as the brightness in the treatment image increases. In addition, the load value identification unit 380 identifies the load values of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 based on the moisture amount per unit mass of the incineration object 400 as a sample acquired from incineration object 400 put into the combustion facility 100. In addition, the load value identification unit 380 identifies the load values of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 based on the lower heating value per unit mass of the sample incineration object 400 acquired from the incineration object 400 put into the combustion facility 100.

[0066]

The second speed calculation unit 381 calculates a second speed correction value, which is a correction value of the speed of the fire grate 61 of each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23, based on the difference between a preset value and the load value. Specifically, the second speed

calculation unit 381 calculates the second speed correction value by the following operation.

[0067]

The second speed calculation unit 381 acquires the load value identified by the load value identification unit 380 and associated with the drying stage 21. The second speed calculation unit 381 calculates the difference between the preset value and the load value and performs PID calculation on the difference to calculate the second speed correction value. The second speed calculation unit 381 performs the same operation as described above in relation to the combustion stage 22 and the post-combustion stage 23 to calculate the second speed correction value.

[0068]

The second air amount calculation unit 382 calculates a second air amount correction value, which is a correction value of the amount of air supplied by the wind box 2 to each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23, based on the difference between a reference load value and the load value. Specifically, the second air amount calculation unit 382 calculates the second air amount correction value by the following operation.

[0069]

The second air amount calculation unit 382 acquires the load value identified by the load value identification unit 380 and associated with the drying stage 21. The second air amount calculation unit 382 calculates the difference between the reference load value and the load value and performs PID calculation on the difference to calculate the second air amount correction value. The second air amount calculation unit 382 performs the same operation as described above in relation to the combustion stage 22 and the post-combustion stage 23 to calculate the second air amount correction value.

[0070]

In a case where the determination unit 379 determines that the burnout point Z is within the preset range, the second speed control unit 383 controls the speed of the fire grate 61 of each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 based on the second speed correction value. Specifically, the second speed control unit 383 controls the speed of the fire grate 61 by the following operation. In a case where the determination unit 379 determines that the burnout point Z is not within the preset range, the second speed control unit 383 does not operate and the speed control unit 360 or the air amount control unit 370 operates to set the burnout point Z within a certain range.

[0071]

The second speed control unit 383 acquires the second speed correction value associated with the drying stage 21 among the second speed correction values calculated by the second speed calculation unit 381. In a case where the second speed correction value associated with the drying stage 21 is equal to or less than a preset lower limit value, the second speed control unit 383 uses the lower limit value as the second speed correction value. In addition, in a case where the second speed correction value associated with the drying stage 21 is equal to or more than a preset upper limit value, the second speed control unit 383 uses the upper limit value as the second speed correction value. Here, the upper limit value of the second speed correction value is a positive value and the lower limit value of the second speed correction value is a negative value. Accordingly, the second speed control unit accelerates the movement of the incineration object such that the load increases in a case where the load is lower than a reference, that is, in a case where the combustion state is a low-load state and accelerates the movement of the incineration object such that the load decreases in a case where the load is higher than the reference, that is, in a case where the combustion state is an overload state.

[0072]

Subsequently, the second speed control unit 383 adds the second speed correction value to the basic fire grate speed associated with the drying stage 21 to calculate a second corrected speed associated with the drying stage 21. The second speed control unit 383 sends an electric signal to the actuator of the movable fire grate 61B of the drying stage 21 such that the movable fire grate 61B is capable of moving at the second corrected speed. The movable fire grate 61B is capable of moving at the second corrected speed with the electric signal received.

The second speed control unit 383 also performs the same operation as described above in relation to the fire grate 61 of the combustion stage 22 and the fire grate 61 of the post-combustion stage 23.

[0073]

In a case where the determination unit 379 determines that the burnout point Z is within the preset range, the second air amount control unit 384 controls the amount of air supplied by the wind box 2 to each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 based on the second air amount correction value calculated by the second air amount calculation unit 382 and the basic correction value calculated by the flow rate concentration calculation unit

350. Specifically, the second air amount control unit 384 controls the wind box 2 by the following operation.

[0074]

The second air amount control unit 384 acquires the second air amount correction value associated with the drying stage 21 among the second air amount correction values calculated by the second air amount calculation unit 382. In a case where the second air amount correction value associated with the drying stage 21 is equal to or less than a preset lower limit value, the second air amount control unit 384 uses the lower limit value as the second air amount correction value. In addition, in a case where the second air amount correction value associated with the drying stage 21 is equal to or more than a preset upper limit value, the second air amount control unit 384 uses the upper limit value as the second air amount correction value. Here, the upper limit value of the second speed correction value is a positive value and the lower limit value of the second speed correction value is a negative value. Accordingly, the second speed control unit accelerates the movement of the incineration object such that the load increases in a case where the load is lower than a reference, that is, in a case where the combustion state is a low-load state and accelerates the movement of the incineration object such

that the load decreases in a case where the load is higher than the reference, that is, in a case where the combustion state is an overload state.

[0075]

Subsequently, the second air amount control unit 384 acquires the basic correction value calculated by the flow rate concentration calculation unit 350. The second air amount control unit 384 calculates a second corrected air amount calculated by adding the basic correction value to the second air amount correction value associated with the drying stage 21. The second air amount control unit 384 sends an electric signal to the wind box 2 of the drying stage 21 such that the amount of air supplied to the drying stage 21 by the wind box 2 becomes the second corrected air amount. With the electric signal received, the wind box 2 changes the opening degree of the damper of the wind box 2 such that the amount of air supplied to the drying stage 21 by the wind box 2 becomes the second corrected air amount.

The second air amount control unit 384 also performs the same operation as described above in relation to the wind box 2 of the combustion stage 22 and the wind box 2 of the post-combustion stage 23.

[0076]

<<Actions and Effects>>

The control device 300 for the combustion facility 100 according to the present disclosure includes the load value identification unit 380 identifying the load value, which is a value indicating the load state of each of the sections, based on at least one of the brightness of the treatment image, the moisture amount of the incineration object 400, and the lower heating value of the incineration object 400, the second speed calculation unit 381 calculating the second speed correction value, which is a correction value of the speed of the fire grate 61 of each of the sections, based on the difference between a preset value and the load value, and the second speed control unit 383 controlling the speed of the fire grate 61 of each of the sections based on the second speed correction value.

[0077]

A user of the combustion facility 100 can control the speed of the fire grate 61 based on the identified load value, and thus the incineration object 400 can be stably burned in the combustion facility 100.

[0078]

The control device 300 for the combustion facility 100 according to the present disclosure includes the second air amount calculation unit 382 calculating the second air amount correction value, which is a correction

value of the amount of air supplied by the wind box 2 to each of the sections, based on the difference between a preset value and the load value and the second air amount control unit 384 controlling the amount of air supplied by the wind box 2 to each of the sections based on the second air amount correction value.

[0079]

A user of the combustion facility 100 can control the wind box 2 based on the identified load value, and thus the incineration object 400 can be stably burned in the combustion facility 100.

[0080]

<Third Embodiment>

Hereinafter, the combustion facility 100 according to a third embodiment will be described. The combustion facility 100 according to the third embodiment identifies the amount of the incineration object 400 put into the drying stage 21 to control the amount of air supplied by the secondary air line L2.

[0081]

Fig. 9 is a schematic block diagram illustrating the configuration of the control device 300 according to the third embodiment. The control device 300 according to the third embodiment includes the determination unit 379, an amount identification unit 385, an amount determination

unit 386, and a secondary air control unit 387 in addition to the configurations of the control device 300 according to the first embodiment.

[0082]

The measuring unit 230 according to the third embodiment is a device measuring the steam flow rate, the oxygen concentration, and the gas temperature in the treatment space V. The acquisition unit 310 acquires the steam flow rate, the oxygen concentration, and the gas concentration from the measuring unit 230.

The determination unit 379 acquires the burnout point Z from the point identification unit 320 and determines whether or not the burnout point Z is within a preset range.

[0083]

The amount identification unit 385 identifies the amount of the incineration object 400 that has flowed into the drying stage 21 based on the treatment image acquired by the acquisition unit 310. Specifically, the amount identification unit 385 identifies the amount of the incineration object 400 by calculating, in the image in the zone where the drying stage 21 is connected to the feeder 31 preset in the flame perspective image of the treatment space V acquired from the camera 220 by the acquisition unit 310, the ratio of the area of the

incineration object 400 in the image corresponding to the zone.

[0084]

The amount determination unit 386 determines whether or not the amount of the incineration object 400 identified by the amount identification unit 385 is equal to or more than a preset value. The threshold is set to a value at which it is possible to detect a state where the clogging of the incineration object 400 is eliminated in the hopper and the incineration object 400 is put into the furnace main body 10 in quantity.

[0085]

In a case where the determination unit 379 determines that the burnout point Z is within the preset range, the secondary air control unit 387 controls the amount of air supplied by the secondary air line L2 based on the content of the determination of the amount determination unit 386 and the oxygen concentration and the gas temperature acquired by the acquisition unit 310. Specifically, the secondary air control unit 387 controls the air amount by the following operation.

[0086]

In a case where the determination unit 379 determines that the burnout point Z is within the preset range and determines that the amount of the incineration

object 400 identified by the amount identification unit 385 is equal to or more than the preset value, the secondary air control unit 387 receives the gas temperature and the oxygen concentration from the acquisition unit 310 and receives the amount of the incineration object 400 from the amount identification unit 385. The secondary air control unit 387 collates the received amount of the incineration object 400, gas temperature, and oxygen concentration with preset information in which the amount of the incineration object 400, gas temperature, oxygen concentration, and air amount are associated to identify the amount of air supplied by the secondary air line L2. The secondary air control unit 387 transmits a signal indicating the air amount to the secondary air line L2 to control the amount of air supplied by the secondary air line L2 to the amount of supply identified above.

[0087]

On the other hand, in a case where the determination unit 379 determines that the burnout point Z is within the preset range and determines that the amount of the incineration object 400 identified by the amount identification unit 385 is not equal to or more than the preset value, the secondary air control unit 387 receives the gas temperature and the oxygen concentration from the

acquisition unit 310. The secondary air control unit 387 collates the received gas temperature and oxygen concentration with preset information in which the gas temperature, oxygen concentration, and air amount are associated to identify the amount of air supplied by the secondary air line L2. The secondary air control unit 387 transmits a signal indicating the air amount to the secondary air line L2 to control the amount of air supplied by the secondary air line L2 to the amount of supply identified above.

[0088]

<<Operation Related to Controlling Secondary Air Control Unit>>

Hereinafter, an operation related to controlling the secondary air control unit 387 will be described. Fig. 10 is a flowchart illustrating the operation related to the control of the secondary air control unit 387 in a case where the determination unit 379 determines that the burnout point Z is within a preset range. In addition, the control of the speed of the fire grate 61 or the control of the opening degree of the damper of the wind box 2 in the third embodiment is the same as the operation according to the first embodiment.

[0089]

The amount identification unit 385 identifies the amount of the incineration object 400 that has flowed into the drying stage 21 based on the treatment image acquired by the acquisition unit 310 (step S41).

The amount determination unit 386 determines whether or not the amount of the incineration object 400 identified by the amount identification unit 385 is equal to or more than a preset value (step S42).

[0090]

In a case where it is determined that the amount of the incineration object 400 identified by the amount identification unit 385 is not equal to or more than the preset value (step S43: NO), the secondary air control unit 387 receives the gas temperature and the oxygen concentration from the acquisition unit 310. The secondary air control unit 387 collates the received gas temperature and oxygen concentration with preset information in which the gas temperature, oxygen concentration, and air amount are associated to identify the amount of air supplied by the secondary air line L2. The secondary air control unit 387 transmits a signal indicating the air amount to the secondary air line L2 to control the amount of air supplied by the secondary air line L2 to the amount of supply identified above (step S44).

[0091]

On the other hand, in a case where it is determined that the amount of the incineration object 400 identified by the amount identification unit 385 is equal to or more than the preset value (step S43: YES), the secondary air control unit 387 receives the amount of the incineration object 400 from the amount identification unit 385 and receives the gas temperature and the oxygen concentration from the acquisition unit 310. The secondary air control unit 387 collates the received amount of the incineration object 400, gas temperature, and oxygen concentration with preset information in which the amount of the incineration object 400, gas temperature, oxygen concentration, and air amount are associated to identify the amount of air supplied by the secondary air line L2. The secondary air control unit 387 transmits a signal indicating the air amount to the secondary air line L2 to control the amount of air supplied by the secondary air line L2 to the amount of supply identified above (step S45).

[0092]

As a result of the above operation, a user of the combustion facility 100 can control the amount of air supplied from the secondary air line L2 based on the amount of the incineration object 400 as well and can

stably maintain the combustion state of the incineration object 400 burned using the air.

In a case where the incineration object 400 is put into the furnace main body 10 in quantity, the combustion state becomes unstable, examples of which include an increase in the ratio of the unburned portion of the incineration object 400 in the combustion facility 100. Accordingly, it is possible to stably burn the incineration object 400 by detecting a state where the incineration object 400 is put into the furnace main body 10 in quantity and increasing the supply of air from the secondary air line L2 used for combustion in the case of that state.

[0093]

<<Actions and Effects>>

The control device 300 for combustion facility 100 according to the embodiment of the present disclosure, in which the combustion facility 100 further includes the secondary air line L2 for air supply from above the fire grate 61, and the control device 300 further includes the amount identification unit 385 identifying the amount of the incineration object 400 that has flowed into the section based on the treatment image, the amount determination unit 386 determining whether or not the identified amount is equal to or more than a preset value,

and the secondary air control unit 387 controlling the amount of air supplied by the secondary air line L2 based on the content of the determination.

[0094]

A user of the combustion facility 100 can control the amount of air supplied from the secondary air line L2 based on the amount of the incineration object 400 as well and can stably maintain the combustion state of the incineration object 400 burned using the air.

[0095]

<Fourth Embodiment>

Hereinafter, the combustion facility 100 according to a fourth embodiment will be described. The combustion facility 100 according to the fourth embodiment calculates the first speed correction value using a trained model generated using the burnout point Z, the speed of the fire grate 61, and the like.

[0096]

Fig. 11 is a block diagram illustrating the configuration of the control device 300 according to the fourth embodiment. The control device 300 according to the fourth embodiment includes a model generation unit 390, a model storage unit 391, a candidate generation unit 392, and a flow rate calculation unit 393 in addition to the

configurations of the control device 300 according to the first embodiment.

[0097]

The model generation unit 390 generates a trained model based on a data set of an input input sample and an output sample and records the trained model in the model storage unit 391. The trained model is a machine learning model trained so as to output the steam flow rate of the combustion facility by inputting the combination of a state quantity indicating the state of the combustion facility and a combustion facility control amount. An example of the operation of the model generation unit 390 will be described below.

[0098]

The model generation unit 390 uses, as the input sample, the ignition point in the combustion stage 22, the burnout point Z, the drying state of the drying stage 21, the combustion state of the combustion stage 22, the post-combustion state of the post-combustion stage 23, the oxygen concentration, the lower heating value of the incineration object 400, the pressure value of the accommodation space V, the gas temperature, the steam flow rate, the opening degree of the damper of the wind box 2, the stroke of the dust collector 11, the speed of the fire grate 61 of the drying stage 21, the speed of the fire

grate 61 of the combustion stage 22, and the speed of the fire grate 61 of the post-combustion stage 23. In other words, the ignition point in the combustion stage 22, the burnout point Z, the drying state of the drying stage 21, the combustion state of the combustion stage 22, the post-combustion state of the post-combustion stage 23, the oxygen concentration, the lower heating value of the incineration object 400, the pressure value of the accommodation space V, and the gas temperature are state quantities indicating the state of the combustion facility. In addition, the opening degree of the damper of the wind box 2, the stroke of the dust collector 11, the speed of the fire grate 61 of the drying stage 21, the speed of the fire grate 61 of the combustion stage 22, and the speed of the fire grate 61 of the post-combustion stage 23 are combustion facility control amounts. The drying state of the drying stage 21, the combustion state of the combustion stage 22, and the post-combustion state of the post-combustion stage 23 can be identified by, for example, the load value or the position of the burnout point Z identified by the point identification unit 320.

[0099]

In addition, the model generation unit 390 uses the steam flow rate as the output sample. The model generation unit 390 performs machine learning model

learning processing using the data set of the input sample and the output sample. Examples of the machine learning model used by the model generation unit 390 include a long short-term memory (LSTM) and a gated recurrent unit (GRU). The machine learning model is a function that has a weighting factor inside. The model generation unit 390 generates the trained model by updating the weighting factor of the machine learning model such that the output sample can be obtained from the input sample using a learning method. The model generation unit 390 records the trained model in the model storage unit 391. The trained model is the combination of the machine learning model and the weighting factor updated by the learning processing.

[0100]

The model storage unit 391 stores the trained model generated by the model generation unit 390.

The candidate generation unit 392 generates candidates for the speeds of the fire grates 61 of the drying stage 21, the combustion stage 22, and the post-combustion stage 23. For example, the candidate generation unit 392 generates a candidate in which the speed of the fire grate 61 of each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23

and the opening rate of the damper of the wind box 2 are associated with each other.

[0101]

The flow rate calculation unit 393 calculates the steam flow rate by inputting, to the trained model stored in the model storage unit 391, the burnout point Z identified by the point identification unit 320, the ignition point in the combustion stage 22, the drying state of the drying stage 21, the combustion state of the combustion stage 22, the post-combustion state of the post-combustion stage 23, the oxygen concentration, the lower heating value of the incineration object 400, the pressure value of the accommodation space V, the gas temperature, the steam flow rate, and the candidate for the speed of the fire grate 61 of each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 generated by the candidate generation unit 392.

[0102]

The first speed calculation unit 330 according to the fourth embodiment calculates the first speed correction value based on a candidate as one of the speed candidates generated by the candidate generation unit 392 in which the difference between the measured steam flow rate value and the steam flow rate value calculated by the flow rate calculation unit 393 is small.

[0103]

For example, the candidate generation unit 392 according to the fourth embodiment calculates a reference damper opening degree and a reference fire grate speed of each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 based on the combustion state of the combustion facility 100. The candidate generation unit 392 generates a plurality of fire grate speed candidates by adding a correction value based on a predetermined fluctuation range to the reference fire grate speed. The candidate generation unit 392 generates a plurality of damper opening degree candidates by adding a correction value based on a predetermined fluctuation range to the reference damper opening degree.

[0104]

The flow rate calculation unit 393 identifies, as state quantities indicating the current state of the combustion facility 100, the burnout point Z identified by the point identification unit 320, the ignition point in the combustion stage 22, the drying state of the drying stage 21, the combustion state of the combustion stage 22, the post-combustion state of the post-combustion stage 23, the oxygen concentration, the lower heating value of the incineration object 400, the pressure value of the accommodation space V, the gas temperature, and the steam

flow rate. The flow rate calculation unit 393 calculates the steam flow rate for each control amount candidate using the identified state quantity and each of the control amount candidates generated by the candidate generation unit 392. The first speed calculation unit 330 determines, as the first speed correction value, the fire grate speed related to the control amount candidate with the smallest difference between the steam flow rate calculated for each control amount candidate and the measured steam flow rate value.

[0105]

In another embodiment, the candidate generation and the first speed correction value determination may be performed based on, for example, a genetic algorithm or the candidate may be generated based on a random number. In addition, in another embodiment, the candidate generation unit 392 may generate one candidate and the first speed calculation unit 330 may obtain the first speed correction value by updating the value of the candidate such that the difference in steam flow rate decreases.

[0106]

In addition, in another embodiment, the state quantity of the combustion facility 100 input to the trained model may include at least the position of the

burnout point Z and the other state quantities may be changed as appropriate. In addition, the control amount input to the trained model may include at least the speed of the fire grate 61 of each section and the other control amounts may be changed as appropriate.

[0107]

<<Actions and Effects>>

The control device 300 for the combustion facility 100 according to the present disclosure includes the model storage unit 391 storing the trained model trained by supervised learning using the data set of the input sample including the burnout point Z and the speed of the fire grate 61 of each section and the output sample including the steam flow rate attributable to the drying in the incineration object 400, the candidate generation unit 392 generating a candidate for the speed of the fire grate 61 of each section, and the flow rate calculation unit 393 calculating the steam flow rate by inputting the burnout point Z and the speed candidate for the fire grate 61 of each section into the trained model and the first speed calculation unit 330 calculates the first speed correction value based on a candidate as one of the speed candidates generated by the candidate generation unit 392 in which the difference between the measured steam flow rate value

and the steam flow rate value calculated by the flow rate calculation unit 393 is small.

[0108]

A user of the combustion facility 100 can control the speed of the fire grate 61 using the trained model generated with the input sample including the burnout point Z and the speed of the fire grate 61 of each section and can stably perform combustion in the combustion facility 100.

[0109]

<Fifth Embodiment>

Hereinafter, the combustion facility 100 according to a fifth embodiment will be described. In the combustion facility 100 according to the fifth embodiment, in addition to the control according to the first embodiment, the position of the flame F is identified and the secondary air line L2 is controlled to change the temperature of the drying stage 21.

[0110]

Fig. 12 is a flowchart illustrating the configuration of the control device 300 according to the fifth embodiment. The control device 300 of the fifth embodiment includes a flame identification unit 394, a temperature identification unit 395, a secondary air calculation unit 396, and a second secondary air control

unit 397 in addition to the configurations of the control device 300 of the first embodiment.

[0111]

The flame identification unit 394 identifies the position of the flame F based on the treatment image acquired by the acquisition unit 310. For example, the flame identification unit 394 identifies a combustion region based on the brightness of the treatment image, identifies the point in the region closest to the drying stage 21 as an ignition point, and identifies the ignition point as the position of the flame F.

[0112]

The temperature identification unit 395 identifies the temperature of the incineration object 400 in the drying stage 21 based on the treatment image acquired by the acquisition unit 310. For example, the temperature identification unit 395 collates the average brightness value of the zone corresponding to the drying stage 21 in the treatment image with information in which the brightness and the temperature are associated to identify the temperature of the incineration object 400 in the drying stage 21.

[0113]

The secondary air calculation unit 396 calculates the secondary air amount and the secondary air supply

angle at which the difference between the temperature identified by the temperature identification unit 395 and a preset value is minimum based on the position of the flame F identified by the flame identification unit 394. The secondary air calculation unit 396 performs the calculation by the following operation.

The secondary air calculation unit 396 receives the position of the ignition point, which is the position of the flame F identified by the flame identification unit 394, and the temperature identified by the temperature identification unit 395. The secondary air calculation unit 396 calculates the temperature difference by subtracting the received temperature from the preset value.

[0114]

The secondary air calculation unit 396 determines whether or not the temperature of the drying stage 21 identified by the temperature identification unit 395 is lower than the target temperature of the drying stage 21 by a predetermined temperature difference or more. In addition, the secondary air calculation unit 396 determines whether or not the position of the flame F identified by the flame identification unit 394 is positioned behind the drying stage 21. In a case where the temperature of the drying stage 21 is lower than the target temperature by the predetermined temperature

difference or more and the position of the flame F is positioned behind the drying stage 21, the secondary air calculation unit 396 calculates the amount and angle of the secondary air such that the flame position approaches the drying stage 21. For example, the secondary air calculation unit 396 stores in advance the amount and angle of the secondary air for bringing the flame closer to the drying stage 21 in association with the position of the flame F and is capable of calculating the amount and angle of the secondary air by reading the amount and angle of the secondary air associated with the position of the flame identified by the flame identification unit 394.

[0115]

The second secondary air control unit 397 controls the secondary air line L2 based on the amount and supply angle of the secondary air calculated by the secondary air calculation unit 396. In other words, the second secondary air control unit 397 controls the angle of the opening of the opening degree of the damper such that the amount and supply angle of the secondary air supplied by the secondary air line L2 become the amount and supply angle of the secondary air calculated by the secondary air calculation unit 396.

[0116]

<<Actions and Effects>>

The control device 300 for combustion facility 100 according to the embodiment of the present disclosure, in which the combustion facility 100 further includes the secondary air line L2 for air supply from above the fire grate 61, and the control device 300 further includes the flame identification unit 394 identifying the position of the flame F based on the treatment image, the temperature identification unit 395 identifying the temperature of the incineration object 400 in the section based on the treatment image, the secondary air calculation unit 396 calculating the amount and supply angle of the secondary air at which the difference between the temperature and a preset value is minimum based on the position of the flame F, and the second secondary air control unit 397 controlling the secondary air line L2 based on the calculated amount and supply angle.

[0117]

A user of the combustion facility 100 can control the amount and supply angle of the secondary air using the position of the flame F, and thus the user can change the mode of the flame F to approach the drying stage 21 and can stably treat the incineration object 400 in the section.

[0118]

<Other Embodiments>

Although one embodiment has been described in detail with reference to the drawings, the specific configuration is not limited to the above description and various design changes and the like can be made.

[0119]

The control device 300 for the combustion facility 100 may separately control the drying stage 21, the combustion stage 22, and the post-combustion stage 23. For example, the drying stage 21 may be controlled with the combustion stage 22 and the post-combustion stage 23 not controlled or the drying stage 21, the combustion stage 22, and the post-combustion stage 23 may be controlled collectively. In addition, control may be performed with priorities given to the plurality of wind boxes 2 in the drying stage 21, the combustion stage 22, and the post-combustion stage 23.

[0120]

Fig. 13 is a schematic block diagram illustrating the configuration of a computer according to at least one embodiment.

A computer 1100 includes a processor 1110, a main memory 1120, a storage 1130, and an interface 1140.

The control device 300 described above is mounted on the computer 1100. The operation of each of the above processing units is stored in the storage 1130 in the form

of a program. The processor 1110 reads a program from the storage 1130, loads the program into the main memory 1120, and executes the above processing in accordance with the program. In addition, the processor 1110 secures a storage region corresponding to each of the above storage units in the main memory 1120 in accordance with the program.

[0121]

The program may be one for realizing some of the functions of the computer 1100. For example, the program may exert a function in combination with another program already stored in the storage 1130 or in combination with another program mounted on another device. In another embodiment, the computer 1100 may include a custom large scale integrated circuit (LSI) such as a programmable logic device (PLD) in addition to or in place of the above configuration. Examples of the PLD include a programmable array logic (PAL), a generic array logic (GAL), a complex programmable logic device (CPLD), and a field programmable gate array (FPGA). In this case, some or all of the functions realized by the processor 1110 may be realized by the integrated circuit.

[0122]

Examples of the storage 1130 include a magnetic disk, a magneto-optical disk, and a semiconductor memory. The

storage 1130 may be internal media directly connected to the bus of computer 1100 or external media connected to the computer via the interface 1140 or a communication line. In addition, in a case where this program is distributed to the computer 1100 via a communication line, the distributed computer 1100 may load the program into the main memory 1120 and execute the above processing. In at least one embodiment, the storage 1130 is a non-temporary tangible storage medium.

[0123]

In addition, the program may be one for realizing some of the functions described above. Further, the program may be a so-called difference file (difference program) that realizes the above function in combination with another program already stored in the storage 1130.

[0124]

<Additional Notes>

The control device 300 of the combustion facility 100 described in each embodiment is, for example, grasped as follows.

[0125]

(1) A control device 300 for a combustion facility 100 according to the present disclosure is a control device 300 for a combustion facility 100 including a furnace main body 10 defining a treatment space V, a fire

grate 61 transporting an incineration object 400 in a transport direction Da in the treatment space V, and a wind box 2 supplying air to the treatment space V. The control device 300 includes: an image acquisition unit acquiring a treatment image showing sections resulting from partitioning the treatment space V in the transport direction Da; a point identification unit 320 identifying a burnout point Z as a rear end in the transport direction of a flame F caused by combustion of the incineration object 400 based on the treatment image; a first speed calculation unit 330 calculating a first speed correction value as a correction value of a speed of the fire grate 61 of the section based on the burnout point Z; and a speed control unit 360 controlling the speed of the fire grate 61 of the section based on the first speed correction value.

[0126]

A user of the combustion facility 100 can control the speed of the fire grate 61 based on the identified burnout point Z, and thus the incineration object 400 can be stably burned in the combustion facility 100.

[0127]

(2) In the control device 300 for the combustion facility 100, the sections resulting from partitioning the treatment space V are a drying stage 21, a combustion

stage 22, and a post-combustion stage 23 from an upstream side in the transport direction Da, the image acquisition unit acquires the treatment image showing the drying stage 21, the combustion stage 22, and the post-combustion stage 23, the first speed calculation unit 330 calculates the first speed correction value of each of the drying stage 21, the combustion stage 22, and the post-combustion stage 23, and the speed control unit 360 controls the speeds of the fire grates 61 of the drying stage 21, the combustion stage 22, and the post-combustion stage 23 based on the respective first speed correction values.

[0128]

A user of the combustion facility 100 can control the speed of the fire grate 61 based on the identified burnout point Z, and thus the incineration object 400 can be stably dried, burned, and post-burned in the combustion facility 100.

[0129]

(3) The control device 300 for the combustion facility 100 further includes: a first air amount calculation unit 340 calculating a first air amount correction value as a correction value of the amount of air supplied to each of the sections based on the burnout point Z; and an air amount control unit 370 controlling the amount of the air supplied to each of the sections by

the wind box 2 based on the first air amount correction value.

[0130]

A user of the combustion facility 100 can control the wind box 2 based on the identified burnout point Z, and thus the incineration object 400 can be stably dried, burned, and post-burned in the combustion facility 100.

[0131]

(4) The control device 300 for the combustion facility 100 according to the present disclosure further includes: a load value identification unit 380 identifying a load value as a value indicating a load state of each of the sections based on at least one of a brightness of the treatment image, a moisture amount of the incineration object 400, and a lower heating value of the incineration object 400; a second speed calculation unit 381 calculating a second speed correction value as a correction value of the speed of the fire grate 61 of each of the sections based on a difference between a preset value and the load value; and a second speed control unit 383 controlling the speed of the fire grate 61 of each of the sections based on the second speed correction value.

[0132]

A user of the combustion facility 100 can control the speed of the fire grate 61 based on the identified

load value, and thus the incineration object 400 can be stably burned in the combustion facility 100.

[0133]

(5) The control device 300 for the combustion facility 100 according to the present disclosure further includes: a second air amount calculation unit 382 calculating a second air amount correction value as a correction value of the amount of air supplied to each of the sections by the wind box 2 based on the difference between the preset value and the load value; and a second air amount control unit 384 controlling the amount of the air supplied to each of the sections by the wind box 2 based on the second air amount correction value.

[0134]

A user of the combustion facility 100 can control the wind box 2 based on the identified load value, and thus the incineration object 400 can be stably burned in the combustion facility 100.

[0135]

(6) The control device 300 for combustion facility 100 according to the embodiment of the present disclosure, in which the combustion facility 100 further includes the secondary air line L2 for air supply from above the fire grate 61, and the control device 300 further includes: an amount identification unit 385 identifying the amount of

the incineration object 400 that has flowed into the section based on the treatment image; an amount determination unit 386 determining whether or not the identified amount is equal to or more than a preset value; and a secondary air control unit 387 controlling the amount of the air supplied by the secondary air line L2 based on a content of the determination.

[0136]

A user of the combustion facility 100 can control the amount of air supplied from the secondary air line L2 based on the amount of the incineration object 400 as well and can stably maintain the combustion state of the incineration object 400 burned using the air.

[0137]

(7) The control device 300 for the combustion facility 100 according to the present disclosure further includes: a model storage unit 391 storing a trained model trained by supervised learning using a data set of an input sample including the burnout point Z and the speed of the fire grate 61 of each of the sections and an output sample including a steam flow rate attributable to drying in the incineration object 400; a candidate generation unit 392 generating candidates for the speeds of the fire grates 61 of the sections; and a flow rate calculation unit 393 performing steam flow rate calculation by

inputting the burnout point Z and the candidate for the speed of the fire grate 61 of each of the sections to the trained model, in which the first speed calculation unit 330 calculates the first speed correction value based on the candidate as one of the speed candidates generated by the candidate generation unit 392 in which a difference between a measured steam flow rate value and a value of the steam flow rate calculated by the flow rate calculation unit 393 is small.

[0138]

A user of the combustion facility 100 can control the speed of the fire grate 61 using the trained model generated with the input sample including the burnout point Z and the speed of the fire grate 61 of each section and can stably perform combustion in the combustion facility 100.

[0139]

(8) The control device 300 for combustion facility 100 according to the embodiment of the present disclosure, in which the combustion facility 100 further includes the secondary air line L2 for air supply from above the fire grate 61, and the control device 300 further includes: a flame identification unit 394 identifying a position of the flame F based on the treatment image; a temperature identification unit 395 identifying a temperature of the

incineration object 400 in the section based on the treatment image; a secondary air calculation unit 396 calculating the amount of the secondary air and a supply angle of the secondary air at which a difference between the temperature and a preset value is minimum based on the position of the flame F; and a second secondary air control unit 397 controlling the secondary air line L2 based on the calculated amount and supply angle.

[0140]

A user of the combustion facility 100 can control the amount and supply angle of the secondary air using the position of the flame F, and thus the user can change the mode of the flame F to approach the drying stage 21 and can stably treat the incineration object 400 in the section.

[0141]

(9) A combustion facility control method according to the present disclosure is a method for controlling a control device 300 for a combustion facility 100 including a furnace main body 10 defining a treatment space V, a fire grate 61 transporting an incineration object 400 in a transport direction Da in the treatment space V, and a wind box 2 supplying air to the treatment space V. The combustion facility control method includes: a step of acquiring a treatment image showing sections resulting

from partitioning the treatment space V in the transport direction Da; a step of identifying a burnout point Z as a rear end in the transport direction of a flame F caused by combustion of the incineration object 400 based on the treatment image; a step of calculating a first speed correction value as a correction value of a speed of the fire grate 61 of the section based on the burnout point Z; and a step of controlling the speed of the fire grate 61 of the section based on the first speed correction value.

[0142]

A user of the method for controlling the combustion facility 100 can control the speed of the fire grate 61 based on the identified burnout point Z, and thus the incineration object 400 can be stably burned in the combustion facility 100.

[0143]

(10) A program for the combustion facility 100 according to the present disclosure is a program for causing a computer of a control device 300 for the combustion facility 100 including a furnace main body 10 defining a treatment space V, a fire grate 61 transporting an incineration object 400 in a transport direction Da in the treatment space V, and a wind box 2 supplying air to the treatment space V to execute: a step of acquiring a treatment image showing sections resulting from

partitioning the treatment space V in the transport direction Da; a step of identifying a burnout point Z as a rear end in the transport direction of a flame F caused by combustion of the incineration object 400 based on the treatment image; a step of calculating a first speed correction value as a correction value of a speed of the fire grate 61 of the section based on the burnout point Z; and a step of controlling the speed of the fire grate 61 of the section based on the first speed correction value.

[0144]

A user of the program for the combustion facility 100 can control the speed of the fire grate 61 based on the identified burnout point Z, and thus the incineration object 400 can be stably burned in the combustion facility 100.

[Industrial Applicability]

[0145]

According to the combustion facility control device, the combustion facility control method, and the program of the present disclosure, it is possible to stably incinerate an incineration object in a combustion facility.

[Reference Signs List]

[0146]

1 stoker furnace

2 wind box

3 hopper

4 gas circulation portion

6 stoker

7 furnace

8 waste heat recovery boiler

9 temperature reduction tower

10 furnace main body

11 dust collector

12 chimney

13 discharge chute

21 drying stage

22 combustion stage

23 post-combustion stage

31 feeder

61 fire grate

61A fixed fire grate

61B movable fire grate

100 combustion facility

300 control device

310 acquisition unit

320 point identification unit

330 first speed calculation unit

340 first air amount calculation unit

350 flow rate concentration calculation unit

360 speed control unit

370 air amount control unit

379 determination unit

380 load value identification unit

381 second speed calculation unit

382 second air amount calculation unit

383 second speed control unit

384 second air amount control unit

385 amount identification unit

386 amount determination unit

387 secondary air control unit

390 model generation unit

391 model storage unit

392 candidate generation unit

393 flow rate calculation unit

394 flame identification unit

395 temperature identification unit

396 secondary air calculation unit

397 second secondary air control unit

400 incineration object

1100 computer

1110 processor

1120 main memory

1130 storage

1140 interface

L1 primary air line

L2 secondary air line

B1 blower

F flame

Z burnout point

Claims

[Claim 1]

A control device for a combustion facility including a furnace main body defining a treatment space, a fire grate transporting an incineration object in a transport direction in the treatment space, and a wind box supplying air to the treatment space, the combustion facility control device comprising:

an image acquisition unit acquiring a treatment image showing sections resulting from partitioning the treatment space in the transport direction;

a point identification unit identifying a burnout point as a rear end in the transport direction of a flame caused by combustion of the incineration object based on the treatment image;

a first speed calculation unit calculating a first speed correction value as a correction value of a speed of the fire grate of the section based on the burnout point;

a speed control unit controlling the speed of the fire grate of the section based on the first speed correction value;

a load value identification unit identifying a load value as a value indicating a load state of each of the sections based on a brightness of the treatment image;

a second speed calculation unit calculating a second speed correction value as a correction value of the speed of the fire grate of each of the sections based on a difference between a preset value and the load value; and

a second speed control unit controlling the speed of the fire grate of each of the sections based on the second speed correction value.

[Claim 2]

The combustion facility control device according to Claim 1, wherein

the sections resulting from partitioning the treatment space are a drying stage, a combustion stage, and a post-combustion stage from an upstream side in the transport direction,

the image acquisition unit acquires the treatment image showing the drying stage, the combustion stage, and the post-combustion stage,

the first speed calculation unit calculates the first speed correction value of each of the drying stage, the combustion stage, and the post-combustion stage, and

the speed control unit controls the speeds of the fire grates of the drying stage, the combustion stage, and the post-combustion stage based on the respective first speed correction values.

[Claim 3]

The combustion facility control device according to Claim 1 or 2, further comprising:

a first air amount calculation unit calculating a first air amount correction value as a correction value of the amount of air supplied to each of the sections based on the burnout point; and

an air amount control unit controlling the amount of the air supplied to each of the sections by the wind box based on the first air amount correction value.

[Claim 4]

The combustion facility control device according to Claim 3, further comprising:

a second air amount calculation unit calculating a second air amount correction value as a correction value of the amount of air supplied to each of the sections by the wind box based on the difference between the preset value and the load value; and

a second air amount control unit controlling the amount of the air supplied to each of the sections by the wind box based on the second air amount correction value.

[Claim 5]

The combustion facility control device according to Claim 1 or 2, wherein the combustion facility further includes a secondary air line supplying air from above the fire grate, and the combustion facility control device further comprises:

an amount identification unit identifying the amount of the incineration object that has flowed into the section based on the treatment image;

an amount determination unit determining whether or not the identified amount is equal to or more than a preset value; and

a secondary air control unit controlling the amount of the air supplied by the secondary air line based on a content of the determination.

[Claim 6]

The combustion facility control device according to Claim 1 or 2, further comprising:

a model storage unit storing a trained model trained by supervised learning using a data set of an input sample including the burnout point and the speed of the fire grate of each of the sections and an output sample including a steam flow rate attributable to drying in the incineration object;

a candidate generation unit generating candidates for the speeds of the fire grates of the sections; and

a flow rate calculation unit performing steam flow rate calculation by inputting the burnout point and the candidate for the speed of the fire grate of each of the sections to the trained model,

wherein the first speed calculation unit calculates the first speed correction value based on the candidate as one of the speed candidates generated by the candidate generation unit in which a difference between a measured steam flow rate value and a value of the steam flow rate calculated by the flow rate calculation unit is small.

[Claim 7]

The combustion facility control device according to Claim 1 or 2, further comprising:

a secondary air line supplying secondary air from above the fire grate;

a flame identification unit identifying a position of the flame based on the treatment image;

a temperature identification unit identifying a temperature of the incineration object in the section based on the treatment image;

a secondary air calculation unit calculating the amount of the secondary air and a supply angle of the air

at which a difference between the temperature and a preset value is minimum based on the position of the flame; and

a second secondary air control unit controlling the secondary air line based on the calculated amount and supply angle.

[Claim 8]

A method for controlling a control device for a combustion facility including a furnace main body defining a treatment space, a fire grate transporting an incineration object in a transport direction in the treatment space, and a wind box supplying air to the treatment space, the combustion facility control method comprising:

a step of acquiring a treatment image showing sections resulting from partitioning the treatment space in the transport direction;

a step of identifying a burnout point as a rear end in the transport direction of a flame caused by combustion of the incineration object based on the treatment image;

a step of calculating a first speed correction value as a correction value of a speed of the fire grate of the section based on the burnout point;

a step of controlling the speed of the fire grate of the section based on the first speed correction value;

a step of identifying a load value as a value indicating a load state of each of the sections based on a brightness of the treatment image;

a step of calculating a second speed correction value as a correction value of the speed of the fire grate of each of the sections based on a difference between a preset value and the load value; and

a step of controlling the speed of the fire grate of each of the sections based on the second speed correction value.

[Claim 9]

A program for causing a computer of a control device for a combustion facility including a furnace main body defining a treatment space, a fire grate transporting an incineration object in a transport direction in the treatment space, and a wind box supplying air to the treatment space to execute:

a step of acquiring a treatment image showing sections resulting from partitioning the treatment space in the transport direction;

a step of identifying a burnout point as a rear end in the transport direction of a flame caused by combustion of the incineration object based on the treatment image;

a step of calculating a first speed correction value as a correction value of a speed of the fire grate of the section based on the burnout point;

a step of controlling the speed of the fire grate of the section based on the first speed correction value;

a step of identifying a load value as a value indicating a load state of each of the sections based on a brightness of the treatment image;

a step of calculating a second speed correction value as a correction value of the speed of the fire grate of each of the sections based on a difference between a preset value and the load value; and

a step of controlling the speed of the fire grate of each of the sections based on the second speed correction value.