

DESCRIPTION

Title of Invention

SYSTEM FOR COMBUSTION EQUIPMENT AND COMBUSTION CONTROL METHOD

[Technical Field]

[0001]

The present disclosure relates to a system for combustion equipment and a combustion control method. Priority is claimed to Japanese Patent Application No. 2023-087635, filed May 29, 2023, the content of which is incorporated herein by reference.

[Background Art]

[0002]

Patent Document 1 discloses a waste incinerator including a plurality of temperature detection means disposed at positions between high-temperature gas blowout ports adjacent to each other within a range from a drying fire grate to a post-combustion fire grate in a furnace length direction, a position of a frontmost high-temperature gas blowout port, and a position of a rearmost high-temperature gas blowout port, and a combustion point position determination means for determining a position of temperature detection means indicating a highest temperature among the plurality of temperature detection means as a combustion point.

[Citation List]

[Patent Document]

[0003]

[Patent Document 1] Japanese Unexamined Patent Application Publication
No. 2015-187514

[Summary of Invention]

[Technical Subject]

[0004]

However, in the waste incinerator described in Patent Document 1, it is necessary to install new equipment (for example, a plurality of temperature detection means) in the incinerator in order to detect the state of the flame, and it becomes difficult to suppress the increase in manufacturing costs.

[0005]

The present disclosure is made to solve the above-described subject, and an object of the present disclosure is to provide a system for combustion equipment and a combustion control method capable of performing appropriate combustion control while suppressing an increase in manufacturing costs.

[Subject to be solved]

[0006]

In order to solve the above-described subject, a system for combustion equipment according to the present disclosure includes a flame information derivation unit that derives a value related to a position or a shape of a flame in an incinerator by using a soft sensor that uses, as input information, one or more pieces of information among information on a temperature in the incinerator, a supply amount of an object to be incinerated, calories of the object to be incinerated, moisture content of the object to be incinerated, a conveyance speed of the object to be incinerated, a supply of combustion air, a temperature of the combustion air, components in an exhaust gas, and an image obtained by imaging an inside of the incinerator, and a control unit that

performs combustion control on the incinerator on the basis of the value related to the position or the shape of the flame derived by the flame information derivation unit.

[0007]

A combustion control method according to the present disclosure includes, by one or more computers, deriving a value related to a position or a shape of a flame in an incinerator by using a soft sensor that uses, as input information, one or more pieces of information among information on a temperature in the incinerator, a supply amount of an object to be incinerated, calories of the object to be incinerated, moisture content of the object to be incinerated, a conveyance speed of the object to be incinerated, a supply of combustion air, a temperature of the combustion air, components in an exhaust gas, and an image obtained by imaging an inside of the incinerator, and performing combustion control on the incinerator on the basis of the derived value related to the position or the shape of the flame.

[Advantageous Effects of Invention]

[0008]

According to the system for combustion equipment and the combustion control method of the present disclosure, it is possible to perform appropriate combustion control while suppressing an increase in manufacturing costs.

[Brief Description of Drawings]

[0009]

FIG. 1 is a schematic configuration diagram for describing an incineration equipment of a first embodiment of the present disclosure.

FIG. 2 is a schematic configuration diagram for describing a storage unit of the first embodiment of the present disclosure.

FIG. 3 is a plan view for describing the storage unit of the first embodiment of

the present disclosure.

FIG. 4 is a block diagram showing a functional configuration of the incineration equipment of the first embodiment of the present disclosure.

FIG. 5 is a diagram for describing a value related to a flame of the first embodiment of the present disclosure.

FIG. 6 is a diagram for describing generation of a soft sensor of the first embodiment of the present disclosure.

FIG. 7 is a flowchart showing a flow of a learning stage of the first embodiment of the present disclosure.

FIG. 8 is a diagram showing a control example based on a center of gravity position of the flame of the first embodiment of the present disclosure.

FIG. 9 is a flowchart showing a control flow of the first embodiment of the present disclosure.

FIG. 10 is a diagram for describing a case where the center of gravity position of the flame is biased to the furnace back side in the present disclosure.

FIG. 11 is a diagram for describing a control example of the second embodiment of the present disclosure.

FIG. 12 is a diagram for describing a control example of the third embodiment of the present disclosure.

FIG. 13 is a block diagram showing a functional configuration of an incineration equipment of a fourth embodiment of the present disclosure.

FIG. 14 is a diagram for describing a control example of the fourth embodiment of the present disclosure.

FIG. 15 is a hardware configuration diagram showing a computer configuration of an embodiment of the present disclosure.

[Description of Embodiments]

[0010]

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

[0011]

In the present application, “acquire” is not limited to a case where the information is actively acquired by transmitting a transmission request, and may also include a case where the information is acquired by passively receiving the information transmitted from another apparatus. In addition, “acquisition” is not limited to a case where the target information (information to be acquired) is directly acquired from the outside, and may also include a case where the target information is generated and acquired by performing calculation or processing on the information obtained from the outside.

[0012]

In addition, in the embodiments described below, for the sake of convenience of description, a side where the furnace body 30 is located with respect to a hopper 21

to be described later is defined as “back”, and an opposite side is defined as “front”. In the following description, for the sake of convenience of description, the “front side” may be referred to as a “furnace front side” and the “rear side” may be referred to as a “furnace back side”. In addition, “left” and “right” are defined with reference to a direction from the hopper 21 toward the furnace body 30.

[0013]

(First Embodiment)

<1. Overall Configuration of Incineration Equipment>

FIG. 1 is a schematic configuration diagram for describing an incineration equipment 1. The incineration equipment 1 is, for example, a stoker furnace in which an object S to be incinerated is, for example, municipal garbage, industrial waste, or biomass. The incineration equipment 1 is not limited to a stoker furnace, and may be another type of incineration equipment. In the following description, for the sake of convenience of description, the “object to be incinerated” may be referred to as “waste”. The incineration equipment 1 includes, for example, a storage unit 2 (refer to FIG. 2), an incinerator 3, a heat recovery steam generator 4, a temperature reduction tower 5, a dust collector 6, a flue 7, a chimney 8, and a control device 100.

[0014]

The storage unit 2 temporarily stores the collected object S to be incinerated. The incinerator 3 is a furnace that combusts the object S to be incinerated charged from the storage unit 2 while transporting the object S to be incinerated. The incinerator 3 generates exhaust gas as a result of combustion of the object S to be incinerated in the incinerator 3. The generated exhaust gas is fed to the heat recovery steam generator 4 provided in an upper portion of the incinerator 3. The heat recovery steam generator 4 heats water by exchanging heat between the exhaust gas

generated in the incinerator 3 and the water, and generates steam. The exhaust gas passing through the heat recovery steam generator 4 is cooled at the temperature reduction tower 5, and thereafter, is fed to the dust collector 6. The exhaust gas is discharged to an atmosphere through the flue 7 and the chimney 8 after soot or dust is removed by the dust collector 6.

[0015]

<2. Storage Unit>

First, the storage unit 2 will be described in detail.

FIG. 2 is a schematic configuration diagram for describing the storage unit 2. The storage unit 2 is an equipment that temporarily stores the collected object S to be incinerated and charges the stored object S to be incinerated into the incinerator 3. The storage unit 2 includes, for example, a waste pit 11, one or more cranes 12, and a camera 13.

[0016]

(Waste Pit)

The waste pit 11 is a housing part that is provided in front of the incinerator 3 and in which the object S to be incinerated before being put into the incinerator 3 is temporarily stored.

[0017]

FIG. 3 is a plan view for describing the storage unit 2. The waste pit 11 includes, for example, a plurality of regions R. In the present embodiment, a first storage area A11 is set for one or more regions R. In addition, a second storage area A12 is set for one or more other regions R. The first storage area A11 is an area where the object S to be incinerated having relatively low calories (hereinafter, referred to as a “low-calorie object S1 to be incinerated”) is stored. On the other

hand, the second storage area A12 is an area where the object S to be incinerated having relatively high calories (hereinafter, referred to as a “high-calorie object S2 to be incinerated”) is stored.

[0018]

Here, whether the object S to be incinerated is the low-calorie object S1 to be incinerated or the high-calorie object S2 to be incinerated may be classified, for example, based on a collection destination of the object S to be incinerated by a packer truck, or may be classified by imaging the object S to be incinerated brought into the waste pit 11 with the camera 13 and performing image diagnosis, or may be classified by other methods. The setting of the first storage area A11 and the second storage area A12 is not limited to the example shown in FIG. 3.

[0019]

(Crane)

The crane 12 is provided on a ceiling of the storage unit 2. The crane 12 is driven based on a control instruction from a control unit 130 to be described later. For example, in a case where the new object S to be incinerated is brought into the waste pit 11 from the packer truck, the object S to be incinerated is moved to the first storage area A11 in a case where the object S to be incinerated that has been brought in is the low-calorie object S1 to be incinerated, and the object S to be incinerated is moved to the second storage area A12 in a case where the object S to be incinerated that has been brought in is the high-calorie object S2 to be incinerated, based on a control instruction (for example, a determination result indicating whether the object S to be incinerated that has been brought in is the low-calorie object S1 to be incinerated or the high-calorie object S2 to be incinerated) from the control unit 130.

[0020]

In addition, in a case where the crane 12 receives a control instruction to charge the object S to be incinerated stored in the waste pit 11 into the hopper 21 of the incinerator 3 from the control unit 130, the crane 12 moves to a region R that is a gripping destination of the object S to be incinerated in the waste pit 11, grips the object S to be incinerated in region R that is the gripping destination, and charges the gripped object S to be incinerated into the hopper 21. In the present embodiment, in a case where the crane 12 receives a control instruction to charge the low-calorie object S1 to be incinerated from the control unit 130, the crane 12 grips the low-calorie object S1 to be incinerated from the region R included in the first storage area A11 and charges the low-calorie object S1 to be incinerated into the hopper 21. On the other hand, in a case where the crane 12 receives a control instruction to charge the high-calorie object S2 to be incinerated from the control unit 130, the crane 12 grips the high-calorie object S2 to be incinerated from the region R included in the second storage area A12 and charges the high-calorie object S2 to be incinerated into the hopper 21.

[0021]

In the above description, an example has been described in which the object S to be incinerated is classified into two types according to the calories of the object S to be incinerated in the present embodiment. The classification according to the calories of the object S to be incinerated may be three or more types. From another viewpoint, the object S to be incinerated may not be classified according to the calories.

[0022]

<3. Incinerator>

Next, the incinerator 3 will be described in detail with reference to FIG. 1.

For example, the incinerator 3 includes a supply mechanism 20, a furnace body 30, a stoker 40, a discharge chute 43, a plurality of wind boxes 50, a furnace 60, and a blowing mechanism 70.

[0023]

<3.1 Supply Mechanism>

The supply mechanism 20 is a mechanism that temporarily stores the object S to be incinerated carried by the crane 12 and sequentially supplies the object S to be incinerated toward a treatment space V of the furnace body 30 to be described later. The supply mechanism 20 includes, for example, a hopper 21, a feeder 22, an extrusion device 23 (refer to FIG. 4), a moisture meter 24, and a water sprinkler device 25.

[0024]

(Hopper)

The hopper 21 is a storage unit provided to supply the object S to be incinerated into the furnace body 30. The hopper 21 has an inlet portion for charging the object S to be incinerated and an outlet portion leading to the treatment space V of the furnace body 30 to be described later. The object S to be incinerated carried by the crane 12 is charged into the hopper 21.

[0025]

(Feeder)

The feeder 22 is provided at the bottom portion of the hopper 21. The feeder 22 is formed in, for example, a plate shape along the bottom portion of the hopper 21. The feeder 22 is driven by the extrusion device 23 and is capable of reciprocating along a direction from the hopper 21 toward the treatment space V of the furnace body 30. The feeder 22 is driven by the extrusion device 23 and extrudes the object S to be

incinerated accumulated in the hopper 21 toward the treatment space V of the furnace body 30.

[0026]

(Moisture Meter)

The moisture meter 24 is a measurement instrument that detects information on moisture content of the object S to be incinerated charged into the hopper 21 (for example, a moisture percentage or a moisture amount). For example, the moisture meter 24 has an irradiation unit and a detection unit provided in the hopper 21, and an analysis unit. The irradiation unit irradiates the object S to be incinerated accumulated in the hopper 21 with electromagnetic waves in a predetermined frequency band. The detection unit receives the electromagnetic waves emitted from the irradiation unit and transmitted through the object S to be incinerated or reflected by the object S to be incinerated. For example, the analysis unit stores in advance correlation information indicating a relationship between a change in the characteristics of electromagnetic waves (for example, a change in amplitude or a change in phase) and the moisture percentage. The analysis unit detects the moisture percentage of the object S to be incinerated based on the change in the characteristics of electromagnetic waves between the irradiation unit and the detection unit, and the correlation information. The moisture meter 24 may detect the moisture amount of the object S to be incinerated based on the moisture percentage and the weight of the object S to be incinerated charged into the hopper 21.

[0027]

(Water Sprinkler Device)

The water sprinkler device 25 is a device that adjusts the moisture content of the object S to be incinerated by performing the water sprinkling on the object S to be

incinerated. The water sprinkler device 25 is provided in the hopper 21, for example. In a case where the moisture content of the object S to be incinerated is adjusted, the water sprinkler device 25 sprinkles water on the object S to be incinerated in the hopper 21 based on a control instruction from a control unit 130 to be described later.

[0028]

<3.2 Furnace Body>

The furnace body 30 is equipment that is provided adjacent to the hopper 21 and combusts the object S to be incinerated while transporting the object S to be incinerated. Hereinafter, a direction in which the object S to be incinerated is transported in the combustion equipment 1 is referred to as a “transport direction D”. The transport direction D may be referred to as a “depth direction”.

[0029]

The furnace body 30 includes a drying stage 30a, a combustion stage 30b, and a post-combustion stage 30c in this order from an upstream side toward a downstream side in the transport direction D. The drying stage 30a is a region that is located upstream of the combustion stage 30b and the post-combustion stage 30c and in which the object S to be incinerated supplied from the hopper 21 is dried prior to combustion on the stoker 40. The combustion stage 30b and the post-combustion stage 30c are regions where the object S to be incinerated in a dried state that has passed through the drying stage 30a is combusted on the stoker 40. In the combustion stage 30b, diffusion combustion occurs due to a pyrolysis gas generated from the object S to be incinerated, and a flame F is generated. In the post-combustion stage 30c, fixed carbon combustion occurs after the diffusion combustion of the object S to be incinerated, and thus the flame F is not generated.

[0030]

(Furnace Temperature Sensor)

The furnace body 30 includes, for example, a furnace temperature sensor 31. The furnace temperature sensor 31 is, for example, a thermocouple, and detects the temperature inside the furnace body 30. In the present embodiment, only one furnace temperature sensor 31 is provided as a temperature sensor that detects the temperature inside the furnace body 30. The temperature inside the furnace body 30 is an example of the “temperature in the incinerator”. The furnace temperature sensor 31 may be provided in the furnace 60 or at another location instead of or in addition to the furnace body 30. The temperature detected in the furnace 60 or at another location is another example of the “temperature in the incinerator”.

[0031]

(Camera)

The furnace body 30 includes, for example, a visible light camera 32 and an infrared camera 33. The visible light camera 32 and the infrared camera 33 image the inside of the furnace body 30. For example, the visible light camera 32 and the infrared camera 33 are provided at an end portion on the downstream side of the furnace body 30 in the transport direction D (hereinafter, referred to as a “furnace back end”), and image the upstream side in the transport direction D from the furnace back end.

[0032]

The visible light camera 32 images the flame F, for example. The infrared camera 33 images, for example, the object S to be incinerated (waste layer) accumulated in the drying stage 30a of the furnace body 30 through the flame F. In addition, the infrared camera 33 may image the outlet portion of the hopper 21 instead of or in addition to the object S to be incinerated accumulated in the drying stage 30a.

That is, the infrared camera 33 may capture an image including the object S to be incinerated accumulated on the feeder 22 (image showing an accumulation state of the object S to be incinerated) at the outlet portion of the hopper 21. The imaging results of the visible light camera 32 and the infrared camera 33 are transmitted to the control device 100. The imaging result of the visible light camera 32 or the infrared camera 33 is an example of an “image obtained by imaging an inside of the incinerator”.

[0033]

The infrared camera 33 may be configured by, for example, a plurality of infrared cameras disposed in a stereo manner. In addition, the visible light camera 32 and the infrared camera 33 may be provided at another position (the left side wall or the right side wall of the furnace body 30) instead of the furnace back end of the furnace body 30. In addition, both or one of the visible light camera 32 and the infrared camera 33 may be omitted.

[0034]

<3.3 Stoker>

The stoker 40 includes a plurality of fire grates 41 and a fire grate drive device 42 (refer to FIG. 4). The plurality of fire grates 41 form a stoker surface 40a that serves as a bottom surface of the furnace body 30. The object S to be incinerated is supplied in a layered shape to the stoker surface 40a by the supply mechanism 20. The stoker surface 40a is provided over the drying stage 30a, the combustion stage 30b, and the post-combustion stage 30c which are described above. The plurality of fire grates 41 include a fixed fire grate and a movable fire grate. The fixed fire grate is fixed to an upper surface of the wind box 50 to be described later. The movable fire grate reciprocates along the transport direction D at a constant speed. In this manner, the object S to be incinerated on the movable fire grate and the fixed fire grate (on the

stoker surface 40a) is transported to the downstream side while the object S to be incinerated is stirred and mixed.

[0035]

<3.4 Discharge Chute>

The discharge chute 43 is a device that drops the object S to be incinerated completely combusted and turned into ash to an ash extrusion device located below the furnace body 30. The discharge chute 43 is provided in a furnace back end of the furnace body 30.

[0036]

<3.5 Wind Box>

The plurality of wind boxes 50 are provided below the stoker 40 and supply primary air for combustion into the furnace body 30 through the stoker 40. The primary air is an example of “combustion air”. In the present embodiment, the plurality of wind boxes 50 are disposed side by side in the transport direction D to correspond to, for example, the plurality of fire grates 41. Each wind box 50 is provided with a wind box pressure sensor 51 that detects a pressure in the wind box 50. The pressure in the wind box 50 corresponds to the pressure of the primary air supplied from the wind box 50 to the inside of the furnace body 30. The set of the detection result of each wind box pressure sensor 51 and/or the detection result of the plurality of wind box pressure sensors 51 is an example of “information on the supply of the combustion air”.

[0037]

<3.6 Furnace>

The furnace 60 extends upward from an upper portion of the furnace body 30. The furnace 60 is disposed above the fire grate 41, and the gas after combustion flows

into the furnace 60. That is, the exhaust gas generated by the combustion of the object S to be incinerated in the furnace body 30 flows to the heat recovery steam generator 4 through the furnace 60. The furnace 60 includes a front wall 60a located on a front side of a space through which the exhaust gas flows, and a rear wall 60b located on a rear side of the space through which the exhaust gas flows. The front wall 60a and the rear wall 60b extend in the vertical direction, for example.

[0038]

<3.7 Blowing Mechanism>

The blowing mechanism 70 supplies combustion air into the furnace body 30 and the furnace 60. The blowing mechanism 70 includes, for example, a blower 71, a primary air line 72, an air preheater 73, a secondary air line 74, a damper 75, and an air flow rate sensor 76.

[0039]

The blower 71 is a pressure blower that pumps the combustion air into the furnace body 30 and the furnace 60. For example, the blower 71 includes a first blower 71A and a second blower 71B. The first blower 71A pumps the primary air for combustion into the furnace body 30 (for example, the treatment space V) through the primary air line 72 and the plurality of wind boxes 50. The second blower 71B pumps the secondary air for combustion into the furnace 60 through the secondary air line 74. The secondary air is another example of the “combustion air”.

[0040]

The primary air line 72 connects the first blower 71A and the plurality of wind boxes 50. One or more (for example, a plurality of) primary air dampers 75A are provided in an intermediate portion of the primary air line 72. In the present embodiment, the plurality of primary air dampers 75A are provided to correspond to

the plurality of wind boxes 50 in a one-to-one manner. The primary air damper 75A changes a flow rate of the primary air flowing from the primary air line 72 into the wind box 50 corresponding to the primary air damper 75A, depending on an opening degree of the primary air damper 75A. In other words, the distribution amount of the primary air in the plurality of wind boxes 50 (which wind box 50 is preferentially supplied with the primary air into the furnace body 30) is changed by the opening degree of the plurality of primary air dampers 75A. The set of the opening degree of each primary air damper 75A and/or the opening degree of the plurality of primary air dampers 75A is another example of the “information on the supply of the combustion air”.

[0041]

The air preheater 73 is a heat exchanger that preheats the primary air pumped from the first blower 71A. For example, the air preheater 73 is provided in an intermediate portion of the primary air line 72. The air preheater 73 has a preheat temperature sensor 73a that detects the temperature of the preheated primary air. The detection result of the preheat temperature sensor 73a is another example of the “information on the temperature of the combustion air”.

[0042]

The secondary air line 74 connects the second blower 71B and the furnace 60. In the present embodiment, the secondary air line 74 has a first supply port 74a and a second supply port 74b. The first supply port 74a is open to the front wall 60a of the furnace 60, and supplies the secondary air from the front wall 60a of the furnace 60 to a space (exhaust gas flow path) in the furnace 60. On the other hand, the second supply port 74b is open to the rear wall 60b of the furnace 60, and supplies the secondary air from the rear wall 60b of the furnace 60 to a space (exhaust gas flow

path) in the furnace 60.

[0043]

One or more (for example, a plurality of) secondary air dampers 75B are provided in an intermediate portion of the secondary air line 74. In the present embodiment, the plurality of secondary air dampers 75B are provided to correspond to the plurality of supply ports (for example, the supply ports 74a and 74b) provided in the furnace 60 in a one-to-one manner. The distribution amount of the secondary air in the plurality of supply ports (for example, the supply ports 74a and 74b) (which supply port is preferentially supplied with the secondary air into the furnace 60) is changed by the opening degree of the secondary air damper 75B. The set of the opening degree of each secondary air damper 75B and/or the opening degree of the plurality of secondary air dampers 75B is another example of the “information on the supply of the combustion air”. In the following description, for the sake of convenience of description, the primary air damper 75A and the secondary air damper 75B will be collectively referred to as a “damper 75”.

[0044]

The air flow rate sensor 76 detects the flow rate of the combustion air supplied to the inside of the furnace body 30 and the furnace 60. The air flow rate sensor 76 includes, for example, a first air flow rate sensor 76A and a second air flow rate sensor 76B. The first air flow rate sensor 76A is provided in an intermediate portion of the primary air line 72 and detects the flow rate of the primary air supplied through the primary air line 72. The second air flow rate sensor 76B is provided in an intermediate portion of the secondary air line 74 and detects the flow rate of the secondary air supplied through the secondary air line 74. The detection result of each of the first air flow rate sensor 76A and the second air flow rate sensor 76B is another

example of the “information related to the supply of the combustion air”.

[0045]

<4. Gas Sensor>

Next, the gas sensor 81 will be described. The gas sensor 81 is a sensor that detects components in the exhaust gas. The gas sensor 81 can detect, for example, an oxygen concentration, a carbon monoxide concentration (unburned content), a carbon dioxide concentration, a NO_x concentration, or the like contained in the exhaust gas. The gas sensor 81 is provided in the flue 7, for example, but may be provided inside the chimney 8 or may be provided at another location. The detection result of the gas sensor 81 is an example of “information on the components in the exhaust gas”.

[0046]

<5. Control Device>

Next, the control device 100 will be described.

FIG. 4 is a block diagram showing a functional configuration of the incineration equipment 1. The control device 100 integrally controls the incineration equipment 1. For example, the control device 100 performs combustion control of the object S to be incinerated in the furnace body 30. In the present disclosure, “combustion control” means broadly control related to combustion of the object S to be incinerated, and means controlling one or more of, for example, the supply amount of the object S to be incinerated, the calories of the object S to be incinerated, the moisture content of the object S to be incinerated, a conveyance speed of the object S to be incinerated, the flow rate and/or the distribution amount of primary air, the temperature of the primary air, and the flow rate and/or the distribution amount of secondary air.

[0047]

In the present embodiment, the control device 100 includes, for example, an information acquisition unit 110, a flame information derivation unit 120, and a control unit 130. A device to be controlled by the control unit 130 (hereinafter, referred to as a “device VD to be controlled”) includes the crane 12, the extrusion device 23, the water sprinkler device 25, the fire grate drive device 42, the blower 71, the air preheater 73, the damper 75, and the like.

[0048]

<5.1 Information Acquisition Unit>

The information acquisition unit 110 acquires a detection result detected by various sensors provided in the incineration equipment 1. For example, the information acquisition unit 110 acquires a detection result of the camera 13 (information on the calories of the object S to be incinerated) provided in the storage unit 2, a detection result of the moisture meter 24 (information on the moisture content of the object S to be incinerated), a detection result of the furnace temperature sensor 31 (information on the temperature in the incinerator 3), an imaging result of the visible light camera 32 (information on a combustion flame viewed from the furnace back end), an imaging result of the infrared camera 33 (information on the waste layer), a detection result of each wind box pressure sensor 51 (information on the flow rate and/or the distribution amount of the primary air), a detection result of the preheat temperature sensor 73a (information on the temperature of the primary air (the temperature of the combustion air)), a detection result of the air flow rate sensor 76 (information on the flow rate of the combustion air), and a detection result of the gas sensor 81 (information on the components in the exhaust gas). Hereinafter, these are collectively referred to as “various types of detection information”.

[0049]

In addition, the information acquisition unit 110 acquires control information indicating the state of each device included in the device VD to be controlled from each device or the control unit 130. For example, the information acquisition unit 110 acquires control information indicating a gripping destination of the crane 12 in the waste pit 11 (information on the calories of the object S to be incinerated), control information indicating a driving state of the feeder 22 by the extrusion device 23 (information on the supply amount of the object S to be incinerated, for example, a moving speed and/or a stroke length of the feeder 22), control information indicating a driving state of the fire grate drive device 42 (information on the conveyance speed of the object S to be incinerated), control information indicating a driving amount of the blower 71 (information on the supply of the combustion air), control information indicating a heating amount of the air preheater 73 (information on the supply of the primary air), and control information indicating an opening degree of the damper 75 (information on the supply of the combustion air). Hereinafter, these are collectively referred to as “various types of control information”.

[0050]

<5.2 Flame Information Derivation Unit>

The flame information derivation unit 120 derives a value related to the position or the shape of the flame F in the incinerator 3, based on one or more pieces of information included in various types of information (various types of detection information and various types of control information described above) acquired by the information acquisition unit 110. In the present embodiment, the flame information derivation unit 120 derives a value related to the position or the shape of the flame F in the incinerator 3, based on one or more pieces of information among information on the temperature in the incinerator 3, the supply amount of the object S to be

incinerated, the calories of the object S to be incinerated, the moisture content of the object S to be incinerated, the conveyance speed of the object S to be incinerated, the supply of the combustion air, the temperature of the combustion air, the components in the exhaust gas, and an image obtained by imaging an inside of the incinerator 3.

[0051]

In the present embodiment, the flame information derivation unit 120 derives a value related to the position or the shape of the flame F in the incinerator 3 by using a soft sensor that uses, as input information, one or more pieces of information included in the various types of information described above. In the present disclosure, “soft sensor” means a sensor that can be treated as if a value is measured by estimating a value that is not actually measured through calculation. The details of the soft sensor of the present embodiment will be described in detail later.

[0052]

In the present embodiment, the flame information derivation unit 120 calculates a center of gravity position G of the flame F, a burnout position PE of the flame F as a value related to the position of flame F. Instead of or in addition to this, in a case where the transport direction D is referred to as a “depth direction”, the flame information derivation unit 120 may derive a width W of the flame F in the depth direction as a value related to the shape of the flame F. First, these contents will be described. However, the embodiments are not limited to the following examples.

[0053]

(Center of Gravity Position of Flame, Burnout Position, and Width in Depth Direction)

FIG. 5 is a diagram for describing values related to the position and the shape of the flame F.

(a) in FIG. 5 shows an example of an image IM1 captured by a furnace top camera 90 (refer to FIG. 1). The furnace top camera 90 is, for example, a special camera temporarily installed to collect information (for example, correct answer data for learning) necessary for generating a soft sensor, which will be described later.

[0054]

(b) in FIG. 5 shows an image IM2 in which a predetermined image processing (for example, binarization processing) is performed on the image IM1 to extract a region where the flame F is present. In the image IM2, an upstream end (end on the furnace front side) of a region where the flame F is present is a starting point PS of the flame F, and a downstream end (end on the furnace back side) of the region where the flame F is present is a burnout position PE of the flame F. Then, in the image IM2, the distance in the depth direction between the starting point PS and the burnout position PE of the flame F (the length of the flame F extending in the depth direction) corresponds to the “width W of the flame F in the depth direction”.

[0055]

(c) in FIG. 5 shows an image IM3 in which the center of gravity position G of the flame F is derived by performing a predetermined image processing (for example, processing using an image moment method) on the image IM2, and the derived center of gravity position G is superimposed on the image IM1. In the present disclosure, “center of gravity position of flame” refers to, for example, a coordinate obtained from the image moment method with respect to a coordinate at which the flame F is present as viewed from above the furnace, and indicates a center position of a location where the flame F is concentrated. The center of gravity position G of the flame F may be a value indicating the center position of the location where the flame F is concentrated, which is obtained by another calculation method.

[0056]

For example, in the image moment method, the center of gravity position G of the flame F is derived based on equation (1) shown below. In equation (1), M is a moment, and x and y are coordinate positions. In this case, the center of gravity position G of the flame F is obtained by (M_{10}/M_{00} , M_{01}/M_{00}).

[0057]

[Equation 1]

$$M_{nm} = \sum (x^n, y^m) \dots \text{Equation (1)}$$

[0058]

In the example shown in equation (1), a case where the center of gravity position G of the flame F is derived based on the image IM2 subjected to the binarization processing has been described. Instead of the above example, the center of gravity position G of the flame F may be obtained by the image moment method or the like that performs weighting on the brightness values included in the image IM1.

[0059]

Here, the center of gravity position G of the flame F may be different from the center position C of the width W of the flame F in the depth direction. The center position C is a position intermediate between the starting point PS and the burnout position PE of the flame F. For example, in a case where the concentration location of the flame F is biased to the furnace back side, the center of gravity position G of the flame F is located on the furnace back side with respect to the center position C of the flame F (refer to (c) in FIG. 5). On the other hand, in a case where the concentration location of the flame F is biased to the furnace front side, the center of gravity position G of the flame F is located on the furnace front side with respect to the center position

C of the flame F.

[0060]

(Soft Sensor)

Next, details of the soft sensor of the present embodiment will be described. In the present embodiment, the flame information derivation unit 120 derives (estimates) each value such as the center of gravity position G of the flame F, the burnout position PE, and the width W in the depth direction by using a soft sensor that performs regression analysis or deep learning with one or more pieces of information included in the various types of information described above as input information (explanatory variables). Hereinafter, a case where the prediction model M trained by deep learning is used will be described as an example. The prediction model M is an example of a “trained model”.

[0061]

FIG. 6 is a diagram for describing generation of the soft sensor. In addition, FIG. 7 is a flowchart showing a flow of the learning stage. First, the learning data including a plurality of images IM1 acquired in a time series is collected using the furnace top camera 90, various sensors, and the like (S101 in FIG. 7).

[0062]

Next, as shown in (a) in FIG. 6, the image processing described above is applied to the plurality of images IM1 acquired in the time series, and the center of gravity position G of the flame F in each image IM1 is obtained. Next, as shown in (b) in FIG. 6, the time change of the center of gravity position G is obtained by arranging the obtained center of gravity positions G of the flame F in the time series.

[0063]

Next, a correlation analysis is performed using the time change in the obtained

center of gravity position G of the flame F and the time change in various types of information (various types of detection information and various types of control information described above) acquired by the information acquisition unit 110, and a correlation coefficient between the center of gravity position G of the flame F and the various types of information acquired by the information acquisition unit 110 is calculated. In the correlation analysis, a time delay and/or a time advance between various types of information may be considered.

[0064]

Then, among various types of information acquired by the information acquisition unit 110, one or more pieces of information in which the calculated correlation coefficient satisfies a predetermined condition (for example, the calculated correlation coefficient is equal to or higher than a threshold value, or the calculated correlation coefficient is within a predetermined number when counted from the top) are extracted (selected) and determined as input information (explanatory variable) of the soft sensor (S102 in FIG. 7). The calculation of the correlation coefficient may be performed based on another index (for example, the burnout position PE of the flame F or the width W of the flame F in the depth direction) instead of or in addition to the center of gravity position G of the flame F.

[0065]

Next, the generation of the prediction model M used in the soft sensor is performed. In the present embodiment, the image processing described above is performed on the plurality of images IM1 acquired in the time series to obtain correct answer data of a value related to the position or the shape of the flame F (for example, the center of gravity position G of the flame F, the burnout position PE of the flame F, and the width W of the flame F in the depth direction). Then, for each of the plurality

of images IM1, the training data is generated by associating one or more pieces of information extracted as the input information (explanatory variable) with correct data of a value related to the position or the shape of the flame F (S103 in FIG. 7). Then, the prediction model M is generated by performing learning using the generated training data (S104 in FIG. 7). That is, the prediction model M that is trained to output a value related to the position or the shape of the flame F in a case where one or more pieces of information extracted as the input information are input is generated.

[0066]

Accordingly, the flame information derivation unit 120 inputs one or more pieces of information extracted as the input information to the prediction model M among various types of information acquired by the information acquisition unit 110 at a predetermined cycle, and outputs a value related to the position or the shape of the flame F (for example, the center of gravity position G of the flame F, the burnout position PE of the flame F, and the width W of the flame F in the depth direction) from the prediction model M, thereby deriving the information. In a case where the input information includes a plurality of pieces of information, a time delay and/or a time advance between various types of information may be taken into consideration in the input information.

[0067]

<5.3 Control Unit>

The control unit 130 performs combustion control on the incinerator 3 on the basis of the value related to the position or the shape of the flame F derived by the flame information derivation unit 120. For example, the control unit 130 performs control of one or more of the supply amount of the object S to be incinerated, the calories of the object S to be incinerated, the moisture content of the object S to be

incinerated, the conveyance speed of the object S to be incinerated, the supply amount and/or the distribution amount of the primary air, the temperature of the combustion air (for example, the temperature of the primary air), and the supply amount and/or the distribution amount of the secondary air, based on one or more of the center of gravity position G of the flame F, the burnout position PE of the flame F, and the width W of the flame F in the depth direction.

[0068]

In the present embodiment, the control unit 130 changes the supply amount of the object S to be incinerated by controlling the extrusion device 23 to change the moving speed or the stroke length of the feeder 22. The control unit 130 changes the calories of the object S to be incinerated by changing the gripping destination of the crane 12 in the waste pit 11. The control unit 130 changes the moisture content of the object S to be incinerated by performing the water sprinkling by the water sprinkler device 25. The control unit 130 changes the conveyance speed of the object S to be incinerated by controlling the fire grate drive device 42 to change the drive speed of the fire grate 41. The control unit 130 controls the blower 71 to change the flow rate of the primary air and/or the flow rate of the secondary air. The control unit 130 changes the temperature of the primary air by performing heating by the air preheater 73. The control unit 130 controls the distribution amount of the primary air and/or the distribution amount of the secondary air by controlling the opening degree of the damper 75.

[0069]

(Control Example in Case of Based on Center of Gravity Position of Flame)

In the present embodiment, the control unit 130 performs combustion control on the incinerator 3 on the basis of the center of gravity position G of the flame F

derived by the flame information derivation unit 120. For example, in a case where the center of gravity position G of the flame F derived by the flame information derivation unit 120 is different from a planned position (center of gravity planned position), the control unit 130 controls one or more of the supply amount of the object S to be incinerated, the calories of the object S to be incinerated, the moisture content of the object S to be incinerated, the conveyance speed of the object S to be incinerated, the flow rate and/or the distribution amount of the primary air, and the temperature of the combustion air (for example, the temperature of the primary air) such that the center of gravity position G of the flame F approaches the planned position. In the present disclosure, “planned position” is not limited to one position, and may be a planned position having a certain width in the depth direction. This definition is also the same in another control described below.

[0070]

For example, the control unit 130 performs combustion control on the incinerator 3 such that the center of gravity position G of the flame F approaches the planned position set to correspond to the center position (the center position between the front wall 60a and the rear wall 60b) in the transport direction D of the furnace 60 as viewed from above.

[0071]

For example, in a case where the center of gravity position G of the flame F is on the furnace back side with respect to the planned position, the control unit 130 performs one or more of reducing the supply amount of the object S to be incinerated (for example, reducing the moving speed of the feeder 22 or shortening the stroke length), reducing the calories of the object S to be incinerated (for example, changing the gripping destination of the crane 12 to charge the low-calorie object S1 to be

incinerated into the hopper 21), maintaining the low moisture content of the object S to be incinerated (for example, suppressing the water sprinkling by the water sprinkler device 25), reducing the conveyance speed of the object S to be incinerated (for example, reducing the drive speed of the fire grate 41), increasing the supply amount of the primary air (for example, increasing the drive amount of the first blower 71A), increasing the distribution amount of the primary air with respect to the position on the furnace front side (for example, increasing the opening degree of the primary air damper 75A corresponding to one or more wind boxes 50 located on the furnace front side), and increasing the preheating temperature by the air preheater 73, so that drying of the object S to be incinerated proceeds on the upstream side. On the other hand, in a case where the center of gravity position G of the flame F is on the furnace front side with respect to the planned position, the control unit 130 performs control opposite to the above-described content.

[0072]

FIG. 8 is a diagram showing a control example based on the center of gravity position G of the flame F. (a) in FIG. 8 shows a case where the center of gravity position G of the flame F is at the planned position. (b) in FIG. 8 shows a case where the flame F has moved to the furnace back side. In this case, the control unit 130 performs control for moving the center of gravity position G of the flame F to the furnace front side, such as reducing the supply amount of the object S to be incinerated. (c) in FIG. 8 shows a state where the flame F has returned to the planned position by the above control.

[0073]

(Control Example in Case of Based on Burnout Position of Flame)

In the present embodiment, the control unit 130 may perform combustion

control on the incinerator 3 on the basis of the burnout position PE of the flame F derived by the flame information derivation unit 120. For example, in a case where the burnout position PE derived by the flame information derivation unit 120 is different from the planned position (burnout planned position), the control unit 130 controls one or more of the supply amount of the object S to be incinerated, the calories of the object S to be incinerated, the moisture content of the object S to be incinerated, the conveyance speed of the incineration object S, the flow rate and/or the distribution amount of the primary air, and the temperature of the combustion air (for example, the temperature of the primary air) such that the burnout position PE approaches the planned position.

[0074]

For example, the control unit 130 performs combustion control on the incinerator 3 such that the burnout position PE of the flame F approaches a planned position set to correspond to a predetermined position in front of the rear wall 60b of the furnace 60 as viewed from above. The details of the control may be replaced with “burnout position PE” instead of “center of gravity position G” in the description of the control based on the center of gravity position G of the flame F described above.

[0075]

(Control Example in Case of Based on Width of Flame in Depth Direction)

In the present embodiment, the control unit 130 may perform the combustion control on the incinerator 3 on the basis of the width W of the flame F in the depth direction derived by the flame information derivation unit 120. For example, in a case where the width W of the flame F in the depth direction which is derived by the flame information derivation unit 120 is different from the planned width, the control unit 130 controls one or more of the supply amount of the object S to be incinerated,

the calories of the object S to be incinerated, the moisture content of the object S to be incinerated, the conveyance speed of the incineration object S, the flow rate and/or the distribution amount of the primary air, and the temperature of the combustion air (for example, the temperature of the primary air) such that the width W of the flame F in the depth direction is brought close to the planned width. In the present disclosure, “planned width” is not limited to one width, and may be a width having a range defined between an upper limit value and a lower limit value in the depth direction.

[0076]

For example, the control unit 130 performs combustion control on the incinerator 3 such that the width W of the flame F in the depth direction is brought close to a predetermined planned width set to be shorter than the length between the front wall 60a and the rear wall 60b of the furnace 60 as viewed from above.

[0077]

For example, in a case where the width W of the flame F in the depth direction is longer than the predetermined planned width, the control unit 130 performs one or more of reducing the supply amount of the object S to be incinerated (for example, reducing the moving speed of the feeder 22 or shortening the stroke length), reducing the calories of the object S to be incinerated (for example, changing the gripping destination of the crane 12 to charge the low-calorie object S1 to be incinerated into the hopper 21), maintaining the low moisture content of the object S to be incinerated (for example, suppressing the water sprinkling by the water sprinkler device 25), reducing the conveyance speed of the object S to be incinerated (for example, reducing the drive speed of the fire grate 41), increasing the supply amount of the primary air (for example, increasing the drive amount of the first blower 71A), increasing the distribution amount of the primary air with respect to the position on the furnace front

side (for example, increasing the opening degree of the primary air damper 75A corresponding to one or more wind boxes 50 located on the furnace front side), and increasing the preheating temperature by the air preheater 73. On the other hand, in a case where the width W of the flame F in the depth direction is shorter than the predetermined planned width, the control unit 130 performs control opposite to the above-described content.

[0078]

<6. Control Flow>

Next, a control flow will be described.

FIG. 9 is a flowchart showing a control flow of the first embodiment. In the present embodiment, the following flow is repeated at predetermined cycles.

[0079]

First, various types of information (for example, various types of detection information and various types of control information) are acquired by the information acquisition unit 110 (S201). Next, one or more pieces of information selected in advance from various types of information acquired by the information acquisition unit 110 are input to the prediction model M as input information (S202). In this manner, the position of the flame F (the center of gravity position G, the burnout position PE, and the like) and the shape of the flame F (the width W in the depth direction and the like) are derived by outputting from the prediction model M (S203).

[0080]

Next, the control unit 130 performs combustion control based on various values output from the prediction model M. In the present embodiment, the control unit 130 performs control based on two or more elements of the center of gravity position G of the flame F, the burnout position PE of the flame F, and the width W of

the flame F in the depth direction. In the present disclosure, “performing control based on two or more elements” may also include, for example, a case where a priority is set for the two or more elements, control is first performed based on a first element in a case where the first element having a high priority deviates from a reference, and control is performed based on a second element in a case where the second element having a low priority deviates from the reference although the first element does not deviate from the reference.

[0081]

In the example shown in FIG. 9, first, the control unit 130 determines whether or not the center of gravity position G of the flame F output from the prediction model M is the planned position (center of gravity position) (S204). In a case where the center of gravity position G of the flame F is not the planned position (S204: NO), the control unit 130 performs control to cause the center of gravity position G of the flame F to approach the planned position (S205). In this case, the control unit 130 waits for a predetermined time after the above control and returns to the process of S201. On the other hand, in a case where the center of gravity position G of the flame F is the planned position (S204: YES), the control unit 130 proceeds to the process of S206.

[0082]

Next, the control unit 130 determines whether or not the width W of the flame F in the depth direction output from the prediction model M is the planned width (S206). In a case where the width W of the flame F in the depth direction is not the planned width (S206: NO), the control unit 130 performs control to bring the width W of the flame F in the depth direction closer to the planned width (S207). In this case, the control unit 130 waits for a predetermined time after the above control and returns to the process of S201. On the other hand, in a case where the width W of the flame

F in the depth direction is the planned width (S206: YES), the control unit 130 proceeds to the process of S208.

[0083]

Next, the control unit 130 determines whether or not the burnout position PE of the flame F output from the prediction model M is the planned position (burnout planned position) (S208). In a case where the burnout position PE of the flame F is not the planned position (S208: NO), the control unit 130 performs control to cause the burnout position PE of the flame F to approach the planned position (S209). In this case, the control unit 130 waits for a predetermined time after the above control and returns to the process of S201. On the other hand, in a case where the burnout position PE of the flame F is the planned position (S208: YES), the control unit 130 waits for a predetermined time and returns to the process of S201.

[0084]

<7. Operation and Effect>

Here, as a comparative example, a combustion equipment is considered in which a plurality of temperature sensors are arranged in the depth direction of an incinerator, a burnout position of a flame is specified by a high or low temperature detected by the plurality of temperature sensors, and combustion control is performed based on the specified burnout position of the flame. In the configuration of the comparative example, first, it is necessary to install new equipment (a plurality of temperature sensors) in the incinerator, and it is difficult to suppress an increase in manufacturing cost. In addition, in a case where combustion control is performed by specifying only the burnout position of the flame as the state of the flame, the stabilization of the flame position or the stabilization of the exhaust gas component by precise control of the combustion may be insufficient.

[0085]

On the other hand, in the present embodiment, since the value related to the position or the shape of the flame is derived based on the soft sensor, it is possible to avoid installing special equipment (for example, a plurality of temperature sensors) in the incinerator. Therefore, the flame can be held at a position along the concept of the furnace while suppressing the increase in manufacturing cost. In addition, by ascertaining a flame state with the soft sensor, it is not necessary to add or modify the hardware, and the flame state can be realized with a simple structure. Therefore, even in a case where it is difficult to install the physical sensor due to a structure or a use environment, a flame position can be ascertained with the soft sensor. In addition, detection failure due to hardware failure is eliminated.

[0086]

In addition, two or more elements related to the position or the shape of the flame (for example, the center of gravity position G, the burnout position PE, and the width W in the depth direction) can be derived based on the soft sensor, and combustion control can be performed based on the two or more elements. For example, by using two types of elements such as a value related to the position of the flame F (for example, the center of gravity position G or the burnout position PE) and a value related to the shape of the flame F (for example, the width W in the depth direction), the entire structure of the flame F can be ascertained and control can be performed. Therefore, stabilization of the flame position and stabilization of exhaust gas components (for example, reduction of NO_x) can be easily achieved by precisely controlling the combustion.

[0087]

Here, an event in which the center of gravity position G of the flame F is

biased to the furnace back side will be described.

FIG. 10 is a diagram for describing a case where the center of gravity position G of the flame F is biased to the furnace back side. As shown in FIG. 10, in a case where the center of gravity position G of the flame F is biased to the furnace back side, as an event (a), the melted ash may adhere to the rear wall 60b of the furnace 60 to form a clinker K, and the clinker K may collapse onto the fire grate 41 to damage the fire grate 41. In addition, as an event (b), the refractory material of the rear wall 60b of the furnace 60 or the vicinity thereof may be exposed to a high temperature and may be damaged.

[0088]

Therefore, in the present embodiment, in a case where the flame information derivation unit 120 derives the center of gravity position G of the flame F, and the derived center of gravity position G of the flame F is different from the planned position, the combustion control is performed such that the center of gravity position G of the flame F approaches the planned position. According to such a configuration, in a case where the center of gravity position G of the flame F is biased to the furnace back side, the control is performed to move the center of gravity position G of the flame F to the upstream side, and it is possible to suppress the occurrence of the above-described event (a) and the above-described event (b).

[0089]

(Second Embodiment)

Next, a second embodiment will be described. The second embodiment is different from the first embodiment in that the control is performed by using different parameters for the center of gravity position G of the flame F and the width W of the flame F in the depth direction. The configurations other than those described below

are the same as the configurations of the first embodiment.

[0090]

In the present embodiment, the flame information derivation unit 120 derives the center of gravity position G of the flame F and the width W of the flame F in the depth direction. Then, the control unit 130 controls the center of gravity position G of the flame F by using one or more parameters (hereinafter, referred to as “parameters for controlling the center of gravity position”) related to the supply amount of the object S to be incinerated, the calories of the object S to be incinerated, the moisture content of the object S to be incinerated, the conveyance speed of the object S to be incinerated, the supply of the combustion air, and the temperature of the combustion air (for example, the temperature of the primary air). On the other hand, the control unit 130 controls the width W of the flame F in the depth direction by using one or more parameters (hereinafter, referred to as “parameters for controlling the width in the depth direction”) related to the supply amount of the object S to be incinerated, the calories of the object S to be incinerated, the moisture content of the object S to be incinerated, the conveyance speed of the object S to be incinerated, the supply of the combustion air, and the temperature of the combustion air (for example, the temperature of the primary air), the one or more parameters being different from the parameters for controlling the center of gravity position.

[0091]

For example, in one combination example, an example of the parameters for controlling the center of gravity position is a supply speed or the conveyance speed of the object S to be incinerated, and an example of the parameters for controlling the width in the depth direction is the distribution amount of the primary air to the plurality of wind boxes 50. In another combination example, an example of the

parameters for controlling the center of gravity position is the calories of the object S to be incinerated, and an example of the parameters for controlling the width in the depth direction is a preheating temperature of the primary air. These are merely examples, and various combinations other than those described above are possible.

[0092]

FIG. 11 is a diagram for describing a control example of the second embodiment. (a) in FIG. 11 shows a state where the width W of the flame F in the depth direction is large and the center of gravity position G of the flame F is biased to the furnace back side. (b) in FIG. 11 shows a state where the width W in the depth direction is reduced by increasing the distribution amount of the primary air to the region on the upstream side in the furnace body 30 with respect to the state of (a) in FIG. 11 (a control example using the parameters for controlling the width in the depth direction). (c) in FIG. 11 shows a state where the center of gravity position G of the flame F is moved to the upstream side by controlling the supply speed of the object S to be incinerated (a driving state of the feeder 22) or the conveyance speed of the object S to be incinerated (a driving state of the fire grate 41) with respect to the state of (b) in FIG. 11.

[0093]

According to such a configuration, for example, it is possible to perform more flexible response to a plurality of elements, such as performing response to an element (for example, the center of gravity position G of the flame F) having a relatively high importance by using a parameter having a relatively high influence and performing response to an element (for example, the width W of the flame F in the depth direction) having a relatively low importance by using a parameter having a relatively low influence. In this manner, more appropriate combustion control can be realized.

[0094]

(Third Embodiment)

Next, a third embodiment will be described. The third embodiment is different from the first embodiment in that the supply of the combustion air is controlled in consideration of the components in the exhaust gas. The configurations other than those described below are the same as the configurations of the first embodiment.

[0095]

In the present embodiment, the control unit 130 controls the supply of the combustion air to the furnace body 30 of the incinerator 3 and/or the furnace 60 such that the combustion air (the primary air and/or the secondary air) is concentrated at the position (for example, the center of gravity position G or the center position C) of the flame F derived by the flame information derivation unit 120. For example, the control unit 130 controls one or more primary air dampers 75A such that the primary air is concentrated at the position of the flame F derived by the flame information derivation unit 120, thereby controlling the distribution amount of the primary air in the depth direction (for example, the distribution amount to the plurality of wind boxes 50). In addition, instead of or in addition to the example, the control unit 130 controls one or more secondary air dampers 75B such that the secondary air is concentrated at the position of the flame F derived by the flame information derivation unit 120, thereby controlling the distribution amount between the secondary air supplied to the furnace 60 from a first side (for example, the furnace front side) in the depth direction and the secondary air supplied to the furnace 60 from a second side (for example, the furnace back side) opposite to the first side in the depth direction.

[0096]

Hereinafter, an example of a case where the distribution amount of the secondary air is controlled will be described. In the present embodiment, in a case where the position (for example, the center of gravity position G or the center position C) of the flame F is located on the first side in the depth direction with respect to the predetermined position in the incinerator 3, the control unit 130 increases the flow rate of the secondary air supplied into the furnace 60 from the second side opposite to the first side, as compared with the flow rate of the secondary air supplied into the furnace 60 from the first side. In one example, the “furnace front side” is an example of a “first side”, and the “furnace back side” is an example of a “second side”. In another example, the “furnace back side” may be an example of the “first side”, and the “furnace front side” may also be an example of the “second side”.

[0097]

FIG. 12 is a diagram for describing a control example of the third embodiment. (a) in FIG. 12 shows a state where the position of the flame F is at the planned position. In this case, the primary air damper 75A is controlled such that the distribution amount of the primary air to the wind box 50 located in the central region in the depth direction is increased. In addition, the secondary air damper 75B is controlled such that the distribution amount of the secondary air supplied into the furnace 60 from the secondary air supply port 74a on the furnace front side and the distribution amount of the secondary air supplied into the furnace 60 from the secondary air supply port 74b on the furnace back side are substantially equal to each other.

[0098]

(b) in FIG. 12 shows a state where the position of the flame F is biased to the furnace back side with respect to the state of (a) in FIG. 12. In this case, the primary air damper 75A is controlled such that the distribution amount of the primary air to the

wind box 50 located on the furnace back side is increased. In addition, the secondary air damper 75B is controlled such that the distribution amount of the secondary air supplied into the furnace 60 from the supply port 74a on the furnace front side is greater than the distribution amount of the secondary air supplied into the furnace 60 from the supply port 74b on the furnace back side (that is, the position where the secondary air from the furnace front side and the secondary air from the furnace back side are merged (the position where the supply amount of the secondary air is the greatest) is located on the furnace back side).

[0099]

(c) in FIG. 12 shows a state where the position of the flame F has returned to the planned position by performing predetermined control with respect to the state of (b) in FIG. 12. The predetermined control is, for example, control using a parameter different from the distribution amount of the primary air and/or the distribution amount of the secondary air, and is control related to one or more of the supply amount of the object S to be incinerated, the calories of the object S to be incinerated, the moisture content of the object S to be incinerated, and the conveyance speed of the object S to be incinerated.

[0100]

Then, in a case where the position of the flame returns to the state of (c) in FIG. 12, the primary air damper 75A is controlled such that the distribution amount of the primary air to the wind box 50 located in the central region in the depth direction is again increased. In addition, the secondary air damper 75B is controlled such that the distribution amount of the secondary air supplied into the furnace 60 from the supply port 74a on the furnace front side and the distribution amount of the secondary air supplied into the furnace 60 from the supply port 74b on the furnace back side are

again substantially equal to each other.

[0101]

According to such a configuration, in a case where the center of gravity position G of the flame F moves, the air distribution from the fire grate 41 in the vicinity of the center of gravity position G of the flame F can be increased, and the exhaust gas distribution flowing into the furnace 60 also moves accordingly. Therefore, the secondary air can be concentrated at the exhaust gas passing location by controlling the front and rear distribution of the secondary air. Accordingly, it is possible to suppress the insufficiency of air supply to a location where the incomplete combustion gas (CO) is excessively generated and/or to suppress the excessive air supply to a location where NO_x is excessively generated.

[0102]

(Fourth Embodiment)

Next, a fourth embodiment will be described. The fourth embodiment is different from the first embodiment in that the powder layer height (for example, the ash layer height of the object S to be incinerated) is acquired, and the control is performed based on the powder layer height and the position of the flame F. The configurations other than those described below are the same as the configurations of the first embodiment.

[0103]

FIG. 13 is a block diagram showing a functional configuration of the incineration equipment 1 of the fourth embodiment. In the present embodiment, the control device 100 includes the powder layer height derivation unit 140.

[0104]

(Powder Layer Height Derivation Unit)

The powder layer height derivation unit 140 derives a value of the powder layer height in the incinerator 3. For example, the powder layer height derivation unit 140 derives the powder layer height in the incinerator 3 by performing image processing on the image captured by the infrared camera 33. Instead, the powder layer height derivation unit 140 may estimate the powder layer height from the differential pressure between the wind box 50 and the inside of the furnace body 30, and may derive the powder layer height based on the measurement result measured from a peep window provided in the side wall of the furnace body. The value of the powder layer height derived by the powder layer height derivation unit 140 may be an actually measured value or an estimated value.

[0105]

(Control Based on Powder Layer Height and Position of Flame)

In the present embodiment, the control unit 130 performs combustion control based on a value related to the position of the flame F derived by the flame information derivation unit 120 and a value of a powder layer height derived by the powder layer height derivation unit 140, such that in a case where the position (for example, the center of gravity position G or the center position C) of the flame F is present in a region where the powder layer height is lower than the threshold value, the position (for example, the center of gravity position G or the center position C) of the flame is moved. For example, the control unit 130 controls one or more of the supply amount of the object S to be incinerated, the calories of the object S to be incinerated, the moisture content of the object S to be incinerated, the conveyance speed of the object S to be incinerated, and the supply of the combustion air such that the position of the flame F moves to a region where the powder layer height is equal to or higher than the threshold value.

[0106]

FIG. 14 is a diagram for describing a control example of the fourth embodiment. (a) in FIG. 14 shows a case where the position of the flame F is present in a region where the powder layer height is equal to or greater than the threshold value. (b) in FIG. 14 shows a state where the powder layer height decreases due to some factor and the position of the flame F is present in a region where the powder layer height is less than the threshold value. (c) in FIG. 14 shows a state where control is performed such that the position of the flame F is moved to the region where the powder layer height is equal to or higher than the threshold value with respect to (b) in FIG. 14.

[0107]

According to such a configuration, it is possible to suppress damage to the fire grate 41 caused by the position of the flame F being present in the region where the powder layer height is less than the threshold value. Accordingly, the operating rate of the combustion equipment 1 can be increased.

[0108]

(Other Embodiments)

Although the embodiments of the present disclosure have been described above, the specific configuration is not limited to the embodiments, and includes design changes and the like within the scope of the concept of the present disclosure. For example, the “temperature of the combustion air” is not limited to the temperature of the primary air, and may also correspond to the temperature of the secondary air. For example, as the “control of the temperature of the combustion air”, the temperature of the secondary air may be controlled by a preheater (not shown).

[0109]

FIG. 15 is a hardware configuration diagram showing a configuration of a computer 1100 according to the embodiment. For example, the computer 1100 includes a processor 1110, a main memory 1120, a storage 1130, and an interface 1140.

[0110]

Each functional unit of the control device 100 is installed in the computer 1100. An operation of each functional unit described above is stored in the storage 1130 in a form of a program. The processor 1110 reads the program from the storage 1130, deploys the read program in the main memory 1120, and executes the above-described process in accordance with the program. In addition, the processor 1110 secures a storage region used by each of the above-described functional units in the main memory 1120 in accordance with the program.

[0111]

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

[0112]

As an example of the storage 1130, a magnetic disk, a magneto-optical disk, or a semiconductor memory can be used. The storage 1130 may be an internal medium

directly connected to a bus of the computer 1100 or may be an external medium connected to the computer 1100 through the interface 1140 or a communication line. In addition, when this program is distributed to the computer 1100 via the communication line, the computer 1100 receiving the distributed program may deploy the program in the main memory 1120 to execute the above-described process. In addition, the program may be a program for realizing some of the above-described functions. In addition, the program may be a so-called difference file (difference program) that realizes the above-described functions in combination with another program previously stored in the storage 1130.

[0113]

<Additional Notes>

The system for combustion equipment and the combustion control method described in each embodiment are understood as follows, for example.

[0114]

(1) A system for combustion equipment according to a first aspect (for example, the control device 100) includes a flame information derivation unit 120 that derives a value related to a position or a shape of a flame F in an incinerator 3 by using a soft sensor that uses, as input information, one or more pieces of information among information on a temperature in the incinerator 3, a supply amount of an object S to be incinerated, calories of the object S to be incinerated, moisture content of the object S to be incinerated, a conveyance speed of the object S to be incinerated, a supply of combustion air, a temperature of the combustion air, components in an exhaust gas, and an image obtained by imaging an inside of the incinerator 3, and a control unit 130 that performs combustion control on the incinerator 3 on the basis of the value related to the position or the shape of the flame F derived by the flame information derivation

unit 120.

[0115]

According to such a configuration, since the value related to the position or the shape of the flame is derived based on the soft sensor, it is possible to avoid installing special equipment (for example, a plurality of temperature sensors) in the incinerator. Therefore, an increase in manufacturing costs can be suppressed. In addition, it is possible to derive an element related to the position or the shape of the flame based on the soft sensor and to perform appropriate combustion control based on the derived element. As a result, for example, stabilization of the flame position and improvement of exhaust gas components (for example, reduction of NO_x) can be easily achieved by precisely controlling the combustion.

[0116]

(2) In a system for combustion equipment according to a second aspect, in the system for combustion equipment described in (1), the flame information derivation unit 120 derives a position G of a center of gravity of the flame F, and the control unit 130 performs combustion control on the incinerator 3 on the basis of the position G of the center of gravity of the flame F derived by the flame information derivation unit 120. According to such a configuration, the combustion air can be preferentially supplied to the vicinity of the center of gravity position G of the flame F, which is the most burning position, and combustion control can be easily performed.

[0117]

(3) In a system for combustion equipment according to a third aspect, in the system for combustion equipment described in (2), in a case where the position G of the center of gravity of the flame F derived by the flame information derivation unit 120 is different from a planned position, the control unit 130 controls one or more of

the supply amount of the object S to be incinerated, the calories of the object S to be incinerated, the moisture content of the object S to be incinerated, the conveyance speed of the object S to be incinerated, the supply of the combustion air, and the temperature of the combustion air such that the position G of the center of gravity of the flame F approaches the planned position. According to such a configuration, for example, it is possible to more effectively suppress the occurrence of damage to the fire grate 41 due to the collapse of the clinker formed in the incinerator on the fire grate 41 or damage to the refractory material of the incinerator due to exposure to a high temperature.

[0118]

(4) In a system for combustion equipment according to a fourth aspect, in the system for combustion equipment described in any one of (1) to (3), in a case where a direction D in which the object S to be incinerated is transported in the incinerator 3 is referred to as a depth direction, the flame information derivation unit 120 derives a width W of the flame F in the depth direction, and the control unit 130 performs combustion control on the incinerator 3 on the basis of the width W of the flame F in the depth direction derived by the flame information derivation unit 120. According to such a configuration, even in a case where the flame F is scattered, the combustion control can be easily performed in accordance with the entire structure of the flame F.

[0119]

(5) In a system for combustion equipment according to a fifth aspect, in the system for combustion equipment described in any one of (1) to (4), the flame information derivation unit 120 derives a position G of a center of gravity of the flame F and the width W of the flame F in the depth direction, and the control unit 130 controls the position G of the center of gravity of the flame F by using one or more

parameters related to the supply amount of the object S to be incinerated, the calories of the object S to be incinerated, the moisture content of the object S to be incinerated, the conveyance speed of the object S to be incinerated, the supply of the combustion air, and the temperature of the combustion air, and controls the width W of the flame F in the depth direction by using one or more other parameters different from the one or more parameters, the one or more parameters being parameters related to the supply amount of the object S to be incinerated, the calories of the object S to be incinerated, the moisture content of the object S to be incinerated, the conveyance speed of the object S to be incinerated, the supply of the combustion air, and the temperature of the combustion air.

[0120]

According to such a configuration, it is possible to perform more flexible response to a plurality of elements. For example, it is possible to perform the response to an element (for example, the center of gravity position G of the flame F) having a relatively high importance by using a parameter having a relatively high influence and to perform the response to an element (for example, the width W of the flame F in the depth direction) having a relatively low importance by using a parameter having a relatively low influence. In this manner, more appropriate combustion control can be realized.

[0121]

(6) In a system for combustion equipment according to a sixth aspect, in the system for combustion equipment described in any one of (1) to (5), in a case where a direction D in which the object S to be incinerated is transported in the incinerator 3 is referred to as a depth direction, the control unit 130 controls the supply of the combustion air to the incinerator 3 such that the combustion air is concentrated at the

position of the flame F derived by the flame information derivation unit 120. According to such a configuration, the combustion air can be more appropriately supplied to the flame F, and the combustion control can be further optimized. As an example, it is possible to suppress the insufficiency of air supply to a location where the incomplete combustion gas (CO) is excessively generated and/or to suppress the excessive air supply to a location where NO_x is excessively generated.

[0122]

(7) A system for combustion equipment according to a seventh aspect, in the system for combustion equipment described in any one of (1) to (6), further includes a powder layer height derivation unit 140 that derives a value of a powder layer height in the incinerator 3, in which the flame information derivation unit 120 derives the value related to the position of the flame F, and the control unit 130 performs the combustion control to move the position of the flame F in a case where the position of the flame F is present in a region where the powder layer height is less than a threshold value, based on the value related to the position of the flame F derived by the flame information derivation unit 120 and the value of the powder layer height derived by the powder layer height derivation unit 140. According to such a configuration, it is possible to suppress damage to the fire grate 41 caused by the position of the flame F being present in the region where the powder layer height is less than the threshold value.

[0123]

(8) A combustion control method according to an eighth aspect includes, by one or more computers, deriving a value related to a position or a shape of a flame in an incinerator 3 by using a soft sensor that uses, as input information, one or more pieces of information among information on a temperature in the incinerator 3, a

supply amount of an object S to be incinerated, calories of the object S to be incinerated, moisture content of the object S to be incinerated, a conveyance speed of the object S to be incinerated, a supply of combustion air, a temperature of the combustion air, components in an exhaust gas, and an image obtained by imaging an inside of the incinerator 3, and performing combustion control on the incinerator 3 on the basis of the derived value related to the position or the shape of the flame F. According to such a configuration, as in the system for combustion equipment of (1), it is possible to perform appropriate combustion control while suppressing an increase in manufacturing costs.

[Industrial Applicability]

[0124]

According to the system for combustion equipment and the combustion control method of the present invention, it is possible to perform appropriate combustion control while suppressing the increase in manufacturing costs.

[Reference Signs List]

[0125]

1: Combustion equipment

2: Storage unit

3: Incinerator

11: Waste pit

12: Crane

21: Hopper

22: Feeder

23: Extrusion device

24: Moisture meter

25: Water sprinkler device

30: Furnace body

31: Furnace temperature sensor

32: Visible light camera

33: Infrared camera

40: Stoker

50: Wind box

51: Wind box pressure sensor

60: Furnace

60a: Front wall

60b: Rear wall

70: Blowing mechanism

71: Blower

73: Air preheater

75: Damper

81: Gas sensor

100: Control device

110: Information acquisition unit

120: Flame information derivation unit

130: Control unit

140: Powder layer height derivation unit

S: Object to be incinerated

M: Prediction model

Claims

[Claim 1]

A system for combustion equipment comprising:

a flame information derivation unit that derives a value related to a position or a shape of a flame in an incinerator by using a soft sensor that uses, as input information, one or more pieces of information among information on a temperature in the incinerator, a supply amount of an object to be incinerated, calories of the object to be incinerated, moisture content of the object to be incinerated, a conveyance speed of the object to be incinerated, a supply of combustion air, a temperature of the combustion air, components in an exhaust gas, and an image obtained by imaging an inside of the incinerator; and

a control unit that performs combustion control on the incinerator on the basis of the value related to the position or the shape of the flame derived by the flame information derivation unit.

[Claim 2]

The system for combustion equipment according to claim 1,

wherein the flame information derivation unit derives a position of a center of gravity of the flame as the value related to the position of the flame, and

the control unit performs combustion control on the incinerator on the basis of the position of the center of gravity of the flame derived by the flame information derivation unit.

[Claim 3]

The system for combustion equipment according to claim 2,

wherein in a case where the position of the center of gravity of the flame derived by the flame information derivation unit is different from a planned position, the control unit controls one or more of the supply amount of the object to be incinerated, the calories of the object to be incinerated, the moisture content of the object to be incinerated, the conveyance speed of the object to be incinerated, the supply of the combustion air, and the temperature of the combustion air such that the position of the center of gravity of the flame approaches the planned position.

[Claim 4]

The system for combustion equipment according to claim 1 or 2,

wherein in a case where a direction in which the object to be incinerated is transported in the incinerator is referred to as a depth direction,

the flame information derivation unit derives a width of the flame in the depth direction as the value related to the shape of the flame, and

the control unit performs combustion control on the incinerator on the basis of the width of the flame in the depth direction derived by the flame information derivation unit.

[Claim 5]

The system for combustion equipment according to claim 4,

wherein the flame information derivation unit derives a position of a center of gravity of the flame and the width of the flame in the depth direction as the value related to the position or the shape of the flame, and

the control unit

controls the position of the center of gravity of the flame by using one or more parameters related to the supply amount of the object to be incinerated, the calories of the object to be incinerated, the moisture content of the object to be incinerated, the conveyance speed of the object to be incinerated, the supply of the combustion air, and the temperature of the combustion air, and

controls the width of the flame in the depth direction by using one or more other parameters different from the one or more parameters, the one or more parameters being parameters related to the supply amount of the object to be incinerated, the calories of the object to be incinerated, the moisture content of the object to be incinerated, the conveyance speed of the object to be incinerated, the supply of the combustion air, and the temperature of the combustion air.

[Claim 6]

The system for combustion equipment according to claim 1 or 2,
wherein the flame information derivation unit derives the value related to the position of the flame, and

in a case where a direction in which the object to be incinerated is transported in the incinerator is referred to as a depth direction, the control unit controls the supply of the combustion air to the incinerator such that the combustion air is concentrated at the position of the flame derived by the flame information derivation unit.

[Claim 7]

The system for combustion equipment according to claim 1 or 2, further comprising:

a powder layer height derivation unit that derives a value of a powder layer

height in the incinerator,

wherein the powder layer height derivation unit derives the value related to the position of the flame, and

the control unit performs the combustion control to move the position of the flame in a case where the position of the flame is present in a region where the powder layer height is less than a threshold value, based on the value related to the position of the flame derived by the flame information derivation unit and the value of the powder layer height derived by the powder layer height derivation unit.

[Claim 8]

A combustion control method comprising:

by one or more computers,

deriving a value related to a position or a shape of a flame in an incinerator by using a soft sensor that uses, as input information, one or more pieces of information among information on a temperature in the incinerator, a supply amount of an object to be incinerated, calories of the object to be incinerated, moisture content of the object to be incinerated, a conveyance speed of the object to be incinerated, a supply of combustion air, a temperature of the combustion air, components in an exhaust gas, and an image obtained by imaging an inside of the incinerator; and

performing combustion control on the incinerator on the basis of the derived value related to the position or the shape of the flame.