

[DESCRIPTION]

[TITLE OF INVENTION]

CONTROL DEVICE FOR INCINERATOR EQUIPMENT

[Technical Field]

5 [0001]

The present disclosure relates to a control device for incinerator equipment.

Priority is claimed on Japanese Patent Application No. 2021-147752, filed September 10, 2021, the content of which is incorporated herein by reference.

[Background Art]

10 [0002]

In general, a hopper is provided in garbage incineration equipment, and garbage input into the hopper using a crane is sequentially supplied to an incinerator by a feeding device provided below the hopper. Patent Document 1 discloses a control device that calculates the specific gravity of garbage from a volume and a weight of garbage input to the hopper of the garbage incineration equipment, calculates the supply weight of garbage supplied to the incinerator by multiplying the specific gravity of garbage by a supply volume of garbage, calculates the heat input from the supply weight of garbage, and supplies garbage into the incinerator such that the heat input per unit time is constant.

[Citation List]

20 [Patent Document]

[0003]

[Patent Document 1]

Japanese Patent No. 6779779

[Summary of Invention]

25 [Technical Problem]

[0004]

In Patent Document 1, a range of time (for example, 1 to 2 hours) required from inputting of garbage into the hopper to supplying of the garbage to the incinerator is set, and the supply weight of the garbage to the incinerator is calculated by multiplying the supply volume of garbage by an average value of specific gravities of garbage input to the hopper in the past in the set range of time from that time point. In order to stabilize a combustion state in the incinerator, it is preferable to more accurately estimate a supply amount of garbage or a control quantity instead thereof and to antecedently perform control based on the estimated supply amount or the like.

10 [0005]

The present disclosure provides a control device for incinerator equipment that can solve the aforementioned problems.

[Solution to Problem]

[0006]

15 According to an aspect of the present disclosure, there is provided a control device for incinerator equipment including a furnace that carries incinerated objects while combusting the incinerated objects and a combustion air supply unit that supplies combustion air to the furnace, the control device including: a combustion air control unit configured to control the combustion air before the incinerated objects are input to the furnace on the basis of a supply amount or a lower heating value of the incinerated
20 objects supplied to the furnace; and a calculation unit configured to detect a change in height of the incinerated objects in a hopper through three-dimensional measurement, to calculate the volume of the incinerated objects input to the hopper on the basis of the change in height of the incinerated objects, to calculate the density on the basis of a weight and the volume of the incinerated objects input to the hopper, to perform
25

comparison of correlation between the lower heating value estimated from the density of the incinerated objects supplied to the furnace in a predetermined period in the past and the lower heating value measured actually, to estimate a retention time from inputting of the incinerated objects to the hopper to supplying of the incinerated objects to the furnace, and to calculate the supply amount or the lower heating value of the incinerated objects supplied to the furnace after the retention time has elapsed on the basis of a consolidation of the incinerated objects, a distribution of the incinerated objects in the hopper, and a proportion of the incinerated objects supplied to the furnace, wherein the combustion air control unit controls the combustion air based on the supply amount or the lower heating value of the incinerated objects in a predetermined time before the retention time estimated by the calculation unit elapses after the incinerated objects have been input to the hopper.

[Advantageous Effects of Invention]

[0007]

With the control device for incinerator equipment, it is possible to stabilize a combustion state in a furnace of garbage incinerator equipment.

[Brief Description of Drawings]

[0008]

FIG. 1 is a diagram illustrating an example of garbage incineration equipment according to an embodiment.

FIG. 2 is a flowchart illustrating an example of an operation flow of a control device according to a first embodiment.

FIG. 3 is a flowchart illustrating an example of an operation flow of a control device according to a second embodiment.

FIG. 4 is a flowchart illustrating an example of an operation flow of a control

device according to a third embodiment.

FIG. 5 is a first diagram illustrating a process of estimating a lower heating value or the like of garbage according to a fourth embodiment.

FIG. 6 is a second diagram illustrating a process of estimating the lower heating value or the like of garbage according to the fourth embodiment.

FIG. 7 is a third diagram illustrating a process of estimating the lower heating value or the like of garbage according to the fourth embodiment.

FIG. 8 is a diagram illustrating an example of a hardware configuration of the control devices according to the embodiments.

10 [Description of Embodiments]

[0009]

Hereinafter, garbage incineration equipment according to embodiments will be described with reference to the accompanying drawings. In the following description, elements having the same or similar functions will be referred to by the same reference signs. Repeated description of such elements will be omitted. “XX or YY” is not limited to one of XX and YY, and may be both of XX and YY. This is true when the number of optional elements is three or more. “XX” and “YY” are arbitrary elements (for example, arbitrary information).

[0010]

20 (System configuration)

FIG. 1 is a diagram illustrating an example of garbage incineration equipment according to an embodiment.

Garbage incineration equipment 100 includes a hopper 1 to which garbage is input, a chute 2 that guides garbage input to the hopper 1 downward, a feeder 10 that supplies garbage supplied through the chute 2 to a combustion chamber 6, a fire grate 3

that receives garbage supplied by the feeder 10, carries garbage, and performs drying and combustion of the garbage, a combustion chamber 6 that combusts garbage, an ash outlet 7 from which discharges ashes, an air blower 4 that supplies air, a plurality of air boxes 5A to 5E that guide air supplied by the air blower 4 to the constituents of the fire grate 3, a pipe line 14 that directly supplies air supplied by the air blower 4 to the combustion chamber 6 (a secondary combustion chamber 6B), a boiler 9, a crane 17 that carries garbage, a sensor 15 that detects a surface of garbage from above the hopper 1, and an image sensor 16 that captures an image in the combustion chamber 6.

[0011]

The crane 17 catches and carries garbage from a garbage pit (not illustrated) and inputs the garbage to the hopper 1. A weight sensor 17a is provided in the crane 17. The weight sensor 17a measures a weight of garbage carried by the crane 17. The weight sensor 17a is connected to a control device 20, and the weight measured by the weight sensor 17a, that is, the weight of garbage input to the hopper 1, is transmitted to the control device 20. The sensor 15 is installed above the hopper 1 such that the whole surface of the garbage input to and accumulated in the hopper 1 can be detected. The sensor 15 is provided to determine the volume of garbage input to the hopper 1 and the height of garbage accumulated in the hopper 1 and the chute 2. The sensor 15 is, for example, a Light Detection and Ranging (LiDAR) device. LiDAR is technology of scanning and irradiating an object with a laser beam or the like and measuring the distance or direction to the object on the basis of luminance of reflected light. The distance of the whole surface of garbage from the sensor 15 can be measured through LiDAR by scanning and irradiating the whole surface of accumulated garbage with a laser beam. Accordingly, it is possible to determine the height of garbage accumulated in the hopper 1 and the chute 2. It is possible to calculate the volume of garbage input

to the hopper 1 on the basis of the difference in height of garbage between before and after garbage is input to the hopper 1 from the crane 17. The sensor 15 is connected to the control device 20, and a measured value measured by the sensor 15 is transmitted to the control device 20.

5 [0012]

The feeder 10 is a feeding device that supplies garbage to the fire grate 3 by extruding garbage supplied through the chute 2. The feeder 10 repeats an operation of extruding garbage to the combustion chamber 6 and an operation of returning to the original position. The control device 20 adjusts a supply amount of garbage to the
10 combustion chamber 6 by controlling the pushing operation and the returning operation of the feeder 10. The fire grate 3 is provided on the bottom of the chute 2 and the combustion chamber 6 and carries garbage. The fire grate 3 includes a drying area 3A in which garbage supplied by the feeder 10 is dried by evaporating moisture of the garbage, a combustion area 3B which is located subsequent to the drying area 3A and in
15 which dried garbage is combusted, and a subsequent combustion area 3C which is located subsequent to the combustion area 3B and in which unburned components such as fixed carbon not being combusted and carried are combusted to be reduced to ashes. An operating speed of the fire grate 3 is controlled under the control of the control device 20.

20 [0013]

The air blower 4 is provided below the fire grate 3 and supplies air to the constituents of the fire grate 3 via the air boxes 5A to 5E. Branch pipes connecting the pipe line 8 and the air boxes 5A to 5E are connected to the pipe line 8 that guides air sent by the air blower 4 to the air boxes 5A to 5E, dampers 8A to 8E are provided in the
25 branch pipes, and a flow rate of combustion air supplied to the air boxes 5A to 5E can be

adjusted by adjusting openings of the dampers 8A to 8E. The control device 20 controls an amount of air blown by the air blower 4 (a rotation speed) and the openings of the dampers 8A to 8E. The dampers 8A to 8E may be generically referred to as a primary combustion air damper.

5 [0014]

The combustion chamber 6 includes a primary combustion chamber 6A and a secondary combustion chamber 6B above the fire grate 3, and the boiler 9 is provided subsequent to the combustion chamber 6. The primary combustion chamber 6A is provided above the fire grate 3, and the secondary combustion chamber 6B is provided
10 above the primary combustion chamber 6A. The primary combustion chamber 6A combusts garbage, thermal-decomposition gas generated in the primary combustion chamber 6A is mixed with secondary combustion air and the mixture is sent to the secondary combustion chamber 6B, and the secondary combustion chamber combusts unburned components of the thermal-decomposition gas. The pipe line 14 connecting
15 the air blower 4 and the secondary combustion chamber 6B is connected to the secondary combustion chamber 6B of the combustion chamber 6, and air can be supplied to the secondary combustion chamber 6B by opening and closing the damper 14A provided in the pipe line 14. The control device 20 controls the opening of the damper 14A. The damper 14A may be referred to as a secondary combustion air damper. The image
20 sensor 16 is installed at a position at which garbage supplied to the combustion chamber 6 can be imaged. The image sensor 16 is connected to the control device 20, and an image captured by the image sensor 16 is transmitted to the control device 20. The image sensor 16 is, for example, an infrared camera. In the example illustrated in FIG. 1, the image sensor 16 is provided at a position at which supply of garbage can be
25 imaged from the front in the horizontal direction, but may be provided, for example, at a

position at which supply of garbage to the combustion chamber 6 can be imaged from above. A temperature sensor 18 measuring the temperature in the combustion chamber 6 is installed in the combustion chamber 6. The temperature sensor 18 is connected to the control device 20, and the temperature in the furnace measured by the temperature sensor 18 is transmitted to the control device 20. An oxygen concentration sensor 19 measuring an oxygen concentration in the combustion chamber 6 is provided in the combustion chamber 6. The oxygen concentration sensor 19 is connected to the control device 20, and the oxygen concentration in the furnace measured by the oxygen concentration sensor 19 is transmitted to the control device 20.

10 [0015]

The boiler 9 generates steam by performing heat exchange between exhaust gas sent from the combustion chamber 6 and water circulating in the boiler 9. Steam is supplied to a power-generation turbine not illustrated via a pipe line 13. A steam flow sensor 11 detecting a flow rate of steam is provided in the pipe line 13. The steam flow sensor 11 is connected to the control device 20, and a main steam flow rate measured by the steam flow sensor 11 is transmitted to the control device 20. The control device 20 controls the operation of the feeder 10 and the openings of the primary combustion air damper and the secondary combustion air damper, for example, such that the main steam flow rate measured by the steam flow sensor 11 reaches a predetermined target value. A gas duct 12 is connected to an exhaust gas outlet of the boiler 9, and exhaust gas from which heat has been recovered by the boiler 9 passes through exhaust gas processing equipment (not illustrated) via the gas duct 12 and then is discharged to the outside.

[0016]

The control device 20 includes a data acquiring unit 21, a garbage height calculating unit 22, an image estimating unit 23, a supply estimating unit 24, a

determination unit 25, a control unit 26, and a storage unit 27.

The data acquiring unit 21 acquires measurement values measured by sensors 11, 14a, 15, 16, 17a, 18, and 19 and various types of data such as an instruction value from a user. For example, the data acquiring unit 21 acquires a measured value of a
5 main steam flow rate measured by the steam flow sensor 11.

[0017]

The garbage height calculating unit 22 calculates the height of garbage at each position on the surface of garbage accumulated in the hopper 1 and the chute 2 on the basis of the distance to the garbage surface detected by the sensor 15. The height of
10 garbage is a height with respect to a predetermined position of the chute 2.

[0018]

The image estimating unit 23 analyzes an image captured by the image sensor 16 and estimates a supply amount (a volume or a weight) and a lower heating value (LHV) of garbage supplied to the furnace by the feeder 10. For example, the image
15 estimating unit 23 compares images captured before and after the feeder 10 performs an operation of extruding garbage, extracts an image area in which extruded garbage appears, and estimates a volume of garbage supplied to the furnace on the basis of the shape or area of the extracted image area and an extrusion output of the feeder 10.

Alternatively, the image estimating unit 23 estimates a volume of garbage on the basis of
20 an estimation model constructed by learning a relationship between an image area in which extruded garbage appears and a supply amount of garbage and the extracted image area. The image estimating unit 23 calculates the weight of garbage supplied to the furnace by multiplying the estimated volume by a density calculated using a calculation method which will be described later. The image estimating unit 23 estimates a heating
25 value (LHV) from the weight of garbage supplied to the furnace on the basis of a

predetermined conversion expression. In general, in garbage incineration equipment, a density and a heating value of garbage are sampled, a relationship therebetween is analyzed, and a conversion expression of calculating the heating value from the density of garbage according to a type or the like of garbage which is processed in the incineration equipment is derived. The image estimating unit 23 estimates the heating value from the weight of garbage acquired through image analysis using the conversion expression. Control using the image estimating unit 23 will be described in a third embodiment.

[0019]

The supply estimating unit 24 calculates the change in volume of garbage in the hopper 1 on the basis of the change in height of garbage calculated by the garbage height calculating unit 22. The supply estimating unit 24 estimates the supply amount of garbage to the furnace per unit time on the basis of the change in volume of garbage in the hopper 1. The supply estimating unit 24 estimates the density or a moisture content of garbage supplied to the furnace on the basis of a distribution of garbage in the hopper 1 and the chute 2 or the retention time ΔT of garbage in the hopper 1 and estimates, for example, the heating value of garbage supplied to the furnace for the retention time in the future. The supply estimating unit 24 estimates a supply amount and/or a heating value of garbage which is supplied when the feeder 10 operates at this time or next before garbage is actually supplied to the furnace. Accordingly, control of primary combustion air supplied into the combustion chamber 6 can be antecedently performed before garbage is supplied to the combustion chamber 6. Details of the process of estimating the supply amount and the heating value of garbage which is performed by the supply estimating unit 24 will be described later in a fourth embodiment.

[0020]

The determination unit 25 determines whether to perform antecedent control for stabilizing a combustion state in the furnace on the basis of the supply amount and/or the heating value of garbage estimated by the supply estimating unit 24. The determination unit 25 determines whether the combustion state in the furnace has become stable as a result of the antecedent control.

[0021]

The control unit 26 controls the operation of the feeder 10, the openings of the primary combustion air damper (the dampers 8A to 8E) and the secondary combustion air damper (the damper 14A), and the like. The control unit 26 performs antecedent control of the primary combustion air damper or the feeder 10 on the basis of the result of determination from the determination unit 25. In the antecedent control, particularly when antecedent control of the primary combustion air is performed to an appropriate supply amount in advance such that the control is not performed excessively antecedently, it is possible to realize stabilization of combustion.

[0022]

The storage unit 27 stores the measured values acquired by the data acquiring unit 21, information required for control such as the conversion expression for calculating a heating value from a density of garbage.

[0023]

<First embodiment>

A process flow (supply control of primary combustion air) according to a first embodiment will be described below with reference to FIG. 2.

(Operation)

FIG. 2 is a flowchart illustrating an example of an operation of a control device according to the first embodiment.

The control device 20 performs the following process flow (antecedent control) at intervals of a predetermined time.

[0024]

The data acquiring unit 21 acquires a measurement value from the sensor 15 and
5 outputs the acquired measurement value to the garbage height calculating unit 22. The
garbage height calculating unit 22 calculates the height of garbage accumulated in the
hopper 1 at that time on the basis of the measurement value from the sensor 15, that is,
information of the distance from the sensor 15 to the garbage surface in the hopper 1.
The garbage height calculating unit 22 outputs the height of garbage every predetermined
10 time to the supply estimating unit 24. The supply estimating unit 24 estimates a supply
amount and/or a heating value of garbage (Step S1). For example, the supply
estimating unit 24 calculates the supply amount of garbage supplied to the combustion
chamber 6 per unit time from a change in height of garbage (a decrease in height) per
unit time. The supply estimating unit 24 calculates the density of garbage from the
15 volume and the weight of garbage which have been measured when garbage is input to
the hopper 1 and calculates the heating value when the garbage is supplied after a
retention time ΔT calculated using a predetermined method has elapsed. At this time,
the supply estimating unit 24 estimates the density of garbage supplied to the furnace
which is supplied after the retention time ΔT has elapsed, in consideration of a
20 distribution of garbage input to the hopper 1 at different timings in the hopper 1 and the
chute 2, proportions of garbage input to the hopper 1 at different timings when the
garbage is simultaneously supplied to the furnace, compression (consolidation) of
garbage input at a certain timing when the garbage moves to a lower part of the chute 2
and is compressed by the weight of garbage input later, and the like (details of which will
25 be described later in a fourth embodiment). The supply estimating unit 24 outputs the

estimated supply amount and the estimated heating value of garbage to the determination unit 25.

[0025]

Then, the determination unit 25 determines whether the supply amount of
5 garbage per unit time and/or the heating value of garbage supplied after the retention
time ΔT has elapsed is increased by a predetermined value or more (Step S2). For
example, the determination unit 25 compares a previously estimated supply amount and a
currently estimated supply amount to determine whether the supply amount has been
increased by a predetermined value or more, compares a previously estimated heating
10 value and a currently estimated heating value to determine whether the supply amount
has been increased by a predetermined value or more. For example, when the supply
amount and the heating value of garbage has been increased by a predetermined value or
more, or when at least one of the supply amount and the heating value has been increased
by a predetermined value or more (Step S2: YES), the control unit 26 determines that a
15 combustion state becomes excessive if control is continued in this state, and the control
unit 26 is instructed to perform antecedent control for curbing the combustion state.
The control unit 26 antecedently performs control for decreasing a supply amount of
primary combustion air (Step S3). For example, the control unit 26 decreases the
openings of the dampers 8A to 8E and decreases the amount of air supplied to the
20 combustion chamber 6. At this time, the control unit 26 may decrease only the opening
of the damper 8A to decrease the amount of air supplied to the drying area 3A or may
decrease the openings of the dampers 8A to 8C to decrease the amount of air supplied to
the drying area 3A and the combustion area 3B. The control unit 26 may decrease the
rotation speed of the air blower 4 in addition to/instead of decreasing the opening of the
25 damper 8A and the like.

[0026]

Decreases of the openings of the dampers 8A to 8E or a decrease of the rotation speed of the air blower 4 may be determined according to the supply amount or the heating value of garbage estimated in Step S1, for example, on the basis of a function for defining a relationship between a control quantity and a supply amount and/or a heating value or the like. The control unit 26 may perform control for decreasing the opening of the damper 8A and the like or the rotation speed of the air blower 4 for only a predetermined time or may continue to perform control of the damper 8A and the like until the supply amount and/or the heating value of garbage per unit time becomes constant.

[0027]

Regarding the timing at which decreasing of the opening of the damper 8A and the like or decreasing of the rotation speed of the air blower 4 is started, (1) for example, when the supply amount (the volume or the weight) of garbage based on the change in volume calculated from the change in height of garbage from time to time measured using LiDAR is estimated in Step S1, antecedent control may be started immediately after the determination of Step S2 (since a newest decrease in volume can be considered to be a supply amount input to the furnace immediately before, start of antecedent control at this timing means that control is immediately started according to the supply amount of garbage actually input to the furnace. This control is antecedent control in comparison with feedback control in the related art). (2) When the heating value is estimated in Step S1, the heating value based on the supply amount of garbage supplied to the furnace in the retention time ΔT after garbage has been input to the hopper 1 can be estimated as will be described later in a fourth embodiment. In other words, the timing at which garbage is supplied to the furnace (the retention time ΔT has elapsed) can

be seen at a time point at which the garbage has been input to the hopper 1.

Accordingly, since the heating value of garbage supplied to the furnace in the near future can be seen at a time point slight before the garbage is supplied to the furnace, for

example, the determination of Step S2 may be performed in a predetermined time before

5 the supply timing and antecedent control may be started on the basis of the determination result. The garbage supplied to the furnace in the near future mentioned herein is

garbage which is present in Pattern 1 in FIGS. 6 and 7 which will be described later.

When antecedent control of Step S3 is started in a predetermined time before the supply timing, antecedent control is started before garbage is actually input to the furnace.

10 Alternatively, the determination of Step S2 may be performed at the supply timing of garbage estimated on the basis of the retention time ΔT (for example, the same time as supply to immediately after the supply), and antecedent control may be started immediately after. In this case, antecedent control is started at a time point immediately before or immediately after garbage is input to the furnace similarly to the supply amount

15 of garbage described above in (1) (The supply amount of garbage is not limited to the example in which the determination of Step S2 is performed on the basis of a result value of the supply amount of garbage based on the change in height of garbage described

above in (1), but the determination of Step S2 may be performed on the basis of a previous estimated value and then antecedent control may be started. That is, similarly

20 to the heating value, the volume or the weight of garbage (that is, the supply amount of garbage which is supplied to the furnace in the near future) present at a position to which garbage is supplied to the furnace with extraction of the feeder 10 in the next time can be estimated and antecedent control can be started before garbage is actually supplied to the furnace. For example, it is estimated garbage input to the hopper 1 reaches a position of

25 Pattern 1 in FIGS. 6 and 7 after the retention time ΔT has elapsed. Then, the volume or

the weight of garbage occupying Pattern 1 may be calculated, it may be estimated that garbage of the calculated supply amount is supplied to the furnace in the near future slightly before the garbage is supplied to the furnace, and the determination of Step S2 may be performed in a predetermined time before the supply timing of garbage). In

5 other words, when it can be estimated that garbage is input to the furnace in the retention time ΔT after garbage has been input to the hopper 1, antecedent control does not have to be performed immediately before garbage is input to the furnace, but the antecedent control can be started earlier. The timing at which antecedent control is to be started can be arbitrarily adjusted according to a type of equipment or garbage or the like. In
10 general, for example, a supply amount of primary combustion air is often feedback-controlled such that the main steam flow rate measured by the steam flow sensor 11 becomes constant, but since the primary combustion air can be controlled according to the supply amount or the heating value of garbage earlier than such control according to the related art, an air condition (atmosphere) in the combustion chamber 6 can be
15 antecedently arranged to correspond to the supply amount or the heating value of garbage and thus it is possible to stabilize the combustion state. This is true in Step S7 (when the supply amount of primary combustion air is increased) which will be described later.
[0028]

The control unit 26 controls the feeder 10 such that garbage is supplied to the
20 furnace (Step S4). For example, the control unit 26 calculates the extrusion output of the feeder 10 with which the main steam flow rate measured by the steam flow sensor 11 reaches a predetermined target value, moves the feeder 10 by the calculated extrusion output to supply garbage to the furnace. The order of Steps S3 and S4 illustrated in FIG. 2 is for convenience, and the control unit 26 performs control for decreasing the
25 supply amount of primary combustion air and control for supplying garbage to the

furnace in parallel. Then, the determination unit 25 acquires the gas temperature in the combustion chamber 6 measured by the temperature sensor 18 via the data acquiring unit 21. The determination unit 25 determines whether the gas temperature in the furnace is maintained in a predetermined range for a predetermined time or more (Step S5). When the gas temperature in the furnace is maintained in the predetermined range for the predetermined time or more (Step S5: YES), the control unit 26 ends the antecedent control according to the first embodiment (antecedent supply of primary combustion air). When the gas temperature in the furnace is not maintained in the predetermined range for the predetermined time or more (Step S5: NO), the control unit 26 repeats the process flow from Step S3.

[0029]

When it is determined in Step S2 that the supply amount of garbage per unit time is not increased by a predetermined value or more (Step S2: NO), the determination unit 25 determines whether the supply amount of garbage per unit time and/or the heating value of garbage supplied after the retention time ΔT has elapsed is decreased by a predetermined value or more (Step S6). When the supply amount and the heating value of garbage are decreased by a predetermined value or more or when one of the supply amount and the heating value of garbage is decreased by a predetermined value (Step S6: YES), the control unit 26 determines that the combustion state deteriorates or decreases with continuous performing of the control, and the control unit 26 is instructed to perform antecedent control to promote combustion in the furnace. The control unit 26 performs control for increasing the supply amount of primary combustion air (Step S7). For example, the control unit 26 increases an amount of air supplied to the combustion chamber 6 by increasing the openings of the dampers 8A to 8E. At this time, the control unit 26 may increase only the opening of the damper 8A to increase the amount

of air supplied to the drying area 3A or may increase the openings of the dampers 8A to 8C to increase the amount of air supplied to the drying area 3A and the combustion area 3B. The control unit 26 may increase the rotation speed of the air blower 4 in addition to/instead of increasing the opening of the damper 8A or the like.

5 [0030]

An increase of the opening of the damper 8A or the like or an increase of the rotation speed of the air blower 4 may be determined according to the supply amount or the heating value of garbage estimated in Step S1 on the basis of a function of defining a relationship between a control quantity and a supply amount and/or a heating value or the like. The control unit 26 may perform control for increasing the opening of the damper 8A or the like or the rotation speed of the air blower 4 for only a predetermined time or may continue to perform control of the damper 8A or the like until the supply amount and/or the heating value of garbage per unit time becomes constant. Increasing of the opening of the damper 8A or the like or increasing of the rotation speed of the air blower 4 is started before garbage is actually supplied or at a timing from immediately before to immediately after supply of garbage as described in Step S3. The control unit 26 controls the feeder 10 such that garbage is supplied to the furnace (Step S8). For example, the control unit 26 controls the feeder 10 on the basis of the main steam flow rate measured by the steam flow sensor 11. The order of Steps S7 and S8 illustrated in FIG. 2 is for convenience, and the control unit 26 performs control for increasing the supply amount of primary combustion air and control for supplying garbage to the furnace in parallel. Then, the determination unit 25 acquires a gas temperature in the combustion chamber 6 measured by the temperature sensor 18 via the data acquiring unit 21. The determination unit 25 determines whether the gas temperature in the furnace is maintained in a predetermined range for a predetermined time or more (Step S9). When

the gas temperature in the furnace is maintained in the predetermined range for the predetermined time or more (Step S9: YES), the control unit 26 ends the antecedent control according to the first embodiment (antecedent supply of primary combustion air). When the gas temperature in the furnace is not maintained in the predetermined range for the predetermined time or more (Step S9: NO), the control unit 26 repeats the process flow from Step S7.

[0031]

When it is determined in Step S6 that the supply amount of garbage per unit time and/or the heating value of garbage supplied after the retention time ΔT has elapsed is not decreased by the predetermined value or more (Step S6: NO), that is, when a change of the supply amount of garbage per unit time or the like is in a predetermined range, the process flow returns to Step S1. When the determination result of Step S6 is NO, the control unit 26 controls the opening of the damper 8A or the like and the feeder 10, for example, such that the main steam flow rate measured by the steam flow sensor 11 reaches a target value. The control of the feeder 10 is the same as the control of Steps S4 and S8.

[0032]

In the flowchart illustrated in FIG. 2, the supply amount of primary combustion air is controlled only when it is determined in Steps S2 and S6 that the supply amount or the heating value of garbage is equal to or greater than a predetermined value or equal to or less than a predetermined value, but this determination may not be performed, and the damper 8A or the like or the air blower 4 may be normally controlled on the basis of a predetermined function indicating a relationship between a supply amount and/or a heating value of garbage and a supply amount of primary combustion air and the supply amount and/or the heating value estimated in Step S1.

[0033]

According to the first embodiment, a supply amount of primary combustion air is adjusted according to the supply amount or the heating value of garbage estimated in advance before garbage is supplied to the combustion chamber 6. Accordingly, it is possible to form the atmosphere in which the combustion state in the combustion chamber 6 is stabilized and to curb occurrence of CO or NO_x.

[0034]

<Second embodiment>

A process flow according to a second embodiment (control of a supply amount of primary combustion air and a supply of garbage) will be described below with reference to FIG. 3. In the second embodiment, the supply amount of garbage supplied to the combustion chamber 6 in addition to primary combustion air is antecedently controlled on the basis of an estimated value of the supply amount or the heating value of garbage.

(Operation)

FIG. 3 is a first flowchart illustrating an example of an operation of a control device according to the second embodiment. The same steps as in the first embodiment will be referred to by the same reference signs and a description thereof will be simplified.

The control device 20 performs the following process flow (antecedent control) at intervals of a predetermined time.

[0035]

First, the supply estimating unit 24 estimates a supply amount and/or a heating value of garbage on the basis of a garbage height measured by LiDAR or the like (Step S1). The supply estimating unit 24 outputs the estimated supply amount and/or heating

value of garbage to the determination unit 25.

[0036]

Then, the determination unit 25 determines whether the supply amount of garbage per unit time and/or the heating value of garbage supplied after the retention

5 time ΔT has elapsed is increased by a predetermined value or more (Step S2). When the supply amount and/or the heating value of garbage has been increased by a predetermined value or more (Step S2: YES), the control unit 26 antecedently performs control for decreasing a supply amount of primary combustion air (Step S3). The control unit 26 decreases the supply amount of primary combustion air by decreasing the
10 openings of the dampers 8A to 8E or decreasing the rotation speed of the air blower 4.

[0037]

In parallel therewith, the control unit 26 controls the feeder 10 such that garbage is supplied to the furnace and decreases the supply amount of garbage to the furnace to curb excessive combustion (Step S41). For example, the control unit 26 decreases the

15 supply amount of garbage supplied to the combustion chamber 6 by decreasing an extrusion output (a stroke) of the feeder 10. Alternatively, the control unit 26 may decrease the supply amount of garbage by decreasing the moving speed of the feeder 10 or decrease the supply amount of garbage supplied to the combustion chamber 6 by decreasing both the extrusion output and the moving speed. The control unit 26 may
20 decrease (temporarily stop) the supply amount of garbage by stopping the feeder 10.

For example, the control unit 26 may supply about a half amount of garbage by moving the feeder 10 by half a normal extrusion output and stop the feeder 10 at that position for a predetermined time. For example, the control unit 26 may control the feeder 10 on the basis of a function of defining a relationship between an extrusion output or a moving

25 speed of the feeder 10 and a supply amount and/or a heating value of garbage, the supply

amount or the heating value of garbage estimated in Step S1, and the like.

[0038]

The control unit 26 may perform decreasing a stroke or a moving speed of the feeder 10 or the like for only a predetermined time or may continue to control the feeder
5 10 until the supply amount and/or the heating value of garbage per unit time becomes constant.

[0039]

Decreasing the supply amount of garbage is performed at a timing closer to supply of target garbage (garbage in which the determination result of Step S2 is YES)
10 than the timing at which the control of Step S3 is started or at a timing of supply of the garbage (after the retention time ΔT has elapsed). For example, the supply amount (the volume or weight) of garbage may be estimated on the basis of a change in volume calculated from a change in height of garbage measured by LiDAR in Step S1 from time to time, and antecedent control may be started immediately after the determination of
15 Step S2 has been performed when the estimated value is considered to be a supply amount of garbage supplied to the furnace in this time.

[0040]

When a heating value is estimated in Step S1, the heating value corresponding to the supply amount of garbage supplied to the furnace in a period from input to the hopper
20 1 to a timing at which the retention time ΔT has elapsed can be estimated as will be described in a fourth embodiment, and thus it is possible to see a heating value of garbage supplied to the furnace in the near future slightly before the garbage is supplied to the furnace. Accordingly, the determination of Step S2 may be performed on the basis of the heating value of garbage which is supplied to the furnace in the near future in
25 advance, the antecedent control of Step S3 may be performed on the basis of the

determination result, and control for decreasing the supply amount of garbage may be started in a predetermined time before the timing of supply of garbage to the furnace (or at the same time as the timing of supply) and after the timing at which the control of Step S3 is started. In general, a supply amount of primary combustion air or a supply

5 amount of garbage is often feedback-controlled such that the main steam flow rate measured by the steam flow sensor 11 becomes constant, but since the supplies of primary combustion air and garbage can be controlled earlier than such control, it is possible to stabilize the combustion state in the combustion chamber 6. This is true for Steps S7 and S81 which will be described later.

10 [0041]

Then, the determination unit 25 acquires a gas temperature in the combustion chamber 6 measured by the temperature sensor 18 via the data acquiring unit 21. The determination unit 25 determines whether the gas temperature in the furnace is maintained in a predetermined range for a predetermined time or more (Step S5). When

15 the gas temperature in the furnace is maintained in the predetermined range for the predetermined time or more (Step S5: YES), the control unit 26 ends the antecedent control of the supplies of primary combustion air and garbage according to the second embodiment. When the gas temperature in the furnace is not maintained in the predetermined range for the predetermined time or more (Step S5: NO), the control unit

20 26 repeats the process flow from Step S3.

[0042]

When the supply amount of garbage per unit time or the like is not increased by a predetermined value or more (Step S2: NO), the determination unit 25 determines whether the supply amount of garbage per unit time and/or the heating value of garbage

25 supplied after the retention time ΔT has elapsed is decreased by a predetermined value or

more (Step S6). When the supply amount and/or the heating value of garbage is decreased by the predetermined value or more (Step S6: YES), the control unit 26 antecedently performs control for increasing the supply amount of primary combustion air (Step S7). The control unit 26 increases the supply amount of primary combustion air by increasing the openings of the dampers 8A to 8E or increasing the rotation speed of the air blower 4.

[0043]

In parallel with Step S7, the control unit 26 controls the feeder 10 such that garbage is supplied to the furnace and increases the supply amount of garbage to the furnace to promote combustion (Step S81). For example, the control unit 26 increases the supply amount of garbage by increasing the extrusion output of the feeder 10, increasing the moving speed of the feeder 10, or increasing both the extrusion output and the moving speed. For example, the control unit 26 may control the feeder 10 on the basis of a function of defining a relationship between an extrusion output or a moving speed of the feeder 10 and a supply amount and/or a heating value of garbage and the supply amount or the heating value of garbage estimated in Step S1. The control unit 26 may perform the control of the feeder 10 for only a predetermined time or may perform the control of the feeder 10 until the supply amount and/or the heating value per unit time becomes constant.

[0044]

Regarding the timing at which the supply amount of garbage is increased, the control of Steps S7 and S81 may be antecedently started as described in Step S41.

[0045]

Then, the determination unit 25 acquires the gas temperature in the combustion chamber 6 measured by the temperature sensor 18 via the data acquiring unit 21. The

determination unit 25 determines whether the gas temperature in the furnace is maintained in a predetermined range for a predetermined time or more (Step S9). When the gas temperature in the furnace is maintained in the predetermined range for the predetermined time or more (Step S9: YES), the control unit 26 ends the antecedent control according to the second embodiment (antecedent supply of primary combustion air). When the gas temperature in the furnace is not maintained in the predetermined range for the predetermined time or more (Step S9: NO), the control unit 26 repeats the process flow from Step S7.

[0046]

When it is determined in Step S6 that the supply amount of garbage per unit time and/or the heating value of garbage supplied after the retention time ΔT has elapsed is not decreased by a predetermined value or more (Step S6: NO), that is, when a change of the supply amount of garbage per unit time or the like is in a predetermined range, the process flow returns to Step S1. When the determination result of Step S6 is NO, the control unit 26 controls the openings of the damper 8A and the like and the feeder 10 on the basis of the steam flow rate measured by the steam flow sensor 11.

[0047]

In the flowchart illustrated in FIG. 2, the supply amount of primary combustion air is controlled only when the supply amount or the heating value of garbage is equal to or greater than a predetermined value or equal to or less than a predetermined value in Steps S2 and S6, but the damper 8A and the like or the air blower 4 may be normally controlled on the basis of a predetermined function of defining a relationship between a supply amount and/or a heating value of garbage and a supply amount of primary combustion air and the supply amount and/or the heating value of garbage estimated in Step S1 instead of performing such determination. Similarly, the operation of the feeder

10 may be controlled on the basis of a predetermined function of defining a relationship between a supply amount and/or a heating value and a stroke or a moving speed of the feeder 10 and the supply amount and/or the heating value of garbage estimated in Step S1.

5 [0048]

According to the second embodiment, by antecedently adjusting the supply amount of garbage in cooperation with primary combustion air according to the estimated supply or heating value immediately after the supply of garbage is estimated amount or with a delay of a predetermined time until garbage is actually supplied after
10 the heating value has been estimated, it is possible to form the atmosphere in which the combustion state of the combustion chamber 6 is stabilized and to curb occurrence of CO or NOx.

[0049]

<Third embodiment>

15 A process flow according to a third embodiment will be described below with reference to FIG. 4. In the third embodiment, antecedent control of primary combustion air or the like is adjusted according to a supply amount of garbage actually supplied to the furnace. The third embodiment can be combined with any of the first embodiment and the second embodiment, and an example of an operation in case of combination with
20 the first embodiment is illustrated in FIG. 4.

[0050]

(Operation)

FIG. 4 is a flowchart illustrating an example of an operation of a control device according to the second embodiment. The same steps as in the first embodiment will be
25 referred to by the same reference signs and a description thereof will be simplified.

The control device 20 performs the following process flow (antecedent control) at intervals of a predetermined time.

[0051]

First, the supply estimating unit 24 estimates a supply amount and/or a heating value of garbage on the basis of a garbage height measured by LiDAR or the like (Step S1). The supply estimating unit 24 outputs the estimated supply amount and/or heating value of garbage to the determination unit 25.

[0052]

Then, the determination unit 25 determines whether the supply amount of garbage per unit time and/or the heating value of garbage supplied after the retention time ΔT has elapsed is increased by a predetermined value or more (Step S2). When the supply amount and/or the heating value of garbage has been increased by a predetermined value or more (Step S2: YES), the control unit 26 antecedently performs control for decreasing a supply amount of primary combustion air (Step S3). The control unit 26 decreases the supply amount of primary combustion air by decreasing the openings of the dampers 8A to 8E or decreasing the rotation speed of the air blower 4.

[0053]

In parallel therewith, the control unit 26 controls the feeder 10 such that garbage is supplied to the furnace (Step S4). Then, the image estimating unit 23 analyzes an image captured by the image sensor 16 and estimates the supply amount of garbage supplied to the combustion chamber 6 (Step S42). The image estimating unit 23 outputs the estimated value of the supply amount of garbage to the control unit 26. The control unit 26 adjusts supplies of primary combustion air and/or secondary combustion air on the basis of the estimated value of the supply amount of garbage (Step S43). For example, when the estimated value of the supply amount of garbage is greater than the

supply amount estimated in Step S1, the openings of the damper 8A and the like are decreased or the rotation speed of the air blower 4 is decreased such that the supply amount of primary combustion air is further decreased. The control unit 26 performs control for decreasing the supply amount of secondary combustion air in addition to the primary combustion air to decrease an oxygen concentration in the secondary combustion chamber 6B by decreasing the opening of the damper 14A. On the other hand, when the estimated value of the supply amount of garbage is less than the supply amount estimated in Step S1, adjustment may be performed such that a degree of decrease of the openings of the damper 8A and the like or the rotation speed of the air blower 4 is reduced. Then, the determination unit 25 determines whether the gas temperature and/or the oxygen concentration in the furnace is maintained in a predetermined range for a predetermined time or more (Step S51). The determination unit 25 acquires the temperature in the combustion chamber 6 measured by the temperature sensor 18 and the oxygen concentration in the combustion chamber 6 measured by the oxygen concentration sensor 19 via the data acquiring unit 21 and determines whether the gas temperature and/or the oxygen concentration in the combustion chamber 6 is in a predetermined range. When the gas temperature and/or the oxygen concentration in the furnace is maintained in the predetermined range for a predetermined time or more (Step S51: YES), the control unit 26 ends the antecedent control of primary combustion air according to the third embodiment. When the gas temperature and/or the oxygen concentration in the furnace is not maintained in the predetermined range for the predetermined time or more (Step S51: NO), the control unit 26 repeats the process flow from Step S3.

[0054]

When the supply amount of garbage per unit time or the like is not increased by

a predetermined value or more (Step S2: NO), the determination unit 25 determines whether the supply amount of garbage per unit time and/or the heating value of garbage supplied after the retention time ΔT has elapsed is decreased by a predetermined value or more (Step S6). When the supply amount and/or the heating value of garbage is

5 decreased by the predetermined value or more (Step S6: YES), the control unit 26 antecedently performs control for increasing the supply amount of primary combustion air (Step S7). The control unit 26 increases the supply amount of primary combustion air by increasing the openings of the dampers 8A to 8E or increasing the rotation speed of the air blower 4.

10 [0055]

In parallel therewith, the control unit 26 controls the feeder 10 such that garbage is supplied to the furnace (Step S8). Then, the image estimating unit 23 analyzes an image captured by the image sensor 16 and estimates the supply amount of garbage supplied to the combustion chamber 6 (Step S82). The image estimating unit 23

15 outputs the estimated value of the supply amount of garbage to the control unit 26. The control unit 26 adjusts supplies of primary combustion air and/or secondary combustion air on the basis of the estimated value of the supply amount of garbage (Step S83). For example, when the estimated value of the supply amount of garbage is less than the supply amount estimated in Step S1, the openings of the damper 8A and the like are

20 increased or the rotation speed of the air blower 4 is increased such that the supply amount of primary combustion air is further increased. The control unit 26 performs control for increasing the supply amount of secondary combustion air in addition to the primary combustion air to increase an oxygen concentration in the secondary combustion chamber 6B by increasing the opening of the damper 14A. For example, the control

25 unit 26 controls the opening of the damper 14A based on the supply amount of garbage

estimated from the image on the basis of the function of defining a relationship between the estimated value of the supply amount of garbage and the opening of the damper 14A.

On the other hand, when the estimated value of the supply amount of garbage is greater than the supply amount estimated in Step S1, adjustment may be performed such that a

5 degree of increase of the openings of the damper 8A and the like or the rotation speed of the air blower 4 is reduced. Then, the determination unit 25 determines whether the gas temperature and/or the oxygen concentration in the furnace is maintained in a

predetermined range for a predetermined time or more (Step S91). The determination unit 25 acquires the temperature in the combustion chamber 6 measured by the

10 temperature sensor 18 and the oxygen concentration in the combustion chamber 6

measured by the oxygen concentration sensor 19 via the data acquiring unit 21 and

determines whether the gas temperature and/or the oxygen concentration in the

combustion chamber 6 is in the predetermined range for the predetermined time or more.

When the gas temperature and/or the oxygen concentration in the furnace is maintained

15 in the predetermined range for the predetermined time or more (Step S91: YES), the

control unit 26 ends the antecedent control of primary combustion air according to the

third embodiment. When the gas temperature and/or the oxygen concentration in the

furnace is not maintained in the predetermined range for the predetermined time or more

(Step S91: NO), the control unit 26 repeats the process flow from Step S7.

20 [0056]

According to the third embodiment, it is possible to further achieve stabilization of combustion by estimating a supply amount and a heating value of garbage from image information after garbage has been input to the furnace and additionally controlling

secondary combustion air. The supply amount and the heating value of garbage are

25 estimated from the measured value of the distance to the garbage surface in the hopper 1

in Step S1, but there is a likelihood of deviation from a supply amount and a heating value of garbage which is actually supplied to the furnace. On the other hand, with the processes of Steps S42, S43, S82, and S83 according to this embodiment, it is possible to compensate for deviation of the estimated value in Step S1 by controlling the supply
5 amount of primary combustion air or secondary combustion air on the basis of an image of garbage which has been actually supplied.

[0057]

According to this embodiment, unlike a technique of detecting a change in volume from a height of a garbage surface in the hopper 1 or detecting a supply amount
10 of garbage to the furnace from the operation of the feeder 10, since an amount of garbage actually input to the furnace is estimated from an image, it is possible to instantaneously estimate a supply amount of garbage and to accurately detect a supply amount of garbage with a less time lag.

[0058]

15 The operation of combination with the first embodiment is illustrated in FIG. 4, but the processes of Steps S4 and S8 are replaced with the processes of Steps S41 and S81 in FIG. 3 in combination with the second embodiment. In Step S43, the stroke and the moving speed of the feeder 10 are adjusted in addition to adjustment of the primary combustion air and the secondary combustion air. For example, when an estimated
20 value of the supply amount of garbage is greater than the supply amount estimated in Step S1, the control unit 26 shortens the stroke of the feeder 10 or decreases the moving speed. Similarly, in Step S83, the stroke and the moving speed of the feeder 10 are adjusted in addition to adjustment of the primary combustion air and the secondary combustion air. For example, when the estimated value of the supply amount of
25 garbage is less than the supply amount estimated in Step S1, the control unit 26 lengthens

the stroke of the feeder 10 or increases the moving speed. When this control of the feeder 10 is performed, the control unit 26 controls the feeder 10 according to the supply amount of garbage estimated from an image on the basis of a function of defining a relationship between an estimated value of a supply amount of garbage and a stroke or a moving speed of the feeder 10 or the like.

[0059]

<Fourth embodiment>

A process flow according to a fourth embodiment will be described below with reference to FIGS. 5 to 7. In the fourth embodiment, the process of Step S1 in the first to third embodiments will be described.

(Estimation method 1)

FIG. 5 is a first diagram illustrating a process of estimating a heating value or the like of garbage according to the fourth embodiment.

A sectional view of the hopper 1 and the chute 2 is illustrated in a left part 50 of FIG. 5. Layers I1 to I5 illustrated therein are layers of garbage formed by inputting garbage to the hopper 1 one time. For example, Layer I5 is formed by garbage input to the hopper 1 five times before now, Layer I4 is formed by garbage input to the hopper 1 fourth times before now, Layer I3 is formed by garbage input to the hopper 1 three times before now, Layer I2 is formed by garbage input to the hopper 1 two times before now, and Layer I1 is formed by garbage input to the hopper 1 immediately before now. In Estimation method 1, the supply estimating unit 24 estimates an average retention time ΔT until garbage of Layer I1 newly input is supplied to the furnace and estimates a heating value (LHV) of garbage input after the average retention time ΔT has elapsed in the sequences described below.

[0060]

(Sequence 1) The garbage height calculating unit 22 detects a distance from the sensor 15 to a garbage surface at each position on the whole garbage surface in the hopper 1 by LiDAR from time to time. When garbage of Layer I5 is input, the supply estimating unit 24 calculates the volume of the input garbage on the basis of the increase in height of garbage before and after garbage is input. The supply estimating unit 24 acquires a weight of garbage measured by the weight sensor 17a at the time of carrying garbage of Layer I5 and calculates the density of garbage of Layer I5 by dividing the weight by the calculated volume of garbage. Similarly, the supply estimating unit 24 calculates the density of garbage of each layer when garbage of Layers I4 to I1 is input. The supply estimating unit 24 records the density of garbage each of Layers I1 to I4 on the storage unit 27. The relationship between the calculated density of garbage and the layer is illustrated in Diagram 51. In Diagram 51, the vertical axis represents density and the horizontal axis represents position (layer) in the hopper 1 and the chute 2. Polygonal line graph 51a represents the density of Layer I5, the density of Layer I4, the density of Layer I3, the density of Layer I2, and the density of Layer I1 sequentially from the left.

[0061]

(Sequence 2) The supply estimating unit 24 calculates the heating value using a conversion expression for calculating a heating value from the densities of the layers and a garbage density derived in advance. In general, it is known that the garbage density and the heating value have a negative correlation. The heating value corresponding to the garbage density of each layer is illustrated in Diagram 52. In Diagram 52, the vertical axis represents heating value (LHV) and the horizontal axis represents time. Diagram 52 illustrating change of the heating value according to the density of garbage supplied to the furnace at each time, for example, when garbage is supplied to the furnace

with a predetermined supply amount per unit time in the state of Diagram 50.

Polygonal line graph 52a represent the heating value of Layer I5, the heating value of Layer I4, the heating value of Layer I3, the heating value of Layer I2, and the heating value of Layer I1 sequentially from the left.

5 [0062]

(Sequence 3) Then, the heating value when garbage of each layer in Diagram 50 is actually input to the incinerator is calculated. For example, this sequence is started from the state in which garbage of Layer I5 is located in Layer I1 (garbage of Layers I4 to I1 in Diagram 50 has not been input yet), then garbage is input in the order of Layers I4 to I1, and a main steam flow rate while garbage of each of Layers I1 to I5 (Layers I1 to I5 in Diagram 50) is being combusted is measured by the steam flow sensor 11, and a heating value (LHV) at each time is calculated using a value obtained by dividing the measured main steam flow rate by an integral value of a weight of garbage input to the hopper 1 by the crane 17 for 1 hour. The method of calculating a heating value is known, and the heating value when garbage of Layers I1 to I5 is combusted can be calculated using a known method. The heating values at the time of combustion of Layers I1 to I5 are illustrated in Diagram 53. In Diagram 53, the vertical axis represents heating value (LHV), and the horizontal axis represents time. Graph 53a indicates change of the heating value (an LHV process value) which is calculated on the basis of a result value of the main steam flow rate. A user registers data indicating the change of the heating value calculated on the basis of the measured value in the storage unit 27. Alternatively, the supply estimating unit 24 calculates the heating value illustrated in Diagram 53 and registers the heating value in the storage unit 27.

[0063]

25 (Sequence 4) Then, the supply estimating unit 24 calculates the degree of

correlation between Graph 52a of the heating value based on the densities of the layers and Graph 53a of the heating value calculated on the basis of the main steam flow rate while moving Graph 52a calculated in Sequence 2 in the direction of the time axis. The supply estimating unit 24 searches a shift ΔT of Graph 52a when the degree of

5 correlation is highest. The shift ΔT of Graph 52a when the degree of correlation is highest is defined as the average retention time ΔT . Since the retention time changes according to a garbage throughput, it is necessary to consider change in garbage quality, an operation plan, and the like. For example, the average retention time ΔT is calculated when the garbage quality or the operation plan changes.

10 [0064]

(Sequence 5) After the average retention time ΔT has been calculated, the supply estimating unit 24 calculates the density of garbage whenever garbage is input to the hopper 1 and calculates the heating value using a conversion expression. Then, the supply estimating unit 24 records the calculation result (an estimated value) along with

15 time in the storage unit 27. Accordingly, at a time point at which feeder control is performed to supply garbage, the heating value estimated in the average retention time ΔT in the past is an estimated value of the heating value of garbage which is supplied in this time. The supply estimating unit 24 reads the estimated value of the heating value in the average retention time ΔT in the past recorded in the storage unit 27 and estimates

20 the heating value (Step S1 in FIGS. 2 to 4). A change in volume of garbage based on a change in height of garbage due to this supply amount of garbage is calculated (for example, unit height $\times$ sectional area of the hopper 1 or the chute 2 is integrated by the change in height of garbage in the height direction, where the sectional area of the hopper 1 or the chute 2 is known), and the estimated value of the supply amount of garbage to

the furnace is calculated (Step S1 in FIGS. 2 to 4). This is an estimated value of a supply amount of garbage which is supplied in this time.

[0065]

The supply estimating unit 24 may record the calculation result of a change in volume based on the change in height in the hopper 1 per unit time along with time in the storage unit 27 and use the change in volume in the average retention time ΔT in the past from now as the estimated value of the supply amount of garbage supplied in this time.

[0066]

(Estimation method 2)

In Estimation method 1, it is assumed that all garbage input to the furnace has been input to the hopper 1 at the same timing and the density of garbage is constant. However, actually, garbage input at different timings is mixed on the basis of a distribution of garbage in the chute 2 and then is supplied to the furnace. In Estimation method 2, a density of garbage input to the furnace is calculated in consideration of a distribution or consolidation of garbage (a density which is a result of compression due to garbage input later) and estimates the heating value of garbage on the basis of the calculated density of garbage and the conversion expression.

[0067]

A method of calculating a density in consideration of a distribution and consolidation of garbage is illustrated in FIG. 6. First, as illustrated in the left diagram 60, distribution and accumulation of garbage input at different timings in the hopper 1 and the chute 2 like Layers I1 to I5 are modeled by antecedent analysis. Garbage of each layer is garbage input to the hopper 1 from the crane 17 by one input. I6 and I7 indicate garbage already supplied into the furnace. In another analysis, when garbage is supplied to the furnace by causing the feeder 10 to perform a predetermined operation in

a state in which garbage is distributed and accumulated like Layers I1 to I5, garbage accumulated in a range surrounded by Pattern 1 is first supplied to the furnace, garbage accumulated in a range surrounded by Pattern 2 is supplied to the furnace in the next time, garbage accumulated in a range surrounded by Pattern 3 is then supplied to the furnace, and garbage in a range surrounded by Pattern 4 is supplied to the furnace through fourth feeder control. Patterns 1 to 4 are examples of a supply pattern when a one extrusion output of the feeder 10 is assumed. With this analysis, garbage of Layers I3 to I5 is to be supplied in Pattern 1 which is a next scheduled supply range. Through another analysis, a weighted moving average coefficient (a garbage input proportion) associated with proportions of garbage of Layers I3 to I5 when garbage in Pattern 1 is supplied is calculated in advance (Diagram 62). For example, when volumes of garbage of Layers I1 to I7 are the same (maximum values of all the weighted moving average coefficients are 0.1), a graph indicating the weighted moving average coefficients of Layers I1 to I7 from time to time is illustrated in Diagram 62. In Diagram 62, the vertical axis represents the weighted moving average coefficient, and the horizontal axis represents time (time in which garbage is supplied to the furnace by the feeder 10). In the graph illustrated in Diagram 62, each mountain corresponds to garbage of the corresponding layer, and the mountains sequentially from the leftmost mountain in the example illustrated in Diagram 62 correspond to Layers I7 to I1. The height of each mountain has a positive correlation with the volume of input garbage, and the peak value of the mountain differs every time when the volume of garbage input to the hopper 1 differs every time. Overlap of the mountains is associated with input proportions of garbage input to the furnace at that time, and input proportions of garbage (the weighted moving average coefficient) of Layers I3 to I5 can be ascertained from the value on the vertical axis at the corresponding time point on the horizontal axis in Diagram 62, for

example, when an input time of Pattern 1 in Diagram 60 with respect to a reference time is known. When the weighted moving average coefficients of Layers I3 to I5 at a time at which garbage in the range surrounded by Pattern 1 is supplied is searched for from Diagram 62, values in the first row of Table 61 are acquired. Similarly, the weighted moving average coefficients of Layers I1 to I7 in Patterns 2 to 4 are illustrated in the second to fourth rows of Table 61.

[0068]

Through another analysis, densities g1 to g7 of garbage in consideration of consolidation of Layers I1 to I7 are calculated. For example, g1 denotes the density of garbage of Layer I1 in consideration of consolidation, g2 denotes the density of garbage of Layer I2 in consideration of consolidation, ..., and g7 denotes the density of garbage of Layer I7 in consideration of consolidation. When a distribution pattern (for example, Pattern 1) of garbage supplied to the furnace and the weighted moving average coefficients of the layers in the pattern are given (Table 61), a garbage density of this pattern is acquired by dividing the sum of values obtained by multiplying the garbage density gX (X=1 to 7) of the layers by the weighted moving average coefficient by the sum of the weighted moving average coefficients of the pattern. For example, in Pattern 1, the garbage density G when garbage in the range of Pattern 1 is supplied to the furnace can be calculated using Expression (1).

$$G=(g1 \times 0 + g2 \times 0 + g3 \times 0.01 + g4 \times 0.1 + g5 \times 0.04 + g6 \times 0 + g7 \times 0) / (0.01 + 0.1 + 0.04) \dots (1)$$

[0069]

The description will be continued below with reference to FIG. 7. Garbage layers I1 to I5 in the hopper 1 and the chute 2 are illustrated in the left diagram 70. In Diagram 71, the vertical axis represents density, and the vertical axis represents time. Polygonal line graph 71a indicate the density of Layer I5, the density of Layer I4, the

density of Layer I3, a density of Layer I2, and the density of Layer I1 sequentially from the left. These are referred to as Density A. Density A is the density of garbage in the uppermost layer at that time. For example, Density A indicates the density of garbage in the uppermost layer in a cycle in which the height of garbage decreases with supply of
 5 garbage to the furnace from time to time when garbage of Layer I5 is input at a certain time and garbage corresponding to Layer I4 is input to the hopper 1 at a certain height.
 [0070]

In Diagram 72, the vertical axis represents retention time and the horizontal axis represents time. Graph 72a indicates a retention time until garbage at each position
 10 (height) in Diagram 71 is supplied to the furnace. The retention time can be calculated by dividing a volume of garbage present from the position (height) of garbage to an entrance of the furnace at the corresponding time in Diagram 71 by average volume change rate per day.
 [0071]

15 Density B after the retention time calculated at each position of each layer has elapsed is calculated. Change of Density B is illustrated in Diagram 73. In Diagram 73, the vertical axis represents density, and the horizontal axis represents time. Density B is a density of garbage immediately before garbage is supplied to the furnace. For example, when garbage supplied to the furnace is in the range of Pattern 1, Density B is a
 20 density which can be calculated using Expression (1). When a position of "X1" min of Layer I4 in Diagram 72 is included in Pattern 1, it can be seen that garbage of Pattern 1 is input to the furnace after "X1" min has elapsed. Then, Density B after "X1" min can be calculated on the basis of Expression (1) using the weighted moving average coefficient of Pattern 1 in Table 61 illustrated in FIG. 6. Similarly, Density B in Other Pattern 2 or
 25 the like can be calculated. In this way, when garbage of a certain layer is input (at a

time point at which garbage of Layers I5 to I3 in Pattern 1 has been input), Density B after a predetermined retention time has elapsed can be calculated even in advance. The supply estimating unit 24 calculates the retention time until garbage input to the hopper 1 with respect to a predetermined time until the garbage is input to the furnace and Density B of garbage when the garbage is supplied to the furnace and acquires Graph 73a in Diagram 73. Then, the supply estimating unit 24 calculates the heating value on the basis of the calculated Density B at each time and the conversion expression. The calculated heating value is indicated by Graph 74a in Diagram 74. In this way, with Estimation method 2, the retention time of garbage, Density B in consideration of a distribution or consolidation of garbage, and a heating value corresponding to Density B can be estimated in advance.

[0072]

Sequences of Estimation method 2 will be described below. The supply estimating unit 24 estimates a heating value of garbage in the following sequences.

- 15 Distributions (I1 to I5) of garbage in the hopper 1 and the chute 2 illustrated in Diagram 60 and the like and information of patterns (Patterns 1 to 4) indicating the range of garbage supplied to the furnace are analyzed in advance and are recorded in the storage unit 27.

[0073]

- 20 (Sequence 1) The garbage height calculating unit 22 detects a distance from the sensor 15 to the garbage surface at each position on the whole garbage surface in the hopper 1 by LiDAR from time to time and calculates the height of garbage. The supply estimating unit 24 calculates the volume and the density of garbage.

[0074]

- 25 (Sequence 2) The supply estimating unit 24 calculates the estimated value of a

retention time by dividing the total volume of garbage remaining in the hopper by an average volume change rate ($\text{m}^3/\text{unit time}$) per day.

[0075]

(Sequence 3) On the basis of the calculated retention time and Diagram 62, the supply estimating unit 24 calculates the density of garbage input to the furnace after the retention time has elapsed using the consolidation and the weighted moving average coefficient of garbage in the hopper 1. For example, the supply estimating unit 24 selects one of garbage supply patterns 1 to 4. By applying a retention time corresponding to the selected pattern to the horizontal axis of Diagram 62, the weighted moving average coefficient is determined and a garbage density corresponding to the pattern is estimated. For example, when Pattern 1 is selected, the supply estimating unit 24 estimates the garbage density of Pattern 1 using Expression (1). The supply estimating unit 24 may analyze consolidation g_1 to g_7 of garbage at each distribution position required for the calculation and a relationship between an input time and an input proportion (Diagram 62) or may perform the calculation of Sequence 3 using information which has been separately analyzed.

[0076]

(Sequence 4) The supply estimating unit 24 selects a pattern of garbage supplied to the furnace. For example, the supply estimating unit 24 selects Pattern 1 as the pattern of garbage supplied to the furnace in the next time. The supply estimating unit 24 selects the garbage density of Pattern 1 estimated in Sequence 3.

[0077]

(Sequence 5) The supply estimating unit 24 estimates a heating value using the selected garbage density of the pattern and the conversion expression. The supply estimating unit 24 may estimate an input fuel flow rate (kJ/h) which is a flow rate of fuel

(garbage) supplied to the furnace.

[0078]

The retention time is calculated by dividing a garbage residual (volume) by the average volume change rate per day in Estimation method 2, but movement of garbage may be estimated on the basis of a change in volume from time to time, movement of garbage at a position of interest (for example, lowest garbage of Layer I4) to a position immediately before being input (for example, a position included in the range of Pattern 1) may be detected, and a heating value or a supply amount of garbage which is input in the next time may be estimated at a timing at which the garbage of interest reaches the position immediately before being input. With this method, antecedent control is started immediately before garbage is supplied to the combustion chamber 6, and it is possible to improve estimation accuracy.

[0079]

According to this embodiment, it is possible to perform more accurate estimation by estimating a heating value of garbage from a density of garbage (which may be a moisture content of garbage) supplied to the furnace which is calculated in consideration of a distribution of garbage or a retention time in the hopper using a change in volume of garbage based on a measured value of LiDAR and result data of a past change in volume.

[0080]

FIG. 8 is a diagram illustrating an example of a hardware configuration of the control device according to the embodiments.

A computer 900 includes a CPU 901, a main storage device 902, an auxiliary storage device 903, an input/output interface 904, and a communication interface 905.

The control device 20 is mounted on the computer 900. The aforementioned

functions are stored in the form of a program in the auxiliary storage device 903. The CPU 901 reads a program from the auxiliary storage device 903, loads the read program to the main storage device 902, and performs the processes in accordance with the program. The CPU 901 secures a storage area in the main storage device 902 in accordance with the program. The CPU 901 secures a storage area for storing data under processing in the auxiliary storage device 903 in accordance with the program.

[0081]

A program for realizing some or all functions of the control device 20 may be recorded on a computer-readable recording medium, and the program recorded on the recording medium may be read and executed by a computer system to perform the processes of the functional units. The “computer system” mentioned herein includes an operating system (OS) or hardware such as peripherals. The “computer system” includes a homepage provision environment (or a homepage display environment) when a WWW system is used. The “computer-readable recording medium” includes a portable medium such as a CD, a DVD, or a USB and a storage device such as a hard disk incorporated into a computer system. When the program is transmitted to the computer 900 via a communication line, the computer 900 receiving the program may load the program to the main storage device 902 and perform the processes. The program may be a program for realizing some of the aforementioned functions or may be a program for realizing the aforementioned functions in combination with a program recorded in advance in the computer system.

[0082]

While some embodiments of the present disclosure have been described above, these embodiments are presented merely as examples and are not intended to limit the scope of the invention. The embodiments can be modified in various forms, and can be

subjected to various omissions, substitutions, and modifications without departing from the gist of the invention. The embodiments or modifications thereof are included in the scope or gist of the invention and are also included in the inventions described in the appended claims and scopes equivalent thereto.

5 [0083]

<Remarks>

The control device 20 according to the embodiments can be understood, for example, as follows.

[0084]

10 (1) The control device 20 for incinerator equipment (garbage incineration equipment) according to a first aspect is a control device 20 for incinerator equipment 1 including a furnace (the combustion chamber 6 and the fire grate 3) that carries incinerated objects (garbage) while combusting the incinerated objects and a combustion
15 air supply unit (the dampers 8A to 8F, the air blower 4, and the damper 14A) that supplies combustion air to the furnace, the control device including a combustion air control unit (the control unit 26) configured to control the combustion air before the incinerated objects are input to the furnace on the basis of a supply amount or a heating value of the incinerated objects supplied to the furnace.

Accordingly, it is possible to form the atmosphere in the furnace (in the
20 combustion chamber 6) based on the supply amount or the heating value of garbage before the garbage is supplied to the furnace and to stabilize combustion in the furnace.

[0085]

(2) A control device 20 according to a second aspect is the control device 20 according to (1) further including a feeder configured to supply the incinerated objects to
25 the furnace and a feed control unit (the control unit 26) configured to control an operation

of the feeder on the basis of the supply amount or the heating value.

Accordingly, it is possible to adjust the supply amount of garbage on the basis of the supply amount or the heating value of the garbage at the time of supply of the garbage and to stability combustion in the furnace.

5 [0086]

(3) A control device 20 according to a third aspect is the control device 20 according to (1) or (2) further including an imaging means (the image sensor 16) configured to image a state in which the incinerated objects are input to the furnace and an estimation unit (the image estimating unit 23) configured to estimate the supply
10 amount or the heating value of the incinerated objects input to the furnace on the basis of image information acquired by the imaging means, wherein the combustion air control unit controls the combustion air (the primary combustion air and the secondary combustion air) on the basis of the supply amount or the heating value of the post-input incinerated objects estimated by the estimation unit.

15 By controlling the combustion air on the basis of the supply amount of garbage which has been actually supplied to the furnace, it is possible to stabilize combustion in the furnace with high accuracy.

[0087]

(4) The control device 20 according to a second aspect is the control device 20 according to any one of (1) to (3) further including a calculation unit (the supply
20 estimating unit) configured to detect a change in height of the incinerated objects in a hopper (in the hopper 1 and the chute 2) through three-dimensional measurement and to calculate the supply amount or the heating value immediately before the incinerated objects are supplied to the furnace on the basis of a consolidation (g1 to g7) of the
25 incinerated objects, a distribution (I1 to I7) of the incinerated objects in the hopper, and a

proportion (an input proportion) of the incinerated objects supplied to the furnace.

Accordingly, it is possible to estimate a supply amount or a heating value of garbage to be supplied before the garbage is actually supplied.

[0088]

5 (5) The control device 20 according to a fifth aspect is the control device 20 according to (4), wherein the calculation unit detects a distance to the whole surface of the incinerated objects using a Light Detection and Ranging (LiDAR) device, calculates the volume of the incinerated objects input to the hopper on the basis of a change in the distance, calculates the density on the basis of the weight and the volume of the
10 incinerated objects input to the hopper, performs comparison of correlation between the heating value estimated from the density of the incinerated objects supplied to the furnace in a predetermined period in the past and the heating value measured actually, estimates a retention time from inputting of the incinerated objects to the hopper to supplying of the incinerated objects to the furnace, and estimates the heating value after
15 the retention time has elapsed.

Accordingly, it is possible to estimate a heating value of garbage which is supplied to the furnace after the retention time has elapsed and to start control of primary combustion air before garbage is supplied to the furnace.

[Industrial Applicability]

20 [0089]

The present disclosure provides a control device for incinerator equipment that can solve the aforementioned problems.

[Reference Signs List]

[0090]

25 100 Garbage incineration equipment

	1 Hopper
	2 Chute
	3 Fire grate
	3A Drying area
5	3B Combustion area
	3C Subsequent combustion area
	4 Air blower
	5A to 5E Air box
	6 Combustion chamber
10	7 Ash outlet
	8A to 8E
	14A Damper
	9 Boiler
	10 Feeder
15	11 Steam flow sensor
	12 Gas duct
	13, 14 Pipe line
	15 Sensor (LiDAR)
	16 Image sensor
20	17 Crane
	17a Weight sensor
	18 Temperature sensor
	19 Oxygen concentration sensor
	20 Control device
25	21 Data acquiring unit

	22 Garbage height calculating unit
	23 Image estimating unit
	24 Supply estimating unit
	25 Determination unit
5	26 Control unit
	27 Storage unit
	900 Computer
	901 CPU
	902 Main storage device
10	903 Auxiliary storage device
	904 Input/output interface
	905 Communication interface

[CLAIMS]

What is claimed is:

[Claim 1]

A control device for incinerator equipment including a furnace that carries
5 incinerated objects while combusting the incinerated objects and a combustion air supply
unit that supplies combustion air to the furnace, the control device comprising:

a combustion air control unit configured to control the combustion air before the
incinerated objects are input to the furnace on the basis of a supply amount or a heating
value of the incinerated objects supplied to the furnace; and

10 a calculation unit configured to detect a change in height of the incinerated
objects in a hopper through three-dimensional measurement, to calculate a volume of the
incinerated objects input to the hopper on the basis of the change in height of the
incinerated objects, to calculate a density on the basis of a weight and the volume of the
incinerated objects input to the hopper, to perform comparison of correlation between the
15 heating value estimated from the density of the incinerated objects supplied to the
furnace in a predetermined period in the past and the heating value measured actually, to
estimate a retention time from inputting of the incinerated objects to the hopper to
supplying of the incinerated objects to the furnace, and to calculate the supply amount or
the heating value of the incinerated objects supplied to the furnace after the retention
20 time has elapsed on the basis of a consolidation of the incinerated objects, a distribution
of the incinerated objects in the hopper, and a proportion of the incinerated objects
supplied to the furnace,

wherein the combustion air control unit controls the combustion air based on the
supply amount or the heating value of the incinerated objects in a predetermined time
25 before the retention time estimated by the calculation unit elapses after the incinerated

objects have been input to the hopper.

[Claim 2]

The control device for incinerator equipment according to claim 1, further comprising:

- 5 a feeder configured to supply the incinerated objects to the furnace; and
 a feed control unit configured to control an operation of the feeder on the basis
of the supply amount or the heating value,

 wherein the feed control unit controls the feeder based on the supply amount or
the heating value of the incinerated objects in a predetermined time before the retention
10 time estimated by the calculation unit elapses after the incinerated objects have been
input to the hopper.

[Claim 3]

The control device for incinerator equipment according to claim 1 or 2, further comprising:

- 15 an imaging means configured to image a state in which the incinerated objects
are input to the furnace; and

 an image estimating unit configured to estimate the supply amount or the
heating value of the incinerated objects input to the furnace on the basis of image
information acquired by the imaging means,

20 wherein the combustion air control unit controls the combustion air on the basis
of the supply amount or the heating value of the post-input incinerated objects estimated
by the image estimating unit.

[Claim 4]

 The control device for incinerator equipment according to any one of claims 1 to
25 3,

wherein the combustion air control unit performs control such that the combustion air is decreased when the supply amount and/or the heating value of the incinerated objects supplied to the furnace after the retention time has elapsed increases by a predetermined value or more, and

5 wherein the combustion air control unit performs control such that the combustion air is increased when the supply amount and/or the heating value of the incinerated objects supplied to the furnace after the retention time has elapsed decreases by a predetermined value or more.

[Claim 5]

10 The control device for incinerator equipment according to claim 2 or 3,
 wherein the feeder control unit performs control such that an extrusion output and/or a moving speed of the feeder is decreased when the supply amount and/or the heating value of the incinerated objects supplied to the furnace after the retention time has elapsed increases by a predetermined value or more, and

15 wherein the feeder control unit performs control such that the extrusion output and/or the moving speed of the feeder is increased when the supply amount and/or the heating value of the incinerated objects supplied to the furnace after the retention time has elapsed decreases by a predetermined value or more.

[Claim 6]

20 The control device for incinerator equipment according to claim 2 or 3,
 wherein the feeder control unit performs control such that the extrusion output and/or the moving speed of the feeder is decreased after the combustion air has been controlled and in a predetermined time before the estimated retention time has elapsed when the supply amount and/or the heating value of the incinerated objects supplied to
25 the furnace after the retention time has elapsed increases by a predetermined value or

more, and

wherein the feeder control unit performs control such that the extrusion output and/or the moving speed of the feeder is increased after the combustion air has been controlled and in a predetermined time before the estimated retention time has elapsed
5 when the supply amount and/or the heating value of the incinerated objects supplied to the furnace after the retention time has elapsed decreases by a predetermined value or more.