

DESCRIPTION

TITLE OF INVENTION: CONTROL APPARATUS

5 Technical Field

[0001] The present disclosure relates to a control apparatus.

 Priority is claimed on Japanese Patent Application No. 2021-169507, filed October 15, 2021, the content of which is incorporated herein by reference.

10 Background Art

[0002] Patent Document 1 discloses a combustion control method that enables waste combustion control without time delay by acquiring information indicating a current combustion state in real time and predicting a combustion heating amount and a boiler evaporation amount on the basis of this information. In this combustion control

15 method, the carbon, hydrogen, and moisture in the waste which are directly related to the heating value of the waste that becomes fuel are obtained from the composition of an exhaust gas immediately after combustion acquired in real time and an oxygen consumption amount, a combustion heating amount, a latent heat amount, and a waste amount (processed amount) are calculated on the basis of these materials.

20 [0003] Patent Document 2 discloses an evaporation amount control method of acquiring videos of a flame reaching a secondary combustion zone from a primary combustion zone using a plurality of imaging devices with different viewpoints and performing an image compositing process on the plurality of acquired videos taken from different viewpoints to generate a 3D video that includes flames in the secondary combustion
25 zone. In this evaporation amount control method, the 3D video is analyzed to calculate

a temporal change in flame flow velocity along a flow path of combustion gas generated in primary combustion or secondary combustion and to obtain an index of a heating amount currently generated in a combustion chamber.

[0004] Patent Document 3 discloses a combustion control method of observing at least waste accumulated in a drying section and a combustion section through a filter that selectively transmits light of a wavelength not radiated by a flame using a plurality of infrared cameras to acquire a plurality of thermal images with different viewpoints and to generate a 3D thermal image on the basis of the plurality of thermal images. In this combustion control method, a thickness progress information indicating how the thickness of the waste has changed over time is calculated on the basis of the 3D thermal image, a combustion correction coefficient is determined on the basis of a change in volumetric flow rate of the waste from the past to the present, and an index of the heating amount generated from the waste is calculated.

15 Citation List

Patent Document

[0005]

Patent Document 1: Japanese Unexamined Patent Application, First Publication
No. 2017-096517

20 Patent Document 2: Japanese Unexamined Patent Application, First Publication
No. 2019-219108

Patent Document 3: Japanese Unexamined Patent Application, First Publication
No. 2021-067381

25 Summary of Invention

Technical Problem

[0006] Incidentally, the main steam flow rate may vary greatly depending on the state of the incineration material. Therefore, in the techniques described in Patent Documents 1 to 3, it may be difficult to perform combustion control on the basis of a highly accurate prediction value of the main steam flow rate.

[0007] The present disclosure has been made to solve the above-described problems and an object of the present disclosure is to provide a control apparatus capable of performing combustion control on the basis of a highly accurate prediction value of a main steam flow rate.

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Solution to Problem

[0008] In order to achieve the aforementioned objects, a control apparatus according to the present disclosure includes an information acquisition unit, a steam flow rate prediction unit, and a control unit. The information acquisition unit acquires information related to an incineration material before being supplied to a processing space inside an incineration facility. The steam flow rate prediction unit predicts a main steam flow rate generated by a boiler of an incineration facility on the basis of prediction information including information acquired by the information acquisition unit. The control unit performs combustion control on the basis of the main steam flow rate predicted by the steam flow rate prediction unit.

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Advantageous Effects of Invention

[0009] According to the control apparatus of the present disclosure, combustion control can be performed on the basis of a highly accurate prediction value of a main steam flow rate.

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Brief Description of Drawings

[0010] FIG. 1 is a schematic configuration diagram showing the overall incineration facility according to an embodiment of the present disclosure.

5 FIG. 2 is a block diagram showing a functional configuration of a combustion facility according to an embodiment of the present disclosure.

 FIG. 3 is a block diagram showing a functional configuration of a data conversion unit according to an embodiment of the present disclosure.

 FIG. 4 is a diagram showing a correlation between an estimation value of a
10 garbage heating value based on the detection result of a moisture measuring device according to an embodiment of the present disclosure and a garbage heating value confirmed in an actual machine.

 FIG. 5 is a diagram showing an example of a process by a first feature amount extraction unit according to an embodiment of the present disclosure.

15 FIG. 6 is a diagram showing an example of a process by an image conversion unit according to an embodiment of the present disclosure.

 FIG. 7 is a diagram showing an example of a process by a garbage layer height detection unit according to an embodiment of the present disclosure.

 FIG. 8 is a diagram showing an example of a correlation between each input
20 information and a main steam flow rate according to an embodiment of the present disclosure.

 FIG. 9 is a diagram showing an example of time delay setting values for each input information according to an embodiment of the present disclosure.

 FIG. 10 is a diagram showing an example of an evaluation process by a
25 prediction model determination unit according to an embodiment of the present

disclosure.

FIG. 11 is a diagram showing an example of control contents by a control unit according to an embodiment of the present disclosure.

FIG. 12 is a flowchart showing a flow of a prediction model generation process according to an embodiment of the present disclosure.

FIG. 13 is a flowchart showing a process flow of an operation stage of a combustion facility according to an embodiment of the present disclosure.

FIG. 14 is a diagram showing an example of a comparison result between a prediction value and an actual measurement value of a main steam flow rate according to an embodiment of the present disclosure.

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

Description of Embodiments

[0011] Hereinafter, a control apparatus according to an embodiment of the present disclosure will be described with reference to the drawings. In the following description, components with the same or similar functions are designated by the same reference numerals. Then, duplicate descriptions of these configurations may be omitted. In the present disclosure, "based on XX" means "based on at least XX" and may include cases based on another element in addition to XX. Furthermore, "based on XX" is not limited to the case where XX is used directly, but may also include the case based on calculations or a process performed on XX. In the present disclosure, "XX or YY" is not limited to either XX or YY, but may include both XX and YY. This also applies to the case where there are three or more selective elements. "XX" and "YY" are arbitrary elements (for example, arbitrary information).

[0012] (Embodiment)

<1. Overall configuration of incineration facility>

FIG. 1 is a schematic configuration diagram showing an overall configuration of an incineration facility SF according to an embodiment. The incineration facility SF is, for example, a stoker furnace whose incineration material G is municipal garbage, industrial waste, or biomass. In the following, for convenience of description, the "incineration material G" will be referred to as "garbage G". Furthermore, the incineration facility SF is not limited to the stoker furnace, and may be another type of incineration facility. In this embodiment, the incineration facility SF includes, for example, a crane 1, an incinerator 2, an exhaust heat recovery boiler 3, a cooling tower 4, a dust collector 5, a flue 6, a chimney 7, and a control apparatus 100.

[0013] The crane 1 carries the garbage G stored in the garbage pit to a hopper 11 of the incinerator 2 to be described later and charges the garbage into the hopper 11. The crane 1 includes a gripper 1a that grips the garbage G and a weight sensor 1b that is provided on the gripper 1a. The weight sensor 1b is, for example, a load cell. The weight sensor 1b detects the weight of the garbage G gripped by the gripper 1a when the garbage G is gripped and lifted by the gripper 1a. The detection result of the weight sensor 1b is transmitted to the control apparatus 100. The detection result of the weight sensor 1b is an example of "information indicating the garbage G before being supplied to the processing space V" and an example of "information indicating the properties of the garbage G".

[0014] In the present disclosure, "information indicating the properties of the garbage G" means information indicating the nature or condition of the garbage G. In addition, in the present disclosure, "information indicating the properties of the garbage G" is not limited to information that directly indicates the properties of the garbage G, but may be

information used to specify the properties of the garbage G (for example, information that can specify the properties of the garbage G by combining with other information) and the like. For example, the weight of garbage G is information that can specify the density of the garbage G when combined with the volume of the garbage G to be described later. The density of the garbage G is an example of the properties of the garbage G.

[0015] The incinerator 2 is a furnace that burns the garbage G put into the hopper 11 to be described later while conveying the garbage. As the garbage G is burned in the incinerator 2, an exhaust gas is generated in the incinerator 2. The generated exhaust gas is sent to the exhaust heat recovery boiler 3 provided at the upper part of the incinerator 2. The exhaust heat recovery boiler 3 performs heat exchange between the exhaust gas generated in the incinerator 2 and water to heat the water and generate steam.

[0016] The exhaust gas that has passed through the exhaust heat recovery boiler 3 is cooled in the cooling tower 4 and then sent to the dust collector 5. After soot and dust are removed from the exhaust gas by the dust collector 5, the exhaust gas is discharged into the atmosphere through the flue 6 and the chimney 7. The flue 6 is provided with a gas concentration sensor 6a. The gas concentration sensor 6a detects the concentration of various gases (for example, oxygen concentration) contained in the exhaust gas flowing through the flue 6. Furthermore, the detection result of the gas concentration sensor 6a may include one or more of CO concentration, NO_x concentration, and SO_x concentration instead of or in addition to oxygen concentration. The detection result of the gas concentration sensor 6a is transmitted to the control apparatus 100.

[0017] <2. Incinerator>

Next, the incinerator 2 will be described in detail. The incinerator 2 includes, for example, a supply mechanism 10, a furnace body 20, a stoker 30, a wind box 41, a

discharge chute 42, a furnace 43, and a blower mechanism 50.

[0018] <2.1 Supply mechanism>

The supply mechanism 10 is a mechanism that temporarily stores the garbage G carried by the crane 1 and sequentially supplies the garbage toward the processing space V of the furnace body 20 to be described later. The supply mechanism 10 includes, for example, a hopper 11, a feeder 12, an extrusion device 13 (see FIG. 2), an object measuring device 14, and a moisture measuring device 15.

[0019] The hopper 11 is a storage unit provided to supply the garbage G to the inside of the furnace body 20. The garbage G carried by the crane 1 is thrown into the hopper 11. The hopper 11 includes an inlet portion 11a and an outlet portion 11b. The inlet portion 11a is an inlet part through which the garbage G is thrown in from the outside. For example, the inlet portion 11a extends in the vertical direction. The garbage G thrown into the inlet portion 11a moves downward due to gravity. The outlet portion 11b is provided below the inlet portion 11a. The outlet portion 11b is an outlet part which guides the garbage G supplied from the inlet portion 11a toward the processing space V inside the furnace body 20 which will be described later. The outlet portion 11b extends, for example, in the horizontal direction.

[0020] The feeder 12 is provided at the outlet portion 11b of the hopper 11. The feeder 12 has a plate shape along the bottom portion of the outlet portion 11b of the hopper 11 and is disposed along the bottom portion of the outlet portion 11b of the hopper 11. The feeder 12 is movable forward and backward in the direction from the outlet portion 11b of the hopper 11 toward the processing space V of the furnace body 20. The feeder 12 is driven by the extrusion device 13 and pushes out the garbage G accumulated inside the hopper 11 (for example, the outlet portion 11b of the hopper 11) toward the processing space V of the furnace body 20.

[0021] The object measuring device 14 is a measuring device that detects the height of the garbage G thrown into the hopper 11 by the crane 1. The object measuring device 14 is, for example, LiDAR (Light Detection and Ranging). The object measuring device 14 is provided, for example, at the inlet portion 11a of the hopper 11, and detects the height of the garbage GM passing through the inlet portion 11a of the hopper 11. Furthermore, the object measuring device 14 may directly detect the volume of the garbage G by three-dimensional measurement instead of the height of the garbage G. The detection result of the object measuring device 14 is transmitted to the control apparatus 100. The detection result of the object measuring device 14 is an example of "information indicating the garbage G before being supplied to the processing space V" and an example of "information indicating the properties of the garbage G".

[0022] The moisture measuring device 15 is a measuring device that detects a value related to moisture (for example, moisture content or moisture amount) contained in the garbage G thrown into the hopper 11. In this embodiment, the moisture measuring device 15 includes an irradiation unit and a detection unit provided in the hopper 11, and an analysis unit. The irradiation unit irradiates the garbage G accumulated in the hopper 11 with electromagnetic waves in a predetermined frequency band. The detection unit receives the electromagnetic waves irradiated from the irradiation unit and transmitted through the garbage G or reflected by the garbage G. For example, the analysis unit stores in advance correlation information indicating the correlation between a change in the characteristics of the electromagnetic wave (for example, a change in amplitude or a change in phase) and the moisture content. The analysis unit detects the moisture content contained in the garbage G on the basis of the change in the characteristics of the electromagnetic waves between the irradiation unit and the detection unit and the above correlation information.

[0023] In this embodiment, the irradiation unit and the detection unit of the moisture measuring device 15 are provided slightly above the feeder 12 and detect the moisture content of the garbage G accumulated on the upper surface of the feeder 12. The detection result of the moisture measuring device 15 is transmitted to the control

5 apparatus 100. The detection result of the moisture measuring device 15 is an example of "information indicating the garbage G before being supplied to the processing space V", an example of "information indicating the properties of the garbage G", and an example of "moisture measurement results in the hopper 11".

[0024] <2.2 Furnace body>

10 The furnace body 20 is a facility that is provided adjacent to the hopper 11 and burns the garbage G while conveying the garbage. Hereinafter, the conveying direction of the garbage G in the combustion facility F will be referred to as the "conveying direction D". The furnace body 20 includes a drying stage 20a, a combustion stage 20b, and a post-combustion stage 20c in this order from the upstream side to the downstream

15 side in the conveying direction D. The drying stage 20a is a region which is located on the upstream side of the combustion stage 20b and the post-combustion stage 20c and in which the garbage G supplied from the hopper 11 is dried before being burned on the stoker 30. The combustion stage 20b and the post-combustion stage 20c are regions in which the dried garbage G that has passed through the drying stage 20a is burned on the

20 stoker 30. In the combustion stage 20b, diffusion combustion occurs due to the pyrolysis gas generated from the garbage G, and a luminous flame F is generated. In the post-combustion stage 20c, combustion of fixed carbon occurs after diffusion combustion of the garbage G, so no luminous flame F is generated. The combustion stage 20b and the post-combustion stage 20c are an example of the processing space V in

25 which the garbage G is burned. The drying stage 20a is an example of a region on the

upstream side of the processing space V in the conveying direction D.

[0025] In this embodiment, the furnace body 20 includes a visible light camera 21 and an infrared camera 22. The visible light camera 21 and the infrared camera 22 are arranged on the downstream side of the processing space V in the conveying direction D and capture an image on the upstream side in the conveying direction D from the downstream side. In this embodiment, the visible light camera 21 and the infrared camera 22 are provided at the downstream end of the furnace body 20 in the conveying direction D (hereinafter, referred to as the "furnace tail"). For example, the visible light camera 21 and the infrared camera 22 capture an image on the upstream side in the conveying direction D from the downstream side through a window portion provided at the furnace tail of the furnace body 20. For example, the visible light camera 21 and the infrared camera 22 are arranged adjacent to each other vertically or horizontally.

[0026] The visible light camera 21 captures an image of the luminous flame F from the furnace tail of the furnace body 20. The image capturing result of the visible light camera 21 is transmitted to the control apparatus 100.

[0027] The infrared camera 22 captures an image of the garbage G accumulated on the drying stage 20a of the furnace body 20 (that is, the upstream side of the processing space V) from the furnace tail of the furnace body 20 through the luminous flame F. Further, in this embodiment, the infrared camera 22 captures an image of the outlet portion 11b of the hopper 11 from the furnace tail of the furnace body 20 through the luminous flame F. For example, the infrared camera 22 captures an image including the garbage G accumulated on the feeder 12 (an image indicating the accumulation state of the garbage G) in the outlet portion 11b of the hopper 11. The image capturing result of the infrared camera 22 is transmitted to the control apparatus 100. The image capturing result of the infrared camera 22 is an example of "information indicating the garbage G

before being supplied to the processing space V" and is an example of "accumulation state information indicating the accumulation state of the garbage G in the hopper 11".

[0028] Furthermore, in this embodiment, an image including both the drying stage 20a of the furnace body 20 and the outlet portion 11b of the hopper 11 (for example, the garbage G accumulated on the feeder 12) is captured by one infrared camera 22.

Instead, the furnace body 20 may separately include a first infrared camera which captures an image of the drying stage 20a of the furnace body 20 and a second infrared camera which captures an image of the outlet portion 11b of the hopper 11 (for example, the garbage G accumulated on the feeder 12). Further, the infrared camera 22 may be provided at a different position instead of the furnace tail of the furnace body 20.

[0029] <2.3 Stoker>

The stoker 30 includes a plurality of grates 31 and a grate drive device 32 (see FIG. 2). The plurality of grates 31 form a stoker surface 30a which serves as a bottom surface of the furnace body 20 (for example, a bottom surface of the processing space V).

The garbage G is supplied in layers to the stoker surface 30a by the supply mechanism 10. The stoker surface 30a is provided across the drying stage 20a, the combustion stage 20b, and the post-combustion stage 20c described above. The plurality of grates 31 include a fixed grate and a movable grate. The fixed grate is fixed onto the upper surface of the wind box 41 to be described later. The movable grate conveys the garbage G on the movable grate and the fixed grate (on the stoker surface 30a) while stirring and mixing the garbage by reciprocating along the conveying direction D at a constant speed.

[0030] <2.4 Wind box, discharge chute, and furnace>

The wind box 41 is provided below the stoker 30 and supplies combustion air into the furnace body 20 through the stoker 30. A plurality of the wind boxes 41 are

arranged in the conveying direction D. The wind box 41 includes a wind box pressure sensor 41a. The wind box pressure sensor 41a detects the pressure inside the wind box 41. The pressure inside the wind box 41 corresponds to the pressure of the combustion air supplied into the furnace body 20 through a primary air line 52 to be described later.

5 The detection result of the wind box pressure sensor 41a is transmitted to the control apparatus 100.

[0031] The discharge chute 42 is a device that allows the garbage G that has become ash after combustion to fall to an ash extrusion device located below the furnace body 20. The discharge chute 42 is provided at the furnace tail of the furnace body 20.

10 [0032] The furnace 43 extends upward from the top of the furnace body 20. An exhaust gas generated by the combustion of the garbage G inside the processing space V is sent to the exhaust heat recovery boiler 3 through the furnace 43.

[0033] <2.5 Blower mechanism>

The blower mechanism 50 supplies air (for example, combustion air) into the
15 furnace body 20. The blower mechanism 50 includes, for example, a blower 51, a primary air line 52, an air preheater 53, a secondary air line 54, a damper 55, and an air flow rate sensor 56.

[0034] The blower 51 is a forced blower that pressure-feeds air (for example, combustion air) into the furnace body 20. The blower 51 includes, for example, a first
20 blower 51A and a second blower 51B. The first blower 51A pressure-feeds combustion air toward the inside of the furnace body 20 (for example, the processing space V) through the primary air line 52 and the wind box 41. The second blower 51B pressure-feeds combustion air into the furnace 43 through the secondary air line 54.

[0035] The primary air line 52 connects the first blower 51A and the wind box 41.

25 One or more (for example, a plurality of) primary air dampers 55A are provided in the

middle of the primary air line 52. The primary air damper 55A changes the flow rate of the combustion air flowing through the primary air line 52 by the opening degree of the primary air damper 55A.

[0036] The air preheater 53 is a heat exchanger that preheats the air pressure-fed from the first blower 51A. For example, the air preheater 53 is provided in the middle of the primary air line 52.

[0037] The secondary air line 54 connects the second blower 51B and the furnace 43. The secondary air supplied into the furnace 43 is directed toward the garbage G from above the stoker 30. One or more (for example, a plurality of) secondary air dampers 55B are provided in the middle of the secondary air line 54. The secondary air damper 55B changes the flow rate of the combustion air flowing through the secondary air line 54 by the opening degree of the secondary air damper 55B. In the following, for convenience of description, the primary air damper 55A and the secondary air damper 55B are collectively referred to as a "damper 55."

[0038] The air flow rate sensor 56 detects the flow rate of the air (for example, combustion air) supplied into the furnace body 20. The air flow rate sensor 56 includes, for example, a first air flow rate sensor 56A and a second air flow rate sensor 56B. The first air flow rate sensor 56A is provided in the middle of the primary air line 52 and detects the flow rate of the air supplied through the primary air line 52. The second air flow rate sensor 56B is provided in the middle of the secondary air line 54 and detects the flow rate of the air supplied through the secondary air line 54. In the following description, "the detection result of the air flow rate sensor 56" includes, for example, the detection result of the first air flow rate sensor 56A and the detection result of the second air flow rate sensor 56B.

[0039] <3. Exhaust heat recovery boiler>

Next, the exhaust heat recovery boiler 3 will be described. The exhaust heat recovery boiler 3 includes, for example, a boiler body 61, a pipe line 62, a radiation temperature sensor (infrared temperature sensor) 63, a furnace pressure sensor 64, a feed water flow rate sensor 65, and a superheater/desuperheater flow rate sensor (steam flow rate sensor) 66.

[0040] The boiler body 61 is connected to the furnace 43 of the incinerator 2. An exhaust gas generated by the incinerator 2 flows into the boiler body 61. The radiation temperature sensor 63 and the furnace pressure sensor 64 are provided in the boiler body 61. The radiation temperature sensor 63 detects the temperature inside the boiler body 61. The furnace pressure sensor 64 detects the pressure inside the boiler body 61. The detection results of the radiation temperature sensor 63 and the furnace pressure sensor 64 are transmitted to the control apparatus 100.

[0041] The pipe line 62 extends inside the boiler body 61. The pipe line 62 is provided with a plurality of superheaters and a plurality of desuperheaters. Water is supplied from a water supply portion to the inlet portion of the pipe line 62. At least a part of the water flowing through the pipe line 62 is heated by heat exchange inside the boiler body 61, becomes main steam, and flows toward an external device (for example, turbine). The "main steam flow rate" described below means the flow rate of steam flowing from the pipe line 62 toward the external device (for example, turbine).

[0042] The feed water flow rate sensor 65 is provided at the inlet portion of the pipe line 62 and detects the flow rate of the water supplied to the pipe line 62. The superheater/desuperheater flow rate sensor 66 is provided in the middle of the pipe line 62 and detects the flow rate of the fluid (for example, steam) flowing through the pipe line 62. For example, the superheater/desuperheater flow rate sensor 66 includes a first superheater/desuperheater flow rate sensor 66A which detects the flow rate of the fluid

passing through the primary desuperheater (primary superheater/desuperheater flow rate) and a second superheater/desuperheater flow rate sensor 66B which detects the flow rate of the fluid passing through the secondary desuperheater (secondary superheater/desuperheater flow rate). In the following description, “the detection result of the superheater/desuperheater flow rate sensor 66” includes, for example, the detection result of the first superheater/desuperheater flow rate sensor 66A and the detection result of the second superheater/desuperheater flow rate sensor 66B. The detection results of the feed water flow rate sensor 65 and the superheater/desuperheater flow rate sensor 66 are transmitted to the control apparatus 100.

10 [0043] <4. Control apparatus>

Next, the control apparatus 100 will be described.

FIG. 2 is a block diagram showing a functional configuration of the incineration facility SF according to the embodiment. The control apparatus 100 centrally controls the incineration facility SF. For example, the control apparatus 100 performs combustion control of the garbage G in the processing space V of the furnace body 20. In this embodiment, the control apparatus 100 includes, for example, an information acquisition unit 110, a data conversion unit 120, a prediction model generation unit 130, a prediction model determination unit 140, a steam flow rate prediction unit 150, and a control unit 160. Devices to be controlled by the control apparatus 100 (hereinafter, referred to as “control target devices S”) include the above-described extrusion device 13, blower 51, damper 55, grate drive device 32, and the like.

20 [0044] <4.1 Information acquisition unit>

The information acquisition unit 110 acquires detection results and the like detected by the various sensors described above included in the incineration facility SF. For example, the information acquisition unit 110 acquires the detection result of the

weight sensor 1b (garbage weight), the detection result of the object measuring device 14 (garbage height), the detection result of the moisture measuring device 15 (garbage moisture detection result), the image capturing result of the visible light camera 21 (combustion flame image), the image capturing result of the infrared camera 22 (garbage layer image), the detection result of the wind box pressure sensor 41a (wind box pressure), the detection result of the air flow rate sensor 56 (forced air flow rate), the detection result of the radiation temperature sensor 63 (furnace temperature), the detection result of the furnace pressure sensor 64 (furnace pressure), the detection result of the feed water flow rate sensor 65 (feed water flow rate), the detection result of the superheater/desuperheater flow rate sensor 66 (superheater/desuperheater flow rate), and the detection result of the gas concentration sensor 6a (oxygen concentration or the like).

[0045] Here, one or more of the detection result of the wind box pressure sensor 41a, the detection result of the air flow rate sensor 56, the detection result of the radiation temperature sensor 63, the detection result of the furnace pressure sensor 64, the detection result of the feed water flow rate sensor 65, the detection result of the superheater/desuperheater flow rate sensor 66, and the detection result of the gas concentration sensor 6a described above are included in process data to be described

later. Each of these detection results corresponds to an example of "prediction information" together with the detection result of the weight sensor 1b, the detection result of the object measuring device 14, the detection result of the moisture measuring device 15, the image capturing result of the visible light camera 21, and the image capturing result of the infrared camera 22 described above. In the present disclosure, "acquiring" is not limited to actively acquiring information by outputting a transmission request, but also includes acquiring information transmitted from various devices by passively receiving the information. This definition also applies in the following

descriptions.

[0046] Further, the information acquisition unit 110 acquires process values indicating the state of each device included in the control target device S as a part of process data to be described later. For example, the control target device S acquires the process value
 5 indicating the state of the extrusion device 13 (for example, the stroke length of the feeder 12 and/or the moving speed of the feeder 12, the process value indicating the state of the blower 51 (for example, the rotation speed of the blower 51), the process value indicating the state of the damper 55 (for example, the opening degree of the damper 55), and the process value indicating the state of the grate drive device 32 (for example, the
 10 moving speed of the grate 31) as a part of the process data. Each of these process data (process values) is an example of "prediction information". The process value indicating the state of the extrusion device 13 (for example, the stroke length of the feeder 12 and/or the moving speed of the feeder 12) is an example of "information indicating the operation of the feeder 12" and is an example of "supply state information
 15 indicating the supply state of the garbage G from the hopper 11 to the processing space V". The information acquisition unit 110 outputs the acquired various information and process data to the data conversion unit 120.

[0047] <4.2 Data conversion unit>

The data conversion unit 120 performs predetermined data conversion on the
 20 information received from the information acquisition unit 110. For example, the data conversion unit 120 performs feature amount extraction, time delay adjustment, an averaging process, and the like as predetermined data conversion.

[0048] FIG. 3 is a block diagram showing a functional configuration of the data conversion unit 120 according to the embodiment. The data conversion unit 120
 25 includes, for example, a first heating value estimation unit 121, a second heating value

estimation unit 122, a first feature amount extraction unit 123, an oxygen concentration estimation unit 124, a flammability coefficient calculation unit 125, an image conversion unit (image processing unit) 126, a garbage layer height detection unit 127, a second feature amount extraction unit 128, a feeder supply amount estimation unit 129, and an
5 adjustment processing unit PU.

[0049] (First heating value estimation unit)

The detection result of the weight sensor 1b (garbage weight) and the detection result of the object measuring device 14 (garbage height) are input to the first heating value estimation unit 121. The first heating value estimation unit 121 calculates the
10 volume of the garbage G on the basis of the height of the garbage G (for example, the height of the garbage G and the size of the gripper 1a of the crane 1). Then, the first heating value estimation unit 121 calculates the density of the garbage G by dividing the weight of the garbage G by the volume of the garbage G. Further, the first heating value estimation unit 121 has correlation information indicating the correlation between
15 the density of the garbage G and the heating value of the garbage G (for example, lower heating value LHV) (hereinafter, referred to as “garbage heating value”). The correlation information is, for example, a heating value estimation formula that calculates the estimation value of the garbage heating value from the density of the garbage G. The first heating value estimation unit 121 calculates the estimation value of the garbage
20 heating value on the basis of the calculated density of the garbage G and the above correlation information. The first heating value estimation unit 121 outputs the calculated estimation value of the garbage heating value to the adjustment processing unit PU.

[0050] Here, the density in this embodiment means, for example, bulk density. Bulk
25 density is not the density inherent to the object (true density), but is the density calculated

from the "weight per unit volume including voids". However, the first heating value estimation unit 121 may estimate and use the true density instead of or in addition to the bulk density. Furthermore, the density of the garbage G calculated by the first heating value estimation unit 121 is based on the weight and the like measured outside the hopper 11, but corresponds to the density of the garbage G inside the hopper 11. Therefore, the density of the garbage G calculated by the first heating value estimation unit 121 corresponds to an example of "the density of the garbage G inside the hopper 11".

[0051] (Second heating value estimation unit)

The detection result of the moisture measuring device 15 (garbage moisture detection result) is input to the second heating value estimation unit 122. Furthermore, the volume of the garbage G calculated by the first heating value estimation unit 121 may be further input to the second heating value estimation unit 122. When the volume of the garbage G is input, the second heating value estimation unit 122 can calculate the moisture amount of the garbage G by multiplying the moisture content of the garbage G by the volume of the garbage G. The second heating value estimation unit 122 has correlation information indicating the correlation between the value related to the moisture of the garbage G (moisture content or moisture amount) and the garbage heating value (for example, lower heating value). The correlation information is, for example, a heating value estimation formula that calculates the estimation value of the garbage heating value from the value related to the moisture of the garbage G. The second heating value estimation unit 122 calculates the estimation value of the garbage heating value on the basis of the value related to the moisture of the garbage G and the correlation information. The second heating value estimation unit 122 outputs the calculated estimation value of the garbage heating value to the adjustment processing unit PU.

[0052] Here, FIG. 4 is a diagram showing the correlation between the estimation value of the garbage heating value based on the detection result of the moisture measuring device 15 and the garbage heating value confirmed in an actual machine. As shown in FIG. 4, the present inventors found that there is a sufficiently high correlation between the estimation value of the garbage heating value based on the detection result of the moisture measuring device 15 and the garbage heating value confirmed in an actual machine. Further, since the estimation value of the garbage heating value based on the detection result of the moisture measuring device 15 is information that precedes the heating value of the garbage G confirmed in an actual machine, the inventors have found that the correlation between the estimation value of the garbage heating value based on the detection result of the moisture measuring device 15 and the garbage heating value confirmed in an actual machine can be increased by considering the time delay.

[0053] (First feature amount extraction unit)

The photographic result of the visible light camera 21 (combustion flame image) is input to the first feature amount extraction unit 123. The first feature amount extraction unit 123 performs a clustering process on the input combustion flame image to convert the image into color image data IM (see FIG. 5) divided into a plurality of color regions according to color information. Then, the first feature amount extraction unit 123 extracts a feature related to the flame state based on the color image data IM.

[0054] An example of "dividing an image into a plurality of color regions according to color information using a clustering process" will be described. The color information is each color component of RGB, and each of the plurality of color regions is set by a clustering process so that each color component of RGB does not overlap with each other. The first feature amount extraction unit 123 decomposes the combustion flame image into RGB color components for each pixel, and determines the color region in

which each pixel is included. Furthermore, the color information is not limited to each color component of RGB, and may be brightness or saturation.

[0055] The algorithm for the clustering process is not particularly limited, and various known clustering algorithms can be used. For example, the clustering process may be performed using an algorithm such as k-means that allows the number of clusters to be specified, or may be performed using an algorithm such as flowsom that automatically determines the number of clusters.

[0056] FIG. 5 is a diagram showing an example of color image data IM. In the color image data IM shown in FIG. 5, seven color regions A are divided by the clustering process and a first color region A1, a second color region A2, a third color region A3, a fourth color region A4, a fifth color region A5, a sixth color region A6, and a seventh color region A7 are included in order of brightness. Each of the first color region A1 to the seventh color region A7 is converted into a black and white (gray scale) shading value, which becomes darker as it progresses from the first color region A1 to the seventh color region A7.

[0057] Next, an example of "extracting feature amount from color image data IM" will be described. The first feature amount extraction unit 123 calculates the total number of pixels (for example, area) divided into the first color region A1, and extracts this total number of pixels as a feature. For example, the first feature amount extraction unit 123 extracts the total number of pixels in the first color region A1 at predetermined intervals (for example, every second). The first feature amount extraction unit 123 also calculates the total number of pixels for each of the second to seventh color regions A2 to A7 at predetermined time intervals, and extracts each total number of pixels as a feature. Furthermore, in this embodiment, the feature amount includes the total number of pixels of all color regions (first color region A1 to seventh color region A7) among the plurality

of color regions, but the present disclosure is not limited to this form. The feature amount may include the total number of pixels of at least one color region among the plurality of color regions.

[0058] The first feature amount extraction unit 123 outputs the extracted feature amount related to the flame state to the oxygen concentration estimation unit 124 and also outputs the feature amount to the adjustment processing unit PU. Furthermore, a method of extracting the feature amount by the first feature amount extraction unit 123 is not limited to clustering, and may be another method.

[0059] (Oxygen concentration estimation unit)

A part or all of the feature amount extracted by the first feature amount extraction unit 123 and the process data obtained by the information acquisition unit 110 are input to the oxygen concentration estimation unit 124. The process data input to the oxygen concentration estimation unit 124 is, for example, one or more of the detection result of the wind box pressure sensor 41a, the detection result of the air flow rate sensor 56, the detection result of the radiation temperature sensor 63, the detection result of the furnace pressure sensor 64, the detection result of the feed water flow rate sensor 65, the detection result of the superheater/desuperheater flow rate sensor 66, and the detection result of the gas concentration sensor 6a. The oxygen concentration estimation unit 124 derives an estimation formula for estimating the oxygen concentration in the processing space V by performing regression analysis using machine learning based on the input feature amount and process data. Then, the oxygen concentration estimation unit 124 calculates the estimation value of the oxygen concentration in the processing space V in real time on the basis of the input feature amount and process data and the above estimation formula. The oxygen concentration estimation unit 124 outputs the estimation value of the calculated oxygen concentration to the flammability coefficient

calculation unit 125. Furthermore, the method of deriving the above estimation formula by the oxygen concentration estimation unit 124 is not limited to regression analysis, and may be another method. Further, the machine learning algorithm is not particularly limited, and various known algorithms can be used.

5 [0060] (Flammability coefficient calculation unit)

A part or all of the estimation value of the oxygen concentration calculated by the oxygen concentration estimation unit 124 and the process data obtained by the information acquisition unit 110 are input to the flammability coefficient calculation unit 125. The process data input to the oxygen concentration estimation unit 124 is, for
10 example, one or more of the detection result of the radiation temperature sensor 63 and the moving speed of the feeder 12. In this embodiment, the flammability coefficient calculation unit 125 calculates a flammability coefficient that quantifies the combustion state of the processing space V based on the estimation value of the oxygen concentration, the detection result of the radiation temperature sensor 63, the amount of
15 change in the moving speed of the feeder 12, and the like. The flammability coefficient calculation unit 125 outputs the calculated flammability coefficient to the adjustment processing unit PU. In the present disclosure, "flammability" means "combustion state".

[0061] (Image conversion unit)

20 The image capturing result of the infrared camera 22 (garbage layer image) is input to the image conversion unit 126. The image conversion unit 126 performs a predetermined image process on the input garbage layer image to simplify the garbage layer image. For example, the image conversion unit 126 binarizes the input garbage layer image. The binarization method is, for example, the Otsu method, but is not
25 limited thereto.

[0062] FIG. 6 is a diagram showing an example of the process by the image conversion unit 126. As shown in FIG. 6, the garbage layer image, which is a color image (or monochrome image) captured by the infrared camera 22, is converted into a black and white image by the image conversion unit 126. The image (for example, a black and white image) obtained by the image conversion unit 126 is output to the garbage layer height detection unit 127.

[0063] (Garbage layer height detection unit)

An image obtained by the image conversion unit 126 is input to the garbage layer height detection unit 127. The garbage layer height detection unit 127 detects the height of the garbage G (garbage layer height) in the drying stage 20a of the furnace body 20 on the basis of the input image.

[0064] FIG. 7 is a diagram showing an example of a process by the garbage layer height detection unit 127. The garbage layer height detection unit 127 sets one or more (two in the example shown in FIG. 6) predetermined interest regions R (see FIG. 6), which are a part of the image, for the image obtained by the image conversion unit 126. Then, the garbage layer height detection unit 127 sets a plurality of divided regions Ra which are divided in the vertical direction and the horizontal direction (for example, a divided region Ra in which the interest region R is divided into 20 in the vertical direction and is divided into 5 in the horizontal direction) for the image of the set interest region R (see FIG. 7(a)). Furthermore, in FIG. 7, data of two interest regions R are shown side by side.

[0065] The garbage layer height detection unit 127 assigns “1” to the divided region Ra when black is larger than 50% for each divided region Ra and assigns “0” to the divided region Ra when black is equal to or smaller than 50% (see FIG. 7(b)). Then, the garbage layer height detection unit 127 calculates the position of the uppermost divided

region Ra of “1” as the garbage layer height. For example, in the example shown in FIG. 7, the height position of the line H is calculated as the garbage layer height. The garbage layer height detection unit 127 outputs the calculated garbage layer height to the feeder supply amount estimation unit 129.

5 [0066] (Second feature amount extraction unit)

The image capturing result of the infrared camera 22 (garbage layer image) is input to the second feature amount extraction unit 128. The second feature amount extraction unit 128 performs a clustering process on the input garbage layer image to convert the image into a color image data divided into a plurality of color regions

10 according to color information. Then, the second feature amount extraction unit 128 extracts a feature related to the garbage supply state on the basis of the color image data. Furthermore, the processing method of “dividing an image into a plurality of color regions according to color information by the clustering process” and the algorithm of the clustering process are, for example, the same as the processing method and algorithm of
15 the first feature amount extraction unit 123, but may be different.

[0067] In this embodiment, the second feature amount extraction unit 128 divides the input garbage layer image into a plurality of color regions by the clustering process.

Then, the second feature amount extraction unit 128 calculates the total number of pixels (for example, area) of each divided color region, and extracts this total number of pixels

20 as a feature related to the supply state of the garbage G. The second feature amount extraction unit 128 extracts the total number of pixels of each color region at predetermined intervals (for example, every second). Furthermore, in this embodiment,

the feature amount includes the total number of pixels of all color regions among the plurality of color regions, but the present disclosure is not limited to this form. The

25 feature amount may include the total number of pixels of at least one color region among

the plurality of color regions. The second feature amount extraction unit 128 outputs the extracted feature amount related to the supply state of the garbage G to the feeder supply amount estimation unit 129. Furthermore, the method of extracting the feature amount by the second feature amount extraction unit 128 is not limited to clustering, and
5 may be another method.

[0068] (Feeder supply amount estimation unit)

Information indicating the garbage layer height calculated by the garbage layer height detection unit 127 and information indicating the feature amount of the supply state of the garbage G extracted by the second feature amount extraction unit 128 are
10 input to the feeder supply amount estimation unit 129. Further, the feeder supply amount estimation unit 129 has correlation information indicating the correlation between the feature amount of the garbage layer height and the supply state of the garbage G and the supply amount of the garbage G from the feeder 12. The above correlation information is, for example, a supply amount estimation formula that
15 calculates the supply amount of the garbage G from the feature amount of the garbage layer height and the supply state of the garbage G from the feeder 12. The feeder supply amount estimation unit 129 calculates an estimation value of the supply amount of the garbage G from the feeder 12 on the basis of information indicating the input garbage layer height, the feature amount of the supply state of the garbage G, and the
20 correlation information. The feeder supply amount estimation unit 129 outputs the calculated estimation value of the supply amount of the garbage G to the adjustment processing unit PU. The estimation value of the supply amount of the garbage G is another example of "the supply state information indicating the supply state of the garbage G from the hopper 11 to the processing space V".

25 [0069] (Adjustment processing unit)

Information calculated by the first heating value estimation unit 121, the second heating value estimation unit 122, the first feature amount extraction unit 123, the flammability coefficient calculation unit 125, and the feeder supply amount estimation unit 129 and process data acquired by the information acquisition unit 110 are input to the adjustment processing unit PU. Hereinafter, these will be collectively referred to as "input information". In this embodiment, the process data input to the adjustment processing unit PU includes, for example, the process value of the feeder 12 (for example, the stroke length of the feeder 12 and/or the moving speed of the feeder 12), the detection result of the wind box pressure sensor 41a, the detection result of the air flow rate sensor 56, the detection result of the furnace pressure sensor 64, the detection result of the radiation temperature sensor 63, the detection result of the feed water flow rate sensor 65, the detection result of the superheater/desuperheater flow rate sensor 66, and the detection result of the gas concentration sensor 6a (for example, oxygen concentration). Furthermore, a part or all of the process data (for example, the process value of the feeder 12) may be omitted.

[0070] The adjustment processing unit PU performs a predetermined process on the input information to convert the input information into data to be input to the main steam flow rate prediction model M described later. The adjustment processing unit PU includes, for example, a preprocessing unit PUa and a time delay adjustment unit PUB.

[0071] The preprocessing unit PUa performs preprocessing such as an averaging process on one or more pieces of input information. For example, the preprocessing unit PUa averages values obtained at a plurality of detection points for one or more pieces of input information. Furthermore, the preprocessing by the preprocessing unit PUa may be a differential process instead of or in addition to the averaging process.

The preprocessing unit PUa outputs the preprocessed input information to the time delay

adjustment unit PUB.

[0072] The time delay adjustment unit PUB correlates input information on the time axis that is simultaneously input to the main steam flow rate prediction model M as one data set (a set of input information) on the basis of each input information and the time delay setting value set individually for each input information. That is, there is a time delay between a change in each input information and a change in the main steam flow rate. In other words, each input information becomes a preceding signal that precedes a change in the main steam flow rate. For example, input information related to the hopper 11 or a position close to the hopper 11 becomes a preceding signal that precedes the input information to a greater extent than input information related to a position close to the processing space V.

[0073] FIG. 8 is a diagram showing an example of the correlation between each input information and the main steam flow rate. In this embodiment, the length of the time delay setting value is changed a plurality of times for each piece of input information, and the time delay setting value that provides the highest correlation between the input information and the main steam flow rate is selected.

[0074] For example, the correlation between the input information indicating the supply amount from the feeder 12 and the main steam flow rate (see FIG. 8(a)) is highest when T2 (minutes) is set as the time delay setting value. In other words, the input information indicating the supply amount from the feeder 12 becomes a preceding signal that precedes the main steam flow rate by T2 (minutes). Similarly, the correlation between the input information indicating the flammability coefficient and the main steam flow rate (see FIG. 8(b)) is highest when T3 (minutes) is set as the time delay setting value. In other words, the input information indicating the flammability coefficient becomes a preceding signal that precedes the main steam flow rate by T3 (minutes). For example,

T3 (minutes) is a shorter time than T2 (minutes).

[0075] FIG. 9 is a diagram showing an example of time delay setting values for each input information. In FIG. 9, T1 (minutes) > T2 (minutes) > T3 (minutes). However, these relationships are not limited. The time delay setting value for each input

5 information can be set as appropriate.

[0076] The time delay adjustment unit PUB generates a data set (for example, a collection of time-adjusted input information) for predicting the main steam flow rate at a certain point in the future by correlating the input information that is simultaneously input to the main steam flow rate prediction model M on the basis of the time delay

10 setting value for each input information as described above. The adjustment processing unit PU outputs the data set generated by the time delay adjustment unit PUB.

[0077] <4.3 Prediction model generation unit>

In the prediction model generation process (learning process), a combination of the data set generated by the adjustment processing unit PU and the correct data of the

15 prediction value of the main steam flow rate corresponding to the data set is input as learning data to the prediction model generation unit 130. The prediction model

generation unit 130 generates a main steam flow rate prediction model M for predicting the main steam flow rate at a future point in time by performing machine learning on the basis of the input learning data. The main steam flow rate prediction model M is a

20 trained model that outputs a prediction value of the main steam flow rate at a future point in time when the data set generated by the adjustment processing unit PU is input. The main steam flow rate prediction model M is, for example, LSTM (Long Short Term

Memory) or XGBoost (eXtreme Gradient Boosting), but is not limited to these. The

machine learning algorithm is not particularly limited, and various known machine

25 learning algorithms can be used.

[0078] In this embodiment, the prediction model generation unit 130 generates a plurality of main steam flow rate prediction models M that predict main steam flow rates at a plurality of mutually different future points. For example, the prediction model generation unit 130 generates a plurality of main steam flow rate prediction models M that output prediction values of the main steam flow rate for 60 seconds ahead, 120 seconds ahead, and 180 seconds ahead, respectively. Furthermore, the prediction model generation unit 130 may generate one main steam flow rate prediction model M that outputs a plurality of prediction values corresponding to a plurality of future points in time instead of generating the plurality of main steam flow rate prediction models M.

[0079] Further, the prediction model generation unit 130 varies a learning period (learning data accumulation period) and generates a plurality of main steam flow rate prediction models M based on learning data of a plurality of learning periods having different lengths. For example, the prediction model generation unit 130 generates the main steam flow rate prediction model M corresponding to one day's worth of learning data, two days' worth of learning data,..., seven days' worth of learning data, respectively.

[0080] <4.4 Prediction model determination unit>

The prediction model determination unit 140 evaluates the plurality of main steam flow rate prediction models M corresponding to the plurality of learning periods generated by the prediction model generation unit 130 and selects the main steam flow rate prediction model M used by the steam flow rate prediction unit 150.

[0081] FIG. 10 is a diagram showing an example of an evaluation process by the prediction model determination unit 140. In this embodiment, the prediction model determination unit 140 evaluates the plurality of main steam flow rate prediction models M corresponding to a plurality of learning periods on the basis of accuracy metrics such

as Root Mean Square Error (RMSE) and Mean Absolute Scale Error (MASE). In this embodiment, as the main steam flow rate prediction model M corresponding to each learning period, a set of the plurality of main steam flow rate prediction models M that respectively predict the main steam flow rate 60 seconds ahead, 120 seconds ahead, and 180 seconds ahead is evaluated. Then, among the plurality of main steam flow rate prediction models M corresponding to a plurality of learning periods, a set of main steam flow rate prediction models M corresponding to the learning period that has the highest overall prediction accuracy for a plurality of future points in time (60 seconds ahead, 120 seconds ahead, and 180 seconds ahead) is selected. In the example shown in FIG. 10, a set of main steam flow rate prediction models M corresponding to a 5-day learning period is selected. The main steam flow rate prediction model M selected by the prediction model determination unit 140 is output to the steam flow rate prediction unit 150. Furthermore, the values S1 to S7 in FIG. 10 are values specifically calculated on the basis of the calculation formula of RMSE or MASE, and show an example where $S1 < S2 < S3 < S4 < S5 < S6 < S7$.

[0082] <4.5 Main steam flow rate prediction unit>

At the operation stage of the incineration facility SF, the steam flow rate prediction unit 150 derives a prediction value of the main steam flow rate at a future point by using the data set generated by the adjustment processing unit PU and the main steam flow rate prediction model M selected by the prediction model determination unit 140. In this embodiment, prediction values of the main steam flow rate 60 seconds ahead, 120 seconds ahead, and 180 seconds ahead are derived by using the plurality of main steam flow rate prediction models M that respectively predict the main steam flow rate 60 seconds ahead, 120 seconds ahead, and 180 seconds ahead. The steam flow rate prediction unit 150 derives a prediction value of the main steam flow rate at a

predetermined period (for example, every second or every 10 seconds). The steam flow rate prediction unit 150 outputs the derived prediction value of the main steam flow rate to the control unit 160.

[0083] <4.6 Control unit>

5 The control unit 160 performs combustion control of the processing space V on the basis of the prediction values (for example, prediction values 60 seconds ahead, 120 seconds ahead, and 180 seconds ahead) of the main steam flow rate derived by the steam flow rate prediction unit 150. Specifically, the control unit 160 controls the control target device S so that the amount of fluctuation in the combustion state of the processing
10 space V becomes small.

[0084] FIG. 11 is a diagram showing an example of control contents by the control unit 160. When the future prediction value of the main steam flow rate (for example, any of the prediction values 60 seconds ahead, 120 seconds ahead, and 180 seconds ahead) is smaller than a preset lower limit threshold TH1, the control unit 160 determines that
15 insufficient combustion will occur in the future and performs control to promote combustion. Further, when the future prediction value of the main steam flow rate (for example, any of the prediction values 60 seconds ahead, 120 seconds ahead, and 180 seconds ahead) exceeds the preset upper limit threshold TH2, the control unit 160 determines that excessive combustion will occur in the future and performs control to
20 suppress combustion.

[0085] In this embodiment, since a control instruction is output on the basis of the deviation of the prediction value from the set value (reference value), the fluctuation in the main steam flow rate can be suppressed. That is, in this embodiment, a control instruction to change combustion control is output at the time point (point B in FIG. 11)
25 when the prediction value of the main steam flow rate at a future point reaches the lower

threshold TH1 or the upper threshold TH2 instead of the time point (point A in FIG. 11) when the actual measurement value of the main steam flow rate reaches the lower threshold TH1 or the upper threshold TH2. The fluctuation in the main steam flow rate when control is performed on the basis of the prediction value (see the two-dot chain line in FIG. 11) is smaller than the fluctuation in the main steam flow rate when control is performed on the basis of the actual measurement value (see the solid line in FIG. 11).

[0086] Specifically, the control unit 160 includes a feeder control unit 161, an air supply control unit 162, and a grate control unit 163. Each control unit performs, for example, PI control (proportional integral control). However, the control algorithm is not limited to PI control, and various known control algorithms can be used.

[0087] The feeder control unit 161 acquires a process value indicating the movement of the feeder 12 from the extrusion device 13, and generates a control instruction value regarding the feeder 12 on the basis of, for example, PI control. The feeder control unit 161 outputs the generated control instruction value to the extrusion device 13 to control the movement of the feeder 12 and the amount of the garbage G supplied to the processing space V. For example, the feeder control unit 161 increases the amount of the garbage G supplied when promoting combustion. On the other hand, the feeder control unit 161 reduces the amount of the garbage G supplied when suppressing combustion.

[0088] The air supply control unit 162 acquires a process value related to the rotation speed of the blower 51 and/or the opening degree of the damper 55 from the blower 51 or the damper 55 and generates control instruction values regarding the blower 51 and/or the damper 55 on the basis of, for example, PI control. The air supply control unit 162 outputs the generated control instruction values to the blower 51 and/or the damper 55 to control the blower 51 and/or the damper 55 and control the supply amount of air (for

example, combustion air) to the processing space V. For example, the air supply control unit 162 increases the amount of air supplied when promoting combustion. On the other hand, the air supply control unit 162 reduces the amount of air supplied when suppressing combustion.

5 [0089] The grate control unit 163 acquires process data regarding the moving speed of the grate 31 from the grate drive device 32, and generates a control instruction value regarding the grate 31 on the basis of, for example, PI control. The grate control unit 163 outputs the generated control instruction value to the grate drive device 32 to control the grate 31 and control the stirring state of the garbage G. For example, the grate
10 control unit 163 increases the moving speed of the grate 31 when promoting combustion. On the other hand, the grate control unit 163 reduces the moving speed of the grate 31 when suppressing combustion.

[0090] <5. Flow of process>

Next, an example of a flow of a process in the control apparatus 100 described
15 above will be described. However, the order of the processes described below is not limited to the following example, and may be changed as appropriate.

[0091] <5.1 Generation of prediction model>

First, the generation process (learning process) of the main steam flow rate prediction model M will be described. The generation process of the main steam flow
20 rate prediction model M to be described later is also executed in parallel during the operation stage of the incineration facility SF to be described later.

[0092] FIG. 12 is a flowchart showing a flow of a prediction model generation process.

First, the information acquisition unit 110 acquires detection results and process data of various sensors (S101). Next, the data conversion unit 120 generates a data set to be
25 input to the main steam flow rate prediction model M on the basis of the detection results

and the process data of various sensors acquired by the information acquisition unit 110 (S102). That is, the data conversion unit 120 generates a data set by performing calculations and clustering using various estimation formulas and performing an adjustment process regarding time delay on the input information obtained therefrom.

5 [0093] Next, the prediction model generation unit 130 accumulates the data set generated by the data conversion unit 120 over a plurality of days (S103). Then, the prediction model generation unit 130 varies the learning period (learning data accumulation period) and generates a plurality of main steam flow rate prediction models M on the basis of learning data of a plurality of learning periods having different lengths
10 (S104).

[0094] Next, the prediction model determination unit 140 evaluates the plurality of main steam flow rate prediction models M with different learning periods generated by the prediction model generation unit 130 and selects the main steam flow rate prediction model M to be used by the steam flow rate prediction unit 150 (S105). In this

15 embodiment, the prediction model determination unit 140 determines whether there is the main steam flow rate prediction model M whose prediction accuracy is higher than the main steam flow rate prediction model M currently in use by the steam flow rate prediction unit 150 among the plurality of main steam flow rate prediction models M newly generated by the prediction model generation unit 130.

20 [0095] Then, when there is no main steam flow rate prediction model M whose prediction accuracy is higher than the main steam flow rate prediction model M currently in use among the plurality of newly generated main steam flow rate prediction models M (S105: NO), the process returns to before the process in S103, and the processes in S103 and S104 are performed again. On the other hand, when there is the main steam flow
25 rate prediction model M whose prediction accuracy is higher than the main steam flow

rate prediction model M currently in use among the plurality of newly generated main steam flow rate prediction models M (S106: YES), the prediction model determination unit 140 outputs the main steam flow rate prediction model M with high prediction accuracy to the steam flow rate prediction unit 150 and updates the main steam flow rate prediction model M in use (S107). The processes from S101 to S107 described above are repeatedly performed during the operation stage of the incineration facility SF.

[0096] <5.2 Process at operation stage of combustion facility>

Next, a process at the operation stage of the incineration facility SF will be described.

FIG. 13 is a flowchart showing a flow of a process at the operation stage of the combustion facility. First, the information acquisition unit 110 acquires the detection results and the process data of various sensors (S201). Next, the data conversion unit 120 generates a data set for to be input to the main steam flow rate prediction model M on the basis of the detection results and the process data of various sensors acquired by the information acquisition unit 110 (S202). The data conversion unit 120 outputs the generated data set to the steam flow rate prediction unit 150.

[0097] Next, the steam flow rate prediction unit 150 derives a prediction value of the main steam flow rate in the future point on the basis of the main steam flow rate prediction model M and the data set received from the data conversion unit 120 (S203). The steam flow rate prediction unit 150 outputs the derived prediction value of the main steam flow rate at a future point to the control unit 160. Next, the control unit 160 derives the control amount of the control target device S on the basis of the prediction value of the main steam flow rate (S204). Then, the control unit 160 outputs a control instruction value based on the derived control amount to the control target device S (S205). The processes from S201 to S205 described above are repeatedly performed

during the operation stage of the incineration facility SF.

[0098] <6. Operation and effect>

The main steam flow rate may vary greatly depending on the supply state of the garbage G and the properties of the garbage G. For this reason, when making a

5 prediction based on information after the combustion process, it may be difficult to improve the prediction accuracy of the main steam flow rate.

[0099] On the other hand, in this embodiment, the control apparatus 100 includes the information acquisition unit 110 which acquires information related to the garbage G

before being supplied to the processing space V inside the incineration facility SF, the

10 steam flow rate prediction unit 150 which predicts the main steam flow rate generated by the exhaust heat recovery boiler 3 of the incineration facility SF on the basis of the

prediction information including the above information acquired by the information

acquisition unit 110, and the control unit 160 which performs combustion control on the basis of the main steam flow rate predicted by the steam flow rate prediction unit 150.

15 [0100] According to such a configuration, since the main steam flow rate is predicted on the basis of the information related to the garbage G before being supplied to the

processing space V, it becomes possible to predict the main steam flow rate with high

accuracy. Accordingly, the control apparatus 100 can perform combustion control on the basis of the high-accuracy prediction value of the main steam flow rate. As a result,

20 the fluctuation range of the main steam flow rate can be suppressed.

[0101] FIG. 14 is a diagram showing an example of a comparison result between

prediction values and actual measurement values according to this embodiment. As

shown in FIG. 14, it can be confirmed that the prediction value of the main steam flow

rate by the control apparatus 100 follows the fluctuation of the actual value of the main

25 steam flow rate with high accuracy. Furthermore, the present inventors have confirmed

that the prediction value of the main steam flow rate by the control apparatus 100 of this embodiment improves the prediction accuracy compared to the case where the prediction is made only from information after the combustion process.

[0102] <7. Modified Example>

5 In the embodiment described above, as for the time delay setting value individually set for each input information, the time delay setting value that has the highest correlation between each input information and the main steam flow rate is selected and set and then the set time delay setting value is used as a fixed value. However, the time delay adjustment unit PUB may recalculate the correlation between
10 each input information and the main steam flow rate at a predetermined period and change the time delay setting value so that the correlation between each input information and the main steam flow rate becomes higher. According to such a configuration, even if the properties of the garbage G change depending on the season or other factors, it may be possible to further improve the accuracy of predicting the main
15 steam flow rate.

[0103] (Other embodiments)

Although the embodiment of the present disclosure has been described above in detail with reference to the drawings, the specific configuration is not limited to this embodiment, and may include design changes without departing from the gist of the
20 present disclosure.

[0104] FIG. 14 is a hardware configuration diagram showing a configuration of a computer 1100 according to this embodiment. The computer 1100 includes, for example, a processor 1110, a main memory 1120, a storage 1130, and an interface 1140.

[0105] Each functional unit of the control apparatus 100 is mounted on the computer
25 1100. Then, the operation of each of the functional units described above is stored in

the storage 1130 in the form of a program. The processor 1110 reads the program from the storage 1130, develops the program to the main memory 1120, and performs the above process according to the program. Further, the processor 1110 reserves the storage areas to be used by each of the above-described functional units in the main
5 memory 1120 according to the program.

[0106] The program may be for realizing some of the functions to be performed by the computer 1100. For example, the program may function in combination with other programs already stored in the storage 1130 or in combination with other programs installed in other devices. Further, the computer 1100 may include a custom LSI (Large
10 Scale Integrated Circuit) such as a PLD (Programmable Logic Device) in addition to or in place of the above configuration. Examples of PLDs include PAL (Programmable Array Logic), GAL (Generic Array Logic), CPLD (Complex Programmable Logic Device), and FPGA (Field Programmable Gate Array). In this case, a part or all of the functions implemented by the processor 1110 may be implemented by the integrated
15 circuit.

[0107] Examples of the storage 1130 include magnetic disks, magneto-optical disks, semiconductor memory, and the like. The storage 1130 may be internal media connected directly to the bus of the computer 1100 or external media connected to the computer 1100 via the interface 1140 or a communication line. Further, when this
20 program is distributed to the computer 1100 via a communication line, the computer 1100 that receives the distribution may develop the program in the main memory 1120 and perform the above process. Additionally, the program may be for realizing some of the functions described above. Furthermore, the program may be a so-called difference file (difference program) that implements the above-described functions in combination
25 with other programs already stored in the storage 1130.

[0108] <Appendix>

The control apparatus 100 described in each embodiment is understood as follows, for example.

[0109] (1) The control apparatus 100 according to a first aspect includes: the

5 information acquisition unit 110 which acquires information related to the incineration material G before being supplied to the processing space V inside the incineration facility SF; the steam flow rate prediction unit 150 which predicts the main steam flow rate generated by the exhaust heat recovery boiler 3 of the incineration facility SF on the basis of the prediction information including the information acquired by the information
10 acquisition unit 110; and the control unit 160 which performs combustion control on the basis of the main steam flow rate predicted by the steam flow rate prediction unit 150. Furthermore, "prediction information" is used not in the sense of information exclusively for prediction, but in the broad sense of information that can be used for prediction. That is, the prediction information may be information that is collected or stored for a
15 purpose different from prediction of the main steam flow rate.

[0110] According to such a configuration, since the main steam flow rate is predicted on the basis of the information related to the incineration material G before being supplied to the processing space V, it becomes possible to predict the main steam flow rate with high accuracy. Accordingly, the control apparatus 100 can perform
20 combustion control on the basis of a highly accurate prediction value of the main steam flow rate.

[0111] (2) The control apparatus 100 according to a second aspect is the control apparatus 100 of the first aspect, wherein the information includes information related to the properties of the incineration material G. "Information related to the properties of
25 the incineration material G" is, for example, one or more of the value related to the

moisture of the incineration material G (moisture content or moisture amount), the weight of the incineration material G, the height of the incineration material G, the volume of the incineration material G, the density of the incineration material G (bulk density or true density), and the heating value of the incineration material G.

5 [0112] According to such a configuration, the main steam flow rate can be predicted by reflecting the properties of the incineration material G that affects the main steam flow rate. Thereby, the main steam flow rate can be predicted with even higher accuracy.

[0113] (3) The control apparatus 100 according to a third aspect is the control apparatus 100 of the first or second aspect, wherein the information includes accumulation state
10 information indicating the accumulation state of the incineration material G inside the hopper 11 of the incineration facility SF.

[0114] According to such a configuration, the main steam flow rate can be predicted by reflecting the accumulation state of the incineration material G in the hopper 11 which affects the main steam flow rate. Thereby, the main steam flow rate can be predicted
15 with even higher accuracy.

[0115] (4) The control apparatus 100 according to a fourth aspect is the control apparatus 100 of the third aspect, wherein the accumulation state information includes an infrared image obtained by capturing an image of the outlet portion 11b of the hopper 11 through the flame of the processing space V from the downstream side in the conveying
20 direction D of the incineration material G in the incineration facility SF.

[0116] According to such a configuration, the accumulation state of the incineration material G inside the hopper 11 can be reflected with higher accuracy on the basis of the infrared image. Thereby, the main steam flow rate can be predicted with even higher accuracy.

25 [0117] (5) The control apparatus 100 according to a fifth aspect is the control apparatus

100 of any one of the first to fourth aspects, wherein the information includes supply state information indicating the supply state of the incineration material G from the hopper 11 of the incineration facility SF to the processing space V.

[0118] According to such a configuration, the main steam flow rate can be predicted by reflecting the supply state of the incineration material G from the hopper 11 to the processing space V which affects the main steam flow rate. Thereby, the main steam flow rate can be predicted with even higher accuracy.

[0119] (6) The control apparatus 100 according to a sixth aspect is the control apparatus 100 of any one of the first to fifth aspects, further including: the heating value estimation unit (the first heating value estimation unit 121 or the second heating value estimation unit 122) which estimates the lower heating value of the incineration material G on the basis of the moisture measurement result of the incineration material G inside the hopper 11 or the density of the incineration material G inside the hopper 11 of the incineration facility SF included in the information or obtained from the information, wherein the steam flow rate prediction unit 150 predicts the main steam flow rate on the basis of the lower heating value predicted by the heating value estimation unit.

[0120] According to such a configuration, the main steam flow rate can be predicted by reflecting the lower heating value of the incineration material G estimated from the moisture measurement result or the density of the incineration material G inside the hopper 11. Thereby, the main steam flow rate can be predicted with even higher accuracy.

[0121] (7) The control method according to a seventh aspect includes: acquiring information indicating the garbage G before being supplied to the processing space V inside the incineration facility SF; predicting the main steam flow rate generated by the exhaust heat recovery boiler 3 of the incineration facility SF on the basis of the prediction

information including the acquired information; and performing combustion control on the basis of the predicted main steam flow rate. According to such a configuration, similarly to the control apparatus 100 according to the first aspect, it is possible to perform combustion control on the basis of a highly accurate prediction value of the main steam flow rate.

[0122] (8) The program according to an eighth aspect allows a computer to acquire information indicating the garbage G before being supplied to the processing space V inside the incineration facility SF, predict the main steam flow rate generated by the exhaust heat recovery boiler 3 of the incineration facility SF on the basis of the prediction information including the acquired information, and perform combustion control on the basis of the predicted main steam flow rate. According to such a configuration, similarly to the control apparatus 100 according to the first aspect, it is possible to perform combustion control on the basis of a highly accurate prediction value of the main steam flow rate.

Industrial Applicability

[0123] The present disclosure relates to a control apparatus for controlling an incineration facility for, for example, municipal garbage, industrial garbage, or biomass. According to the control apparatus of the present disclosure, combustion control can be performed on the basis of a highly accurate prediction value of the main steam flow rate.

Reference Signs List

[0124] SF Incineration facility

G Incineration material (garbage)

1 Crane

	2 Incinerator
	3 Exhaust heat recovery boiler
	4 Cooling tower
	5 Dust collector
5	6 Flue
	7 Chimney
	10 Supply mechanism
	11 Hopper
	11a Inlet portion
10	11b Outlet portion
	12 Feeder
	13 Extrusion device
	14 Object measuring device
	15 Moisture measuring device
15	20 Furnace body
	20a Drying stage
	20b Combustion stage
	20c Post-combustion stage
	V Processing space
20	21 Visible light camera
	22 Infrared camera
	30 Stoker
	31 Grate
	32 Grate drive device
25	41 Wind box

	41a Wind box pressure sensor
	50 Blower mechanism
	51 Blower
	52 Primary air line
5	53 Air preheater
	54 Secondary air line
	55 Damper
	56 Air flow rate sensor
	61 Boiler body
10	62 Pipe line
	63 Radiation temperature sensor
	64 Furnace pressure sensor
	65 Feed water flow rate sensor
	66 Superheater/desuperheater flow rate sensor
15	100 Control apparatus
	110 Information acquisition unit
	120 Data conversion unit
	130 Prediction model generation unit
	140 Prediction model determination unit
20	150 Steam flow rate prediction unit
	160 Control unit

CLAIMS

What is claimed is:

[Claim 1] A control apparatus comprising:

5 an information acquisition unit which is configured to acquire information related to an incineration material before being supplied to a processing space inside an incineration facility;

a steam flow rate prediction unit which is configured to predict a main steam flow rate generated by a boiler of the incineration facility on the basis of prediction
10 information including the information acquired by the information acquisition unit; and
a control unit which is configured to perform combustion control on the basis of the main steam flow rate predicted by the steam flow rate prediction unit.

[Claim 2] The control apparatus according to claim 1,

15 wherein the information includes information related to properties of the incineration material.

[Claim 3] The control apparatus according to claim 1 or 2,

wherein the information includes accumulation state information indicating an
20 accumulation state of the incineration material inside a hopper of the incineration facility.

[Claim 4] The control apparatus according to claim 3,

wherein the accumulation state information includes an infrared image obtained
by capturing an image of an outlet portion of the hopper through a flame of the
25 processing space from a downstream side in a conveying direction of the incineration

material in the incineration facility.

[Claim 5] The control apparatus according to any one of claims 1 to 4,
 wherein the information includes supply state information indicating a supply
5 state of the incineration material from a hopper of the incineration facility to the
processing space.

[Claim 6] The control apparatus according to any one of claims 1 to 5, further
comprising:

10 a heating value estimation unit which is configured to estimate a lower heating
value of the incineration material on the basis of density of the incineration material
inside the hopper of the incineration facility or a moisture measurement result of the
incineration material inside the hopper included in the information or obtained from the
information,

15 wherein the steam flow rate prediction unit predicts the main steam flow rate on
the basis of the lower heating value estimated by the heating value estimation unit.