DESCRIPTION

Title of Invention

COMBUSTION FACILITY SYSTEM, AND INFORMATION PROCESSING METHOD

[Technical Field]

[0001]

The present disclosure relates to a combustion facility system, and an information processing method. Priority is claimed on Japanese Patent Application No. 2023-91600, filed on June 2, 2023, the content of which is incorporated herein by reference.

[Background Art]

[0002]

Patent Document 1 discloses a device including display means for causing a screen to display a hierarchical structure formed by setting a final target at a highest level, aligning a plurality of evaluation references for solving a problem or selecting an alternative plan under the set final target, connecting the plurality of evaluation references and the final target with a line, aligning the plurality of alternative plans under the plurality of evaluation references, and connecting the plurality of alternative plans and the plurality of evaluation references with a line, as a decision-making support device used for determining a degree of requirement relating to renewal of an automatic control facility of a building, input means for allowing an operator to input a comparison value obtained by pairwise comparison of the respective evaluation references in the hierarchical structure displayed on the screen, an alternative plan name evaluated by a

quantitative value or an absolute evaluation value, and the quantitative value or the absolute evaluation value, and calculation processing means for executing calculation processing of calculating a weight obtained by the pairwise comparison and the absolute evaluation or the quantitative value of the respective evaluation references, based on data input from the input means, determining a total weight obtained by adding all of the weights of the respective evaluation references as an importance degree of the respective alternative plans in the hierarchical structure, and outputting a result thereof.

[Citation List]

[Patent Document]

[0003]

[Patent Document 1] Japanese Unexamined Patent Application Publication No. H9-69051

[Summary of Invention]

[Technical Subject]

[0004]

However, in the technology disclosed in Patent Document 1, it is difficult to appropriately determine parameters relating to a combustion facility.

[0005]

The present disclosure has been made to solve the above-described subject, and an object of the present disclosure is to provide a combustion facility system and an information processing method, which can appropriately determine parameters relating to a combustion facility.

[Subject to be solved]

[0006]

According to the present disclosure, in order to solve the above-described

subject, there is provided a combustion facility system including a Pareto solution generating unit that generates a plurality of Pareto solutions relating to control parameters of a combustion facility by setting a plurality of indicators relating to a combustion state as objective functions, based on a model relating to the combustion facility, and a preferred solution determining unit that determines one or more preferred solutions from the plurality of Pareto solutions by using an analytic hierarchy process with respect to the plurality of Pareto solutions generated by the Pareto solution generating unit.

[0007]

According to the present disclosure, in order to solve the above-described subject, there is provided an information processing method executed by one or more computers. The method includes generating a plurality of Pareto solutions relating to control parameters of a combustion facility by setting a plurality of indicators relating to a combustion state as objective functions, based on a model relating to the combustion facility, and determining one or more preferred solutions from the plurality of Pareto solutions by using an analytic hierarchy process with respect to the plurality of generated Pareto solutions.

[Advantageous Effects of Invention]

[0008]

According to a combustion facility system and an information processing method of the present disclosure, it is possible to appropriately determine parameters relating to a combustion facility.

[Brief Description of Drawings]

[0009]

FIG. 1 is a diagram showing an overall configuration of a combustion facility

of a first embodiment of the present disclosure.

FIG. 2 is a block diagram showing a functional configuration of an incineration facility of the first embodiment of the present disclosure.

FIG. 3 is a diagram for describing an outline of a plant model of the first embodiment of the present disclosure.

FIG. 4 is a graph showing a relationship between an O_2 concentration and a CO concentration in the first embodiment of the present disclosure.

FIG. 5 is a diagram showing a relationship between the O_2 concentration and a NOx concentration in the first embodiment of the present disclosure.

FIG. 6 is a diagram for describing a change pattern of the O_2 concentration in the first embodiment of the present disclosure.

FIG. 7 is a diagram for describing a Pareto solution relating to model parameters of the first embodiment of the present disclosure.

FIG. 8 is a diagram showing a flow of an analytic hierarchy process used in the first embodiment of the present disclosure.

FIG. 9 is a diagram for describing a hierarchical structure relating to derivation of optimal model parameters of the first embodiment of the present disclosure.

FIG. 10 is a diagram conceptually showing a process of a pairwise comparison between model parameters of the first embodiment of the present disclosure.

FIG. 11 is a diagram for describing a Pareto solution relating to control parameters of the first embodiment of the present disclosure.

FIG. 12 is a diagram for describing a hierarchical structure relating to derivation of the optimal control parameters of the first embodiment of the present disclosure.

FIG. 13 is a diagram showing an example of a result of a pairwise comparison between evaluation references of the control parameters of the first embodiment of the

present disclosure.

FIG. 14 is a diagram conceptually showing a process of the pairwise comparison between the control parameters of the first embodiment of the present disclosure.

FIG. 15 is a diagram showing an example of a control parameter set of the first embodiment of the present disclosure.

FIG. 16 is a flowchart showing an information processing flow of the first embodiment of the present disclosure.

FIG. 17 is a block diagram showing a functional configuration of an incineration facility of a second embodiment of the present disclosure.

FIG. 18 is a flowchart showing an information processing flow of the second embodiment of the present disclosure.

FIG. 19 is a hardware configuration diagram showing a configuration of a computer of an embodiment of the present disclosure.

[Description of Embodiments]

[0010]

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

and "YY" are any elements (for example, any information).

[0011]

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

[0012]

(First Embodiment)

<1. Overall Configuration of Incineration Facility>

FIG. 1 is a diagram showing an overall configuration of a combustion facility 1 according to a first embodiment. For example, the combustion facility 1 is an incineration facility that uses municipal waste, industrial waste, biomass, or the like as an incineration target G. In the following description, the "incineration target" may be referred to as "refuse" for convenience of description. For example, the combustion facility 1 is a stoker furnace. The combustion facility 1 is not limited to the stoker furnace, and may be a combustion facility of a different type. In the present embodiment, for example, the combustion facility 1 includes an incinerator 2, a heat recovery steam generator 3, a temperature reduction tower 4, a dust collector 5, a flue 6, a chimney 7, and a control device 100.

[0013]

The incinerator 2 is a furnace that combusts the incineration target G while

transporting the incineration target G loaded into a hopper 21 (to be described later). The incinerator 2 generates an exhaust gas as a result of combustion of the incineration target G inside the incinerator 2. The generated exhaust gas is fed to the heat recovery steam generator 3 provided in an upper portion of the incinerator 2. The heat recovery steam generator 3 heats water by exchanging heat between the exhaust gas generated in the incinerator 2 and the water, and generates steam. The exhaust gas passing through the heat recovery steam generator 3 is cooled at the temperature reduction tower 4, and thereafter, is fed to the dust collector 5. The exhaust gas is discharged to an atmosphere through the flue 6 and the chimney 7 after soot or dust is removed by the dust collector 5.

[0014]

<2. Incinerator>

Next, the incinerator 2 will be described in detail. For example, the incinerator 2 includes a supply mechanism 20, a furnace body 30, a stoker 40, a discharge chute 43, a plurality of wind boxes 50, a furnace 60, and a blowing mechanism 70.

[0015]

<2.1 Supply Mechanism>

The supply mechanism 20 is a mechanism that temporarily stores the incineration target G transported by a crane (not shown), for example, and sequentially supplies the temporarily stored incineration target G to a treatment space V of the furnace body 30 (to be described later). For example, the supply mechanism 20 includes a hopper 21, a feeder 22, an extrusion device 23 (refer to FIG. 2), and a moisture meter 24.

[0016]

(Hopper)

The hopper 21 is a temporary storage portion provided to supply the incineration target G into the furnace body 30. The hopper 21 includes an inlet portion into which the incineration target G is loaded, and an outlet portion leading to the treatment space V of a furnace body 30 (to be described later). The incineration target G transported by the crane is loaded into the hopper 21.

[0017]

(Feeder)

The feeder 22 is a device for extruding the incineration target G inside the hopper 21 toward the treatment space V of the furnace body 30. The feeder 22 is provided in a bottom portion of the hopper 21. For example, the feeder 22 is formed in a plate shape along the bottom portion of the hopper 21. The feeder 22 is driven by the extrusion device 23, and can reciprocate along a direction from the hopper 21 toward the treatment space V of the furnace body 30. The feeder 22 is driven by the extrusion device 23, and extrudes the incineration target G stored inside the hopper 21 toward the treatment space V of the furnace body 30.

[0018]

(Moisture Meter)

The moisture meter 24 is a measuring instrument that detects information (for example, a moisture content or a moisture amount) relating to the moisture contained in the incineration target G to be loaded into the hopper 21. For example, the moisture meter 24 includes an irradiation unit and a detection unit which are provided in the hopper 21, and an analysis unit. The irradiation unit irradiates the incineration target G accumulated inside the hopper 21 with an electromagnetic wave in a predetermined frequency band. The detection unit receives the electromagnetic wave emitted from the irradiation unit and transmitted through the incineration target G or reflected on the

incineration target G. For example, the analysis unit stores in advance correlation information indicating a relationship between a change in characteristics of the electromagnetic waves (for example, a change in an amplitude or a change in a phase) and the moisture content. The analysis unit detects the moisture content of the incineration target G, based on a change in the characteristics of the electromagnetic wave between the irradiation unit and the detection unit, and the correlation information. The moisture meter 24 may detect the moisture amount of the incineration target G, based on the moisture content and a weight of the incineration target G to be loaded into the hopper 21.

[0019]

<2.2 Furnace Body>

The furnace body 30 is a facility provided adjacent to the hopper 21 to combust the incineration target G while transporting the incineration target G. Hereinafter, a transport direction of the incineration target G in the combustion facility 1 will be referred to as a "transport direction D". The furnace body 30 includes a drying stage 30a, a combustion stage 30b, and a post-combustion stage 30c in this order from an upstream side toward a downstream side in the transport direction D. The drying stage 30a is a region located on the upstream side with respect to the combustion stage 30b and the post-combustion stage 30c, and in which the incineration target G supplied from the hopper 21 is dried prior to combustion on the stoker 40. The combustion stage 30b and the post-combustion stage 30c are regions where the incineration target G in a dried state after passing through the drying stage 30a is combusted on the stoker 40. In the combustion stage 30b, diffusion combustion occurs due to a pyrolysis gas generated from the incineration target G, and a flame F is generated. In the post-combustion stage 30c, fixed carbon combustion after diffusion combustion of the incineration target

G occurs. Therefore, the flame F is not generated.

[0020]

<2.3 Stoker>

The stoker 40 includes a plurality of fire grates 41 and a fire grate drive device 42 (refer to FIG. 2). The plurality of fire grates 41 form a stoker surface 40a which is a bottom surface of the furnace body 30. The incineration target G is supplied to the stoker surface 40a in a layered manner by the supply mechanism 20. The stoker surface 40a is provided over the drying stage 30a, the combustion stage 30b, and the post-combustion stage 30c which are described above. The plurality of fire grates 41 include a fixed fire grate and a movable fire grate. The fixed fire grate is fixed to an upper surface of the wind box 50 (to be described later). The movable fire grate reciprocates along the transport direction D at a constant speed. In this manner, the incineration target G is transported to the downstream side while the incineration target G located on the movable fire grate and the fixed fire grate (on the stoker surface 40a) is stirred and mixed.

[0021]

<2.4 Discharge Chute>

The discharge chute 43 is a device that drops the incineration target G completely combusted and turned into ash to an ash extrusion device located below the furnace body 30. The discharge chute 43 is provided in a furnace back side of the furnace body 30.

[0022]

<2.5 Wind Box>

The plurality of wind boxes 50 are provided below the stoker 40, and supply primary air for combustion into the furnace body 30 through the stoker 40. The

primary air is an example of "combustion air". In the present embodiment, the plurality of wind boxes 50 are aligned in the transport direction D to correspond to the plurality of fire grates 41, for example.

[0023]

<2.6 Furnace>

The furnace 60 extends upward from an upper portion of the furnace body 30. The furnace 60 is disposed above the fire grate 41, and a gas after combustion flows into the furnace 60. That is, an exhaust gas generated by the combustion of the incineration target G inside the furnace body 30 flows to the heat recovery steam generator 3 through the furnace 60.

[0024]

<2.7 Blowing Mechanism>

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

[0025]

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

[0026]

The primary air line 72 connects the first blower 71A and the plurality of wind

boxes 50. One or more (for example, a plurality of) primary air dampers 75A are provided in an intermediate portion of the primary air line 72. In the present embodiment, the plurality of primary air dampers 75A are provided to correspond to the plurality of wind boxes 50 in a one-to-one manner. The primary air damper 75A changes a flow rate of the primary air supplied into the furnace body 30 from the wind box 50 corresponding to the primary air damper 75A, depending on an opening degree of the primary air damper 75A.

[0027]

The air preheater 73 is a heat exchanger that preheats the primary air pumped from the first blower 71A. For example, the air preheater 73 is provided in an intermediate portion of the primary air line 72.

[0028]

The secondary air line 74 connects the second blower 71B and the furnace 60. The secondary air line 74 includes a supply port that is open in a wall portion of the furnace 60, and supplies the secondary air to a space (exhaust gas flow path) inside the furnace 60. One or more (for example, a plurality of) secondary air dampers 75B are provided in an intermediate portion of the secondary air line 74. The secondary air damper 75B changes a flow rate of the secondary air supplied into the furnace 60 from the supply port corresponding to the secondary air damper 75B, depending on an opening degree of the secondary air damper 75B. Hereinafter, for convenience of description, the primary air damper 75A and the secondary air damper 75B will be collectively referred to as a “damper 75”.

[0029]

<3. Various Sensors>

Next, various sensors provided in the combustion facility 1 will be described.

[0030]

<3.1 Radiation Temperature Sensor>

For example, the radiation temperature sensor (infrared temperature sensor) 81 is provided inside the furnace 60, and measures a temperature inside the furnace 60. Instead of or in addition to this configuration, the radiation temperature sensor 81 may be provided inside the heat recovery steam generator 3 to measure the temperature inside the heat recovery steam generator 3.

[0031]

<3.2 Steam Flow Rate Sensor>

The steam flow rate sensor 82 is provided in an intermediate portion of a pipe path inside the heat recovery steam generator 3, and measures a flow rate of the steam flowing through the pipe path. For example, the steam flow rate sensor 82 includes a first steam flow rate sensor 82A that measures the flow rate (flow rate of a primary superheater temperature reducer) of the steam passing through a primary temperature reducer, and a second steam flow rate sensor 82B that measures the flow rate (flow rate of a secondary superheater temperature reducer) of the steam passing through a secondary temperature reducer. In the following description, for example, a "measurement result of the steam flow rate sensor 82" includes a measurement result of the first steam flow rate sensor 82A and a measurement result of the second steam flow rate sensor 82B.

[0032]

<3.3 Gas Sensor>

For example, the gas sensor 83 is provided in the flue 6, and detects the oxygen concentration, the carbon monoxide concentration, the carbon dioxide concentration, the NOx concentration, or the like contained in the exhaust gas flowing through the flue 6.

The gas sensor 83 may be provided in the furnace 60, the heat recovery steam generator 3, the temperature reduction tower 4, the dust collector 5, the chimney 7, or the like instead of or in addition to the flue 6.

[0033]

<3.4 External Environment Sensor>

For example, an external environment sensor 84 (refer to FIG. 2) detects a value (for example, a value fluctuating according to a seasonal change) relating to an environment in which the combustion facility 1 is installed while being exposed to the outside of the combustion facility 1. For example, the external environment sensor 84 is a temperature sensor that measures an outside air temperature, but is not limited thereto. The external environment sensor 84 may be any sensor that can detect a value fluctuating according to the seasonal change. For example, the moisture meter 24 may correspond to an example of the external environment sensor 84.

[0034]

<4. Control Device>

Next, the control device 100 will be described.

FIG. 2 is a block diagram showing a functional configuration of the incineration facility 1. The control device 100 comprehensively controls the incineration facility 1. In the present embodiment, the control device 100 identifies a mathematical model imitating the combustion facility 1 and determines control parameters by using the analytic hierarchy process, and performs combustion control, based on the determined control parameters. In the present disclosure, the “combustion control” broadly means controlling relating to the combustion of the incineration target G, and for example, the “combustion control” means controlling one or more of a supply amount of the incineration target G (for example, a moving speed of the feeder 22), a transport speed

of the incineration target G (for example, a driving speed of the fire grate 41), a flow rate of the primary air, a distribution amount of the primary air to the plurality of wind boxes 50, a preheating temperature of the primary air, a flow rate of the secondary air, and a distribution amount of the secondary air to the plurality of supply ports of the furnace 60.

[0035]

In the present embodiment, for example, the control device 100 includes an information acquisition unit 110, a monitoring unit 120, a model identifying unit 130, a control parameter determining unit 140, a control unit 150, and a storage unit 160. A control target device of the control unit 150 (hereinafter, referred to as a "control target device VD") includes the extrusion device 23, the fire grate drive device 42, the blower 71, the air preheater 73, the damper 75, and the like.

[0036]

Hereinafter, an example in which both identifying the model and determining the control parameters are performed by using the analytic hierarchy process will be described. However, only one of identifying the model and determining the control parameters may be performed by using the analytic hierarchy process.

[0037]

<4.1 Information Acquisition unit>

The information acquisition unit 110 acquires a measurement result measured by various sensors provided in the incineration facility 1. For example, the information acquisition unit 110 acquires a measurement result of the moisture meter 24 (information relating to the moisture content of the incineration target G), a measurement result of the radiation temperature sensor 81, a measurement result of the steam flow rate sensor 82, a measurement result of the gas sensor 83, and a measurement result of the external

environment sensor 84.

[0038]

<4.2 Monitoring Unit>

The monitoring unit 120 monitors a state of an external environment such as a season. Here, the state (for example, a property of the incineration target G) relating to the combustion facility 1 differs depending on the external environment such as the season. Therefore, identifying the model and determining the control parameters which relate to the combustion facility 1 need to be performed every time the external environment such as the season is changed.

[0039]

In the present embodiment, the monitoring unit 120 determines whether or not to require a process of the model identifying unit 130 and a process of the control parameter determining unit 140 by monitoring a predetermined indicator value relating to the seasonal fluctuations. An example of the predetermined indicator value is an average value of the measurement values (for example, the outside air temperature) measured by the external environment sensor 84 in a predetermined period. Instead of the above-described example, the predetermined indicator value may be an average value or the like of the moisture content of the incineration target G which is measured by the moisture meter 24 in a predetermined period.

[0040]

The determination of the monitoring unit 120 is repeatedly performed at a predetermined cycle (for example, once a day). When the predetermined indicator value of the monitoring target is changed beyond a predetermined threshold value, the monitoring unit 120 outputs a signal indicating that the model needs to be re-identified to the model identifying unit 130, and outputs a signal indicating that the control

parameter needs to be re-determined to the control parameter determining unit 140.

[0041]

<4.3 Model Identifying Unit>

Next, the model identifying unit 130 will be described.

The model identifying unit 130 identifies a plant model M as a model relating to the combustion facility 1. The plant model M is a mathematical model (calculation model) that simulates characteristics of an actual machine of the combustion facility 1. In the present embodiment, the model identifying unit 130 identifies the plant model M by using the analytic hierarchy process. The model identifying unit 130 identifies one or more parameters (hereinafter, referred to as “model parameters”) defining the plant model M such that a behavior of the actual machine of the combustion facility 1 and a calculation value derived through calculation by using the plant model M match each other. For example, the model identifying unit 130 includes a Pareto solution generating unit 131 and a preferred solution determining unit 132.

[0042]

(Outline of Plant Model)

First, an outline of the plant model M will be described.

FIG. 3 is a diagram for describing the outline of the plant model M. As shown in FIG. 3, the furnace 60 includes an exhaust gas header 61 and a secondary combustion header 62 provided on the downstream side of the exhaust gas header 61. The secondary air line 74 includes a secondary air header 74a.

[0043]

In the plant model M, for example, conditions are set as follows. First, a reaction of a solid fuel (incineration target G) is set as follows.

$C+1/2O_2 \rightarrow CO$

$2H+1/2O_2 \rightarrow H_2O$

[0044]

When the solid fuel is excessively supplied to the furnace body 30, the carbon element (C) and the hydrogen element (H) in some of the solid fuel are volatilized. The volatilized carbon element and hydrogen element flow into the secondary combustion header 62 through the exhaust gas header 61, and react in the secondary combustion header 62. In the furnace body 30, a gaseous fuel (nitrogen element (N) and oxygen element (O)) is gasified, and nitrogen (N_2) and oxygen (O_2) are generated.

[0045]

In addition, when a reduction command of the carbon monoxide (CO) is output and an exhaust gas (IGR gas) containing a large amount of oxygen is generated, a portion of the IGR gas is used as a portion of the secondary air via the secondary air header 74a. The reaction of the secondary combustion in the exhaust gas header 61 is set as follows.

$CO+1/2O_2 \rightarrow CO_2$

[0046]

In the present embodiment, the model identifying unit 130 identifies the plant model M by using the analytic hierarchy process. In the present application, for example, "identifying the model" means determining one or more model parameters defining the model.

[0047]

For example, in the present embodiment, as the model parameter relating to the plant model M, a parameter for simulating a relationship between a supply state of the incineration target G and one or more indicators (one or more process values) relating to a combustion state is determined. For example, the one or more indicators include one or more of a carbon monoxide (CO generation amount) generation amount, a

nitrogen oxide (NOx generation amount) generation amount, an oxygen concentration (O_2 concentration), a temperature (IR temperature) measured by the temperature sensor 81, and the like.

[0048]

In the present embodiment, in order to simplify the calculation, the CO generation amount and the NOx generation amount are defined as functions of the O_2 concentration as described below.

[0049]

FIG. 4 is a diagram showing a relationship between the O_2 concentration and the CO concentration. In the present embodiment, the relationship between the O_2 concentration and the CO concentration is defined as shown in FIG. 4, based on actual measurement data in the combustion facility 1. FIG. 5 is a diagram showing a relationship between the O_2 concentration and the NOx concentration. In the present embodiment, the relationship between the O_2 concentration and the NOx concentration is defined as shown in FIG. 5, based on the actual measurement data in the combustion facility 1.

[0050]

On the other hand, the O_2 concentration is defined as shown below in order to consider influence of falling-off of the incineration target G. In the present application, the term “falling-off” means that a predetermined amount or more of the incineration target G extruded toward the furnace body 30 by the feeder 22 are unintentionally fallen off (are supplied) onto the stoker 40 all at once. An occurrence state of "falling-off" varies depending on a property of the incineration target G. Therefore, the occurrence state is changed depending on the season.

[0051]

FIG. 6 is a diagram for describing a change pattern of the O_2 concentration. In the present embodiment, when the falling-off occurs, the change pattern (change pattern of the supply amount) of the incineration target G supplied onto the stoker 40 is simulated in a trapezoidal shape. Specifically, when a time of the occurrence of the falling-off is defined as t0, a time at which an increase in the supply amount of the incineration target G is stagnated is defined as t1, a time at which the supply amount of the incineration target G is turned to decrease is defined as t2, and a time at which the supply amount of the incineration target G returns to an initial value is defined as t3, the falling-off of the incineration target G is simulated by using four model parameters of a maximum supply amount S of the incineration target G per hour, a time T (=t2-t0) until the increased incineration target G is turned to decrease, an increase speed α (=S/(t1-t0)) of the supply amount of the incineration target G, and a decrease speed β (=S/t3-t2) of the supply amount of the incineration target G. Each of the four model parameters (maximum supply amount S, time T, increase speed α, and decrease speed β) is a model parameter defining the plant model M. The change pattern of the O_2 concentration is simulated in an arc shape protruding downward between time t0 and time t3.

[0052]

(Pareto Solution Generating Unit Relating to Model Parameter)

Next, the Pareto solution generating unit 131 will be described. Based on the measurement value measured in the actual machine of the combustion facility 1 and the calculation value derived through calculation by using the plant model M, the Pareto solution generating unit 131 generates a Pareto solution relating to one or more (for example, a plurality of) model parameters defining the plant model M by setting the minimization of the error between the measurement value and the calculation value of the plurality of indicators (for example, two or more indicators, more specifically, for

example, three or more indicators) relating to the combustion state of the combustion facility 1, as an objective function.

[0053]

For example, as the plurality of indicators relating to the combustion state of the combustion facility 1, the Pareto solution generating unit 131 generates a plurality of Pareto solutions of one or more (for example, a plurality of) model parameters in which an error is minimized between the measurement value (for example, the measurement value obtained by the radiation temperature sensor 81 or the gas sensor 83) measured in the actual machine of the combustion facility 1 and the calculation value derived through calculation by using the plant model M with regard to each of the CO generation amount, the NOx generation amount, the IR temperature, and the O_2 concentration.

[0054]

In the present embodiment, the plurality of model parameters include the four model parameters (maximum supply amount S, time T until decrease, increase speed α, and decrease speed β) described above. In addition, in addition to the four model parameters, the plurality of model parameters may include the model parameters relating to one or more of moisture content of the incineration target G, a calorific value of the incineration target G, a supply amount of the incineration target G, a transport speed of the incineration target G, a flow rate of the primary air, a distribution amount of the primary air to the plurality of wind boxes 50, a temperature of the primary air, a flow rate of the secondary air, a distribution amount of the secondary air to the plurality of supply ports of the furnace 60, and the like.

[0055]

For example, the Pareto solution generating unit 131 generates the plurality of Pareto solutions by using a multiobjective evolutionary algorithm based on

decomposition (MOEA/D). However, the algorithm for generating the Pareto solution is not limited to the above-described example, and other methods may be used.

[0056]

FIG. 7 is a diagram for describing the plurality of Pareto solutions of the model parameters generated by the Pareto solution generating unit 131. Each of a plurality of black triangles in FIG. 7 indicates the plurality of Pareto solutions (Pareto solution sets) relating to a model parameter set. The "model parameter set" indicates a combination of the plurality of model parameters which are generation targets of the Pareto solutions. Each of the plurality of black triangles which are the Pareto solutions indicates a plurality of the model parameter sets (model parameter set A, model parameter set B, model parameter set C, and so forth) in which values of one or more model parameters are different from each other.

[0057]

In FIG. 7, for convenience of description, the Pareto solution is shown on a two-dimensional plane in which two indicators of the IR temperature and the O_2 concentration are set as evaluation functions. In practice, for example, the Pareto solution is obtained on a four-dimensional space in which four indicators of the CO generation amount, the NOx generation amount, the IR temperature, and the O_2 concentration are set as evaluation functions. However, the Pareto solution is not limited to the above-described example, and may be obtained based on two or three indicators, or may be obtained based on five or more indicators.

[0058]

(Preferred Solution Determining Unit Relating to Model Parameter)

Next, the preferred solution determining unit 132 will be described. The preferred solution determining unit 132 determines (selects) one or more preferred

solutions (optimal model parameter sets) from the plurality of Pareto solutions by using the analytic hierarchy process for the plurality of Pareto solutions relating to the model parameters generated by the Pareto solution generating unit 131.

[0059]

FIG. 8 is a diagram showing a flow of the analytic hierarchy process used in the present embodiment. In the analytic hierarchy process, the process proceeds in the order of constructing a hierarchical structure (S101), performing a pairwise comparison (S102), calculating an importance degree (S103), and performing comprehensive evaluation (S104).

[0060]

(Construction of Hierarchical Structure)

First, the preferred solution determining unit 132 performs a process of constructing a hierarchical structure.

FIG. 9 is a diagram for describing the hierarchical structure relating to derivation of an optimal model parameter generated by the preferred solution determining unit 132. In the present embodiment, as the evaluation references, four evaluation references relating to the CO generation amount, the NOx generation amount, the IR temperature, and the O_2 concentration are set. That is, (1) minimizing an error between the measurement value and the calculation value of the CO generation amount in the actual machine, (2) minimizing an error between the measurement value and the calculation value of the NOx generation amount in the actual machine, (3) minimizing an error between the measurement value and the calculation value of the IR temperature in the actual machine, and (4) minimizing an error between the measurement value and the calculation value of the O_2 concentration in the actual machine are respectively set as evaluation references. The "calculation value" referred to herein means a

calculation value derived through calculation (simulation) by using the plant model M.

[0061]

In the present embodiment, the weights of all of the four evaluation references are the same. Therefore, the process of the pairwise comparison between the four evaluation references will be omitted. However, weighting according to a priority may be performed on the four evaluation references. In this case, as a part of the process of the pairwise comparison (to be described later), a score may be assigned based on the pairwise comparison between the four evaluation references.

[0062]

In the present embodiment, the preferred solution determining unit 132 sets a plurality of alternative plans as a process of constructing the hierarchical structure. For example, as the respective alternative plans, the preferred solution determining unit 132 sets the plurality of model parameter sets (model parameter set A, model parameter set B, model parameter set C, and so forth) which are respectively the Pareto solutions generated by the Pareto solution generating unit 131.

[0063]

(Performing Pairwise Comparison)

Next, the preferred solution determining unit 132 performs a process of the pairwise comparison between the plurality of alternative plans.

FIG. 10 is a diagram conceptually showing the process of the pairwise comparison relating to the model parameters. For example, FIG. 10 shows a result of the pairwise comparison of the plurality of model parameter sets when minimizing the error between the measurement value and the calculation value of the O_2 concentration in the actual machine is set as the evaluation reference. In FIG. 10, a section 1 to a section 9 are sections in which a magnitude of the error between the measurement value

and the calculation value of the O_2 concentration in the actual machine is divided by a predetermined reference.

[0064]

(Calculation of Importance Degree)

Next, the preferred solution determining unit 132 calculates an importance degree for each model parameter set, based on a result of the pairwise comparison. For example, the preferred solution determining unit 132 calculates an evaluation value of the importance degree of each model parameter set relating to each evaluation reference, for example, by using a geometric mean method, based on a score set in advance for each of the sections 1 to 9.

[0065]

(Comprehensive Evaluation)>

Next, the preferred solution determining unit 132 calculates a comprehensive evaluation value of each model parameter set. For example, the preferred solution determining unit 132 calculates the comprehensive evaluation value of each model parameter set by adding the evaluation value of the importance degree calculated for each evaluation reference to the plurality of evaluation references. The preferred solution determining unit 132 identifies the plant model M by deriving the model parameter set having the highest comprehensive evaluation value from the plurality of model parameter sets, as an optimal model parameter set. The preferred solution determining unit 132 outputs information indicating the identified plant model M (for example, information indicating the derived optimal model parameter set) to the control parameter determining unit 140.

[0066]

<4.4 Control Parameter Determining Unit>

Next, the control parameter determining unit 140 will be described.

The control parameter determining unit 140 determines a control parameter used for controlling the combustion facility 1. In the present embodiment, the control parameter determining unit 140 determines the control parameter by using the analytic hierarchy process. For example, the control parameter determining unit 140 includes a Pareto solution generating unit 141 and a preferred solution determining unit 142.

[0067]

(Pareto Solution Generating Unit Relating to Control Parameter)

First, the Pareto solution generating unit 141 will be described. The Pareto solution generating unit 141 generates the plurality of Pareto solutions relating to the control parameters of the combustion facility 1 by setting a plurality of indicators (for example, two or more indicators, more specifically, for example, three or more indicators) relating to the combustion state of the combustion facility 1 as objective functions, based on the plant model M identified by the model identifying unit 130.

[0068]

For example, as the plurality of indicators relating to the combustion state of the combustion facility 1, the Pareto solution generating unit 141 generates the plurality of Pareto solutions relating to one or more control parameters which minimize the calculation value derived through calculation by using the plant model M with regard to each of the CO generation amount, the NOx generation amount, the IR temperature fluctuations, and the O_2 concentration fluctuations.

[0069]

For example, the control parameter is an opening degree of the damper 75 for the combustion air. Hereinafter, an example will be described in which the opening degree of the secondary air damper 75B is derived by the analytic hierarchy process, as

the control parameter. However, instead of or in addition to the above-described example, the control parameters derived by the analytic hierarchy process may include the control parameters relating to one or more of the moisture content of the incineration target G, the calorific value of the incineration target G, the supply amount of the incineration target G (for example, the speed of the feeder 22), the transport speed of the incineration target G (for example, the moving speed of the fire grate 41), the flow rate of the primary air (for example, the opening degree of the primary air damper 75A and/or the drive amount of the first blower 71A), the distribution amount of the primary air to the plurality of wind boxes 50 (for example, the opening degree of the primary air damper 75A), the temperature of the primary air (for example, the heating amount of the air preheater 73), the flow rate of the secondary air (for example, the drive amount of the secondary air damper 75B and/or the second blower 71B), and the distribution amount of the secondary air to the plurality of supply ports of the furnace 60 (for example, the secondary air damper 75B).

[0070]

For example, the Pareto solution generating unit 141 generates the plurality of Pareto solutions relating to the control parameters by using the multiobjective evolutionary algorithm based on decomposition (MOEA/D). However, the algorithm for generating the Pareto solution is not limited to the above-described example, and other methods may be used.

[0071]

FIG. 11 is a diagram for describing the plurality of Pareto solutions relating to the control parameters (for example, the opening degree of the secondary air damper 75B) generated by the Pareto solution generating unit 141. Each of a plurality of white triangles in FIG. 11 indicates the plurality of Pareto solutions (Pareto solution set) of the

control parameters. The plurality of white triangles which are respectively the Pareto solutions indicate a plurality of opening degrees (opening degree A, opening degree B, opening degree C, and so forth) of the secondary air damper 75B, as the plurality of control parameters having mutually different values of the control parameters.

[0072]

In FIG. 11, for convenience of description, the Pareto solution is shown on a two-dimensional plane in which the two indicators of the CO generation amount and the NOx generation amount are set as evaluation functions. In practice, for example, the Pareto solution is obtained on a four-dimensional space in which four indicators of the CO generation amount, the NOx generation amount, the IR temperature fluctuation amount, and the O_2 concentration fluctuation amount are set as evaluation functions. However, the Pareto solution is not limited to the above-described example, and may be obtained based on two or three indicators, or may be obtained based on five or more indicators.

[0073]

(Preferred Solution Determining Unit Relating to Control Parameter)

Next, the preferred solution determining unit 142 will be described. The preferred solution determining unit 142 selects and determines (selects) one or more preferred solutions (optimal control parameters, for example, optimal opening degree of the secondary air damper 75B) from the Pareto solutions by using the analytic hierarchy process for the plurality of the Pareto solutions relating to the control parameters generated by the Pareto solution generating unit 141.

[0074]

A flow of the analytic hierarchy process relating to the control parameter is the same as a flow of the analytic hierarchy process relating to the model parameter

described with reference to FIG. 8. Therefore, repeated description will be omitted. Hereinafter, a specific process of the analytic hierarchy process relating to the control parameter will be described.

[0075]

(Construction of Hierarchical Structure)

First, the preferred solution determining unit 142 performs a process of constructing the hierarchical structure.

FIG. 12 is a diagram for describing the hierarchical structure relating to the derivation of the optimal control parameter generated by the preferred solution determining unit 142. In the present embodiment, as the evaluation references, four evaluation references relating to the CO generation amount, the NOx generation amount, the IR temperature fluctuations, and the O_2 concentration fluctuations are set. That is, (1) minimizing the calculation value of the CO generation amount, (2) minimizing the calculation value of the NOx generation amount, (3) minimizing the calculation value of the IR temperature fluctuation amount (or the fluctuation rate), and (4) minimizing the calculation value of the O_2 concentration fluctuation amount (or the fluctuation rate) are respectively set as the evaluation references. The "calculation value" referred to herein means the calculation value derived through calculation (simulation) by using the optimal model parameter set derived by the model identifying unit 130, and the plant model M.

[0076]

In the present embodiment, the preferred solution determining unit 142 sets a plurality of alternative plans as a process of constructing the hierarchical structure. For example, as the respective alternative plans the preferred solution determining unit 142 sets the plurality of control parameters (for example, opening degrees A, B, C, and so

forth relating to the secondary air damper 75B) which are respectively the Pareto solutions generated by the Pareto solution generating unit 141.

[0077]

(Performing Pairwise Comparison)

Next, the preferred solution determining unit 142 performs a process of the pairwise comparison for each of the plurality of evaluation references and the plurality of alternative plans. First, the pairwise comparison between the plurality of evaluation references will be described. When there are four references as in the present embodiment, six pairwise comparisons are performed such as (i) CO generation priority and O_2 fluctuation priority, (ii) CO generation priority and NOx generation priority, (iii) CO generation priority and IR temperature fluctuation priority, (iv) NOx generation priority and O_2 fluctuation priority, (v) NOx generation priority and IR temperature fluctuation priority, and (vi) O_2 fluctuation priority and IR temperature fluctuation priority.

[0078]

FIG. 13 is a diagram showing an example of a result of the pairwise comparison between the evaluation references of the control parameters. In the present embodiment, as the pairwise comparison between the evaluation references of the control parameters, a priority different in each of a plurality of operation situations which can occur in the combustion facility 1 is assigned. FIG. 13 shows the pairwise comparison in each of three operation situations such as (a) a CO priority operation situation, (b) a NOx priority operation situation, and (c) an IR temperature (steam flow rate) priority operation situation.

[0079]

The "CO priority" operation situation indicates a situation where a calculation

value of the CO generation amount is equal to or greater than a predetermined threshold value (for example, a great threshold value for CO), but a calculation value of the NOx generation amount is smaller than the predetermined threshold value (for example, a small threshold value for NOx), and the CO generation amount is strict but the NOx generation amount is sufficient. In this case, scores are assigned to the plurality of evaluation references such that a highest priority is given to the fluctuations in the CO generation amount, a subsequent priority is given to the fluctuations in the IR temperature (steam flow rate), and a subsequent priority is given to the fluctuations in the O_2 concentration or the fluctuations in the NOx (for example, the priority is given to the fluctuations in the O_2 concentration from a viewpoint of a stable operation of the combustion facility 1). In FIG. 13, a larger number means a higher priority. For example, a score "7" assigned to an intersection portion indicated by A in FIG. 13 means that the priority is given to the fluctuations in CO 7 times the priority given to the fluctuations in NOx.

[0080]

The "NOx priority" operation situation indicates a situation where the calculation value of the CO generation amount is less than a predetermined threshold value (for example, a low threshold value for CO), but the calculation value of the NOx generation amount is equal to or greater than a predetermined threshold value (for example, a great threshold value for NOx), and there is a margin in the CO generation amount but the NOx generation amount is strict. In this case, scores are assigned to the plurality of evaluation references such that the highest priority is given to the fluctuations in the NOx generation amount, the subsequent priority is given to the fluctuations in the IR temperature (steam flow rate, and the subsequent priority is given to the fluctuations in the O_2 concentration or the fluctuations in the CO (for example,

the priority is given to the fluctuations in the CO generation amount from a viewpoint of a stable operation of the combustion facility 1).

[0081]

A situation of the "IR temperature (steam flow rate) priority" indicates a situation where the calculation value of the CO generation amount is smaller than a predetermined threshold value (for example, a small threshold value for CO), the calculation value of the NOx generation amount is smaller than the predetermined threshold value (for example, a small threshold value for NOx), and there is a margin in both the CO generation amount and the NOx generation amount. In this case, scores are assigned to the plurality of evaluation references such that the highest priority is given to the fluctuations in the IR temperature (steam flow rate), the subsequent priority is given to the fluctuations in the CO generation amount, and the subsequent priority is given to the fluctuations in the O_2 concentration or the fluctuations in the NOx (for example, the priority is given to the fluctuations in the O_2 generation amount from a viewpoint of a stable operation of the combustion facility 1).

[0082]

Next, the preferred solution determining unit 142 performs the process of the pairwise comparison between the plurality of alternative plans. In the present embodiment, the preferred solution determining unit 142 performs the following process for each of the three operation situations.

[0083]

FIG. 14 is a diagram conceptually showing the process of the pairwise comparison between the control parameters. For example, FIG. 14 shows a result of the pairwise comparison between the plurality of control parameters (for example, a plurality of opening degrees of the secondary air damper 75B) when minimizing the O_2

concentration fluctuation is the evaluation reference. In FIG. 14, sections 1 to 9 are sections in which a magnitude of the O_2 concentration fluctuation is divided by a predetermined reference.

[0084]

(Calculation of Importance Degree)

Next, the preferred solution determining unit 142 calculates the importance degree of each evaluation reference, based on the result of the pairwise comparison between the plurality of evaluation references. For example, the preferred solution determining unit 142 calculates an evaluation value of the importance degree (hereinafter, referred to as an "evaluation reference importance degree") of each evaluation reference, for example, by using the geometric mean method, based on the score set by the pairwise comparison.

[0085]

Next, the preferred solution determining unit 142 calculates the importance degree of each control parameter (for example, each opening degree of the secondary air damper 75B), based on the result of the pairwise comparison between the plurality of control parameters (for example, the plurality of opening degrees of the secondary air damper 75B). For example, the preferred solution determining unit 142 calculates the evaluation value of the importance degree of each control parameter (for example, each opening degree of the secondary air damper 75B) relating to each evaluation reference, for example, by using a geometric mean method, based on the score set in advance for each of the section 1 to the section 9.

[0086]

(Comprehensive Evaluation)>

Next, the preferred solution determining unit 142 calculates the comprehensive

evaluation value of each control parameter (for example, each opening degree of the secondary air damper 75B). For example, the preferred solution determining unit 142 reflects (for example, multiplies) the evaluation reference importance degree of each evaluation reference for each control parameter (for example, each opening degree of the secondary air damper 75B), and thereafter, adds the evaluation values of the importance degree of the control parameter (opening degree) to the plurality of evaluation references. In this manner, the preferred solution determining unit 142 calculates the comprehensive evaluation value of each control parameter (for example, each opening degree of the secondary air damper 75B). The preferred solution determining unit 142 derives the control parameter having the greatest comprehensive evaluation value from the plurality of control parameters (for example, the plurality of opening degrees of the secondary air damper 75B), as an optimal control parameter (for example, an optimal opening degree).

[0087]

In the present embodiment, the preferred solution determining unit 142 derives (determines) the above-described optimal control parameter (for example, the optimal opening degree) for each of the plurality of situations described above, based on the result of the pairwise comparison between the plurality of evaluation references for each of the plurality (for example, three) of operation situations described above. For example, the preferred solution determining unit 142 derives an optimal control parameter S1 (for example, an optimal opening degree S1) in the operation situation of the "CO priority", an optimal control parameter S2 (for example, an optimal opening degree S2) in the operation situation of the "NOx priority", and an optimal control parameter S3 (for example, an optimal opening degree S3) in the operation situation of the "IR temperature (steam flow rate) priority". The preferred solution determining

unit 142 derives a control parameter set which can correspond to a larger number of various operation situations, based on a plurality of the optimal control parameters S1, S2, and S3 derived for each operation situation.

[0088]

FIG. 15 is a diagram showing an example of the control parameter set derived by the preferred solution determining unit 142. (a) in FIG. 15 shows the control parameter set of a maximum opening degree (unit: [%]) of the secondary air damper 75B. (b) in FIG. 15 shows the control parameter set of an intermediate opening degree (unit: [%]) of the secondary air damper 75B. For example, the "maximum opening degree" is an opening degree set by the control unit 150 for a predetermined time (first predetermined time) when the CO concentration or the NOx concentration increases beyond a predetermined reference (for example, when the "falling-off" occurs). For example, the "intermediate opening degree" is an opening degree set by the control unit 150 for a predetermined time (second predetermined time) after the secondary air damper 75B is set to have the maximum opening degree over the predetermined time.

[0089]

In the present embodiment, the preferred solution determining unit 142 determines each of the control parameter set corresponding to the "maximum opening degree" and the control parameter set corresponding to the "intermediate opening degree", as the control parameter sets.

[0090]

For example, when the preferred solution determining unit 142 derives the control parameter set corresponding to the "maximum opening degree", the processes in S101 to S104 described above are performed by setting a constraint condition that the opening degree is 20% or higher and 100% or lower. In this manner, the preferred

solution determining unit 142 derives the plurality of optimal control parameters S1, S2, and S3 suitable for each of the operation situations, as the plurality of optimal control parameters S1A, S2A, and S3A. For example, the preferred solution determining unit 142 derives the control parameter set shown in (a) in FIG. 15 by performing linear interpolation based on the control parameters S1A, S2A, and S3A.

[0091]

Similarly, when the preferred solution determining unit 142 derives the control parameter set corresponding to the "intermediate opening degree", the processes in S101 to S104 described above are performed by setting the constraint condition that the opening degree is 10% or higher and 60% or lower. In this manner, the preferred solution determining unit 142 derives the plurality of optimal control parameters S1, S2, and S3 suitable for each of the operation situations, as the plurality of optimal control parameters S1B, S2B, and S3B. For example, the preferred solution determining unit 142 derives the control parameter set shown in (b) in FIG. 15 by performing linear interpolation based on the control parameters S1B, S2B, and S3B.

[0092]

In FIG. 15, in each of the CO concentration and the NOx concentration, a section having a small numerical value in the sections 1 to 5 means a severe situation, and a section having a great numerical value means a situation having a large margin. For example, the section 1 relating to the CO concentration means that the CO generation amount is equal to or greater than the great threshold value for CO. For example, the section 5 relating to the CO concentration means that the CO generation amount is smaller than the small threshold value for CO. Similarly, the section 1 relating to the NOx concentration means that the NOx generation amount is equal to or greater than the great threshold value for NOx. For example, the section 5 relating to

the NOx concentration means that the NOx generation amount is smaller than the small threshold value for NOx. The section 1 to the section 5 of the CO concentration and the NOx concentration set in (a) in FIG. 15 and the section 1 to the section 5 of the CO concentration and the NOx concentration set in (b) in FIG. 15 may be the same or may be different.

[0093]

<4.5 Control Unit>

The control unit 150 comprehensively manages the whole combustion facility 1. In the present embodiment, the control unit 150 performs combustion control relating to the combustion facility 1 by controlling a control target device VD, based on various measurement values acquired by the information acquisition unit 110 and the control parameters determined by the control parameter determining unit 140. For example, in the present embodiment, the control unit 150 controls the secondary air damper 75B, based on the measurement value (for example, the measurement value obtained by the gas sensor 83) relating to the CO and NOx acquired by the information acquisition unit 110 and the control parameters (for example, the control parameters set shown in (a) or (b) in FIG. 15) determined by the control parameter determining unit 140.

[0094]

For example, when the CO concentration (CO generation amount) or the NOx concentration (NOx generation amount) detected by the gas sensor 83 increases beyond the predetermined reference (for example, when the “falling-off” occurs), the control unit 150 controls the secondary air damper 75B to have the opening degree (first opening degree) corresponding to the CO concentration (CO generation amount) and the NOx concentration (NOx generation amount) detected by the gas sensor 83, in the plurality

of opening degrees shown in (a) in FIG. 15.

[0095]

The control unit 150 sets the secondary air damper 75B to have the first opening degree, and operates the combustion facility 1 for a predetermined time, and thereafter, controls the secondary air damper 75B to have the opening degree (second opening degree) corresponding to the CO concentration (CO generation amount) and the NOx concentration (NOx generation amount) detected by the gas sensor 83, in the plurality of opening degrees shown in (b) in FIG. 15. Thereafter, the control unit 150 sets the secondary air damper 75B to have the second opening degree, operates the combustion facility 1 for a predetermined time, and thereafter, returns the secondary air damper 75B to a preset reference opening degree.

[0096]

<5. Flow of Information Processing>

Next, a flow of information processing performed by the control device 100 will be described.

FIG. 16 is a flowchart showing the flow of the information processing. In the present embodiment, first, the monitoring unit 120 calculates and acquires a predetermined indicator value (for example, an average value of the measurement values measured by the external environment sensor 84 in a predetermined period) relating to seasonal fluctuations, based on the measurement value acquired by the information acquisition unit 110 (S111). The monitoring unit 120 determines whether or not the acquired predetermined indicator value is changed beyond a predetermined threshold value (S112).

[0097]

When it is determined that the predetermined indicator value is not changed

beyond the predetermined threshold value (S112: NO), the monitoring unit 120 waits for a predetermined time (for example, waits for one day), and repeats the process in S111. On the other hand, when it is determined that the predetermined indicator value is changed beyond the predetermined threshold value (S112: YES), the process proceeds to S121.

[0098]

In the present embodiment, when it is determined that the predetermined indicator value is changed beyond the predetermined threshold value (S112: YES), the processes of re-identifying the model and resetting the control parameters are performed. For example, the information acquisition unit 110 acquires various data relating to the combustion facility 1 which is a target plant (S121). For example, the information acquisition unit 110 acquires a measurement result of the radiation temperature sensor 81, a measurement result of the gas sensor 83, and the like. The information acquisition unit 110 acquires a required measurement value by performing correction corresponding to a time delay or a time advance for each measurement value, for example.

[0099]

Next, based on the measurement value acquired by the information acquisition unit 110 in the process in S121 and the calculation values derived through calculation by using the plant model M, the Pareto solution generating unit 131 of the model identifying unit 130 generates the plurality of Pareto solutions relating to one or more model parameters defining the plant model M by setting the minimization of the error between the measurement value and the calculation value for example, which relate to the CO generation amount, the NOx generation amount, the IR temperature, and the O_2 concentration, as the objective function (S131).

[0100]

Next, the preferred solution determining unit 132 of the model identifying unit 130 determines one or more preferred solutions (optimal model parameter sets) from the plurality of Pareto solutions by using the analytic hierarchy process for the plurality of Pareto solutions relating to the model parameters generated by the Pareto solution generating unit 131 (S132). In this manner, the plant model M is identified.

[0101]

Next, the Pareto solution generating unit 141 of the control parameter determining unit 140 generates the plurality of Pareto solutions relating to the control parameters which minimize the calculation value relating to the CO generation amount, the NOx generation amount, the IR temperature fluctuations, and the O_2 concentration fluctuations, for example, based on the plant model M identified by the model identifying unit 130 (S141).

[0102]

Next, the preferred solution determining unit 142 of the control parameter determining unit 140 determines one or more preferred solutions (optimal control parameters) from the plurality of Pareto solutions by using the analytic hierarchy process for the plurality of Pareto solutions relating to the control parameters generated by the Pareto solution generating unit 141 (S142). In the present embodiment, the preferred solution determining unit 142 derives the control parameter set, based on the plurality of preferred solutions (control parameters S1, S2, and S3) obtained by determining one or more preferred solutions for each operation situation of the combustion facility 1 (S143).

[0103]

Next, the control unit 150 performs the combustion control relating to the

combustion facility 1, based on one or more preferred solutions determined by the control parameter determining unit 140 (for example, based on the derived control parameter set) (S151). When a predetermined period (for example, one day) elapses, the process returns to S111, and a series of processes from S111 are repeated.

[0104]

<6. Operational Effects>

For example, in order to correspond to unique characteristics of each combustion facility 1 and/or changes or the like in fuel properties due to seasons, the combustion facility needs to optimize the control parameters. However, in order to determine the optimal control parameter, it is necessary to identify the plant model or to select a solution from the Pareto solutions for the trade-off of a plurality of objectives. Consequently, the determination is less likely to be completely automated.

[0105]

On the other hand, in the present embodiment, the control device 100 includes the Pareto solution generating unit 141 that generates the plurality of Pareto solutions relating to the control parameters of the combustion facility 1 by setting the plurality of indicators relating to the combustion state as the objective functions, based on the plant model M, and the preferred solution determining unit 142 that determines one or more preferred solutions from the plurality of Pareto solutions by using the analytic hierarchy process for the plurality of Pareto solutions generated by the Pareto solution generating unit 141. According to this configuration, the control parameters of the combustion facility 1 can be appropriately determined by the control device 100, and automation of the operation of the combustion facility 1 can be promoted.

[0106]

(Second Embodiment)

Next, a second embodiment will be described. The second embodiment is different from the first embodiment in that a response surface relating to the plant model M is generated, and optimization calculation is performed based on the generated response surface. The configurations other than those described below are the same as the configurations of the first embodiment.

[0107]

FIG. 17 is a block diagram showing a functional configuration of the incineration facility 1 of the second embodiment. In the present embodiment, the control device 100 includes a response surface generating unit 170. The response surface generating unit 170 generates a response surface relating to the plant model M by using a response surface creation method (for example, a linear interpolation method). For example, the response surface generating unit 170 generates the response surface relating to the plant model M by changing a target parameter (model parameter) relating to the plant model M.

[0108]

FIG. 18 is a flowchart showing a flow of the information processing of the second embodiment. In the present embodiment, the response surface generating unit 170 generates the response surface (S161). The Pareto solution generating unit 131 of the model identifying unit 130 performs optimization calculation, based on the response surface generated by the response surface generating unit 170 (S131).

[0109]

According to this configuration, as in the first embodiment, the control parameters of the combustion facility 1 can be appropriately determined by the control device 100, and the automation of the operation of the combustion facility 1 can be promoted. In addition, a calculation time of the optimization calculation of the model

identifying unit 130 can be shortened by generating the response surface as in the present embodiment, and the optimal control parameter can be quickly derived in accordance with the combustion state. A response surface creation method is not limited to the linear interpolation method, and a Kriging method or the like may be used.

[0110]

(Other Embodiments)

Hitherto, the embodiments of the present disclosure have been described. Meanwhile, the specific configuration is not limited to the embodiments, and the present disclosure includes a design change or the like within the scope not departing from the concept of the present disclosure.

[0111]

FIG. 19 is a hardware configuration diagram showing a configuration of a computer 1100 according to the embodiment. For example, the computer 1100 includes a processor 1110, a main memory 1120, a storage 1130, and an interface 1140.

[0112]

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

[0113]

The program may be intended to realize some of functions fulfilled by the computer 1100. For example, the program may fulfill a function in combination with

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

[0114]

As an example of the storage 1130, a magnetic disk, a magneto-optical disk, or a semiconductor memory can be used. The storage 1130 may be an internal medium directly connected to a bus of the computer 1100 or may be an external medium connected to the computer 1100 through the interface 1140 or a communication line. In addition, when this program is distributed to the computer 1100 via the communication line, the computer 1100 receiving the distributed program may develop the program in the main memory 1120 to execute the above-described process. In addition, the program may be used to partially realize the above-described functions. In addition, the program may be a so-called difference file (difference program) that realizes the above-described functions in combination with another program previously stored in the storage 1130.

[0115]

<Additional Notes>

The combustion facility system and the information processing method which are described in each embodiment are understood as follows, for example.

[0116]

(1) The combustion facility system (for example, the control device 100) of a first aspect includes the Pareto solution generating unit 141 that generates the plurality of Pareto solutions relating to control parameters of the combustion facility 1 by setting the plurality of indicators relating to the combustion state as the objective functions, based on the model relating to the combustion facility 1, and the preferred solution determining unit 142 that determines one or more preferred solutions from the plurality of Pareto solutions by using the analytic hierarchy process with respect to the plurality of Pareto solutions generated by the Pareto solution generating unit 141. According to this configuration, the control parameters of the combustion facility 1 can be appropriately determined by the control device 100, and the automation of the operation of the combustion facility 1 can be promoted.

[0117]

(2) As the combustion facility system of a second aspect, in the combustion facility system according to (1), the plurality of indicators are indicators relating to two or more of the carbon monoxide generation amount, the nitrogen oxide generation amount, the oxygen concentration fluctuations, the gas temperature fluctuations, or the steam flow rate fluctuations. According to this configuration, the control parameters of the combustion facility 1 can be appropriately determined based on the component contained in the exhaust gas, the steam flow rate, or the like.

[0118]

(3) As the combustion facility system of a third aspect, in the combustion facility system according to (1) or (2), the control parameter is one or more control parameters relating to the moisture content of the incineration target, the calorific value of the incineration target, the supply amount of the incineration target, the transport speed of the incineration target, the flow rate of combustion air, the distribution amount of the

combustion air, or the temperature of the combustion air. According to this configuration, as the control parameters of the combustion facility 1, the moisture content of the incineration target, the calorific value of the incineration target, the supply amount of the incineration target, the transport speed of the incineration target, the flow rate of the combustion air, the distribution amount of the combustion air, or the temperature of the combustion air can be appropriately adjusted. In this manner, the automation of the control relating to the combustion facility 1 can be promoted.

[0119]

(4) As the combustion facility system of a fourth aspect, in the combustion facility system according to any one of (1) to (3), the preferred solution determining unit 142 determines the preferred solution for each of the operation situation in which a value relating to a first indicator included in a plurality of indicators is equal to or greater than a predetermined threshold value and the operation situation in which the value relating to the first indicator is smaller than the threshold value. According to this configuration, the control parameters suitable for each operation situation can be appropriately determined in accordance with a plurality of operation situations.

[0120]

(5) As the combustion facility system of a fifth aspect, the combustion facility system according to any one of (1) to (4) further includes the monitoring unit 120 that monitors a predetermined indicator value relating to seasonal fluctuations, and the model identifying unit 130 that re-identifies the model when the predetermined indicator value monitored by the monitoring unit 120 is changed beyond the threshold value. According to this configuration, the control parameters can be appropriately determined by using the model corresponding to the external environment.

[0121]

(6) The information processing method of a sixth aspect which is executed by one or more computers includes generating the plurality of Pareto solutions relating to the control parameters of the combustion facility 1 by setting the plurality of indicators relating to the combustion state as the objective functions, based on the model relating to the combustion facility 1, and determining one or more preferred solutions from the plurality of Pareto solutions by using an analytic hierarchy process with respect to the plurality of generated Pareto solutions. According to this configuration, the control parameter of the combustion facility 1 can be appropriately determined, and the automation of the operation of the combustion facility 1 can be promoted.

[Industrial Applicability]

[0122]

According to a combustion facility system, and an information processing method of the present invention, parameters relating to a combustion facility can be appropriately determined.

[Reference Signs List]

[0123]

1: combustion facility

2: incinerator

21: hopper

22: feeder

23: extrusion device

24: moisture meter

30: furnace body

40: stoker

50: wind box

60: furnace

70: blowing mechanism

71: blower

73: air preheater

75: damper

81: radiation temperature sensor

82: steam flow rate sensor

83: gas sensor

100: control device

110: information acquisition unit

120: monitoring unit

130: model identifying unit

131: Pareto solution generating unit

132: preferred solution determining unit

140: control parameter determining unit

141: Pareto solution generating unit

142: preferred solution determining unit

150: control unit

170: response surface generating unit

G: Incineration target

Claims

[Claim 1]

A combustion facility system comprising:

a Pareto solution generating unit that generates a plurality of Pareto solutions relating to control parameters of a combustion facility by setting a plurality of indicators relating to a combustion state as objective functions, based on a model relating to the combustion facility; and

a preferred solution determining unit that determines one or more preferred solutions from the plurality of Pareto solutions by using an analytic hierarchy process with respect to the plurality of Pareto solutions generated by the Pareto solution generating unit,

wherein the plurality of indicators include a first indicator and a second indicator different from the first indicator, and

the preferred solution determining unit changes a priority in a pairwise comparison between the first indicator and the second indicator in the analytic hierarchy process, in a first operating situation in which the first indicator is prioritized over the second indicator and a second operating situation in which the second indicator is prioritized over the first indicator, and determines the preferred solution in each of the first operating situation and the second operating situation.

[Claim 2]

The combustion facility system according to Claim 1,

wherein the plurality of indicators are indicators relating to two or more of a carbon monoxide generation amount, a nitrogen oxide generation amount, oxygen

concentration fluctuations, gas temperature fluctuations, or steam flow rate fluctuations.

[Claim 3]

The combustion facility system according to Claim 1 or 2,

wherein the control parameter is one or more control parameters relating to moisture content of an incineration target, calorific value of the incineration target, a supply amount of the incineration target, a transport speed of the incineration target, a flow rate of combustion air, a distribution amount of the combustion air, or a temperature of the combustion air.

[Claim 4]

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

a monitoring unit that monitors a predetermined indicator value relating to seasonal fluctuations; and

a model identifying unit that re-identifies the model when the predetermined indicator value monitored by the monitoring unit is changed beyond a threshold value.

[Claim 5]

An information processing method executed by one or more computers, the method comprising:

generating a plurality of Pareto solutions relating to control parameters of a combustion facility by setting a plurality of indicators relating to a combustion state as objective functions, based on a model relating to the combustion facility; and

determining one or more preferred solutions from the plurality of Pareto solutions by using an analytic hierarchy process with respect to the plurality of generated

Pareto solutions,

wherein the plurality of indicators include a first indicator and a second indicator different from the first indicator, and

determining the preferred solution is changing a priority in a pairwise comparison between the first indicator and the second indicator in the analytic hierarchy process, in a first operating situation in which the first indicator is prioritized over the second indicator and a second operating situation in which the second indicator is prioritized over the first indicator, and determining the preferred solution in each of the first operating situation and the second operating situation.