

DESCRIPTION

Title of Invention

CONTROL DEVICE FOR INCINERATOR EQUIPMENT

[Technical Field]

[0001]

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

This application claims the priority of Japanese Patent Application No. 2021-107370 filed in Japan on June 29, 2021, the content of which is incorporated herein by reference.

[Background Art]

[0002]

PTL 1 discloses a waste incineration device as follows. That is, in the waste incineration device disclosed in PTL 1, a supply amount of waste actually supplied to a furnace is detected, based on a difference image between an image of the waste before the waste falls into the furnace and an image of the waste after the waste falls into the furnace. In addition, in the waste incineration device disclosed in PTL 1, when a current value of a waste supply amount is greater than a predetermined supply amount range, operation conditions are changed in such a manner that a command to

reduce a waste supply speed to reduce the supply amount of the waste to a fire grate and a command to increase the amount of primary combustion air to promote combustion of the waste are issued to a dust feeder. In this manner, the waste incineration device performs control to reduce the waste supply amount to the fire grate, to promote the combustion of the waste in the fire grate, and to reduce the waste amount on the fire grate.

[Citation List]

[Patent Document]

[0003]

[PTL 1] Japanese Unexamined Patent Application
Publication No. 2020-128837

[Summary of Invention]

[Technical Subject]

[0004]

However, in the waste incineration device disclosed in PTL 1, the operation conditions are changed, based on the current value of the waste supply amount. Therefore, for example, there is a subject that a delay may occur in controlling an increase in the amount of combustion air corresponding to a change in the waste supply amount.

[0005]

The present disclosure is made to solve the above-described subject, and an object of the present disclosure

is to provide a control device for incinerator equipment which can improve a delay in control corresponding to a change in a supply amount of a combustion object such as waste.

[Subject to be solved]

[0006]

According to the present disclosure, in order to solve the above-described subject, there is provided a control device for incinerator equipment having a furnace body that transports an incineration object while combusting the incineration object, and a feeder that supplies the incineration object to the furnace body. The control device for incinerator equipment includes an image information acquisition unit that periodically acquires image information including an inlet of the furnace body, which is connected to an end portion of the feeder, an image information recognition unit that recognizes whether or not the incineration object in the inlet is in a state of protruding to the furnace body, based on the image information, and a supply state determination unit that determines that there is a prediction that the incineration object is excessively supplied to the furnace body, when it is continuously recognized for a predetermined time that the incineration object is in a state of protruding to the furnace body.

[Advantageous Effects of Invention]

[0007]

According to a control device for the incinerator equipment of the present disclosure, it is possible to improve a delay in control corresponding to a change in a supply amount of a combustion object such as waste.

[Brief Description of Drawings]

[0008]

Fig. 1 is a schematic view illustrating a configuration example of incinerator equipment according to an embodiment of the present disclosure.

Fig. 2 is a block diagram illustrating a configuration example of a control device according to the embodiment of the present disclosure.

Fig. 3 is a view illustrating an example of an infrared image according to the embodiment of the present disclosure.

Fig. 4 is a flowchart illustrating an operation example of the control device according to the embodiment of the present disclosure.

Fig. 5 is a schematic view for describing an operation example of the control device according to the embodiment of the present disclosure.

Fig. 6 is a schematic view for describing an operation example of the control device according to the embodiment of the present disclosure.

Fig. 7 is a schematic view for describing an operation example of the control device according to the embodiment of the present disclosure.

Fig. 8 is a schematic view for describing an operation example of the control device according to the embodiment of the present disclosure.

Fig. 9 is a schematic view for describing an operation example of the control device according to the embodiment of the present disclosure.

Fig. 10 is a schematic block diagram illustrating a configuration of a computer according to the embodiment of the present disclosure.

[Description of Embodiments]

[0009]

(Configuration of Control Device for Incinerator Equipment)

Hereinafter, a control device for incinerator equipment according to an embodiment of the present disclosure will be described with reference to Figs. 1 to 10. Fig. 1 is a schematic view illustrating a configuration example of the incinerator equipment according to the embodiment of the present disclosure. Fig. 2 is a block diagram illustrating a configuration example of the control device according to the embodiment of the present disclosure. Fig. 3 is a view illustrating an example of an infrared

image according to the embodiment of the present disclosure. Fig. 4 is a flowchart illustrating an operation example of the control device according to the embodiment of the present disclosure. Figs. 5 to 9 are schematic views for describing operation examples of the control device according to the embodiment of the present disclosure. Fig. 10 is a schematic block diagram illustrating a configuration of a computer according to the embodiment of the present disclosure. In each drawing, the same reference numerals will be assigned to the same or corresponding configurations, and description thereof will be omitted as appropriate.

[0010]

(Configuration of Incinerator Equipment)

Fig. 1 illustrates a configuration example of an incinerator equipment 100 according to the embodiment of the present disclosure. In an exemplary form illustrated in Fig. 1, the incinerator equipment 100 is a stoker-type waste incinerator that uses municipal waste, industrial waste, or biomass as a solid fuel Fg. The incinerator equipment 100 is not limited to the stoker-type waste incinerator.

[0011]

As illustrated in Fig. 1, the incinerator equipment 100 includes a hopper 102, a feeder unit 104, a combustion chamber 108, an extruding device 110 (refuse feeding

equipment), an air supply device 112, and a heat recovery steam generator 114, a desuperheater tower 116, a dust collector 118, and a stack 120. The combustion chamber 108 is an example of a furnace body that transports an incineration object according to the present disclosure while combusting the incineration object. The extruding device 110 is an example of a feeder that supplies the incineration object to the furnace body according to the present disclosure.

[0012]

The feeder unit 104 is a passage extending toward the combustion chamber 108. The feeder unit 104 is configured so that the solid fuel Fg which is a combustion object such as waste (dust) loaded into the hopper 102 is accumulated. When a direction in which the solid fuel Fg moves inside the incinerator equipment 100 is defined as a moving direction W1, a downstream end portion 121 (end portion of the feeder unit 104 on the combustion chamber 108 side) on a downstream side in the moving direction W1 of the feeder unit 104 is connected to an inlet 122 of the combustion chamber 108.

[0013]

The extruding device 110 has an extruding arm 124 for extruding the solid fuel Fg accumulated in the feeder unit 104 to the combustion chamber 108 via the inlet 122. The

extruding arm 124 is configured to be movable inside the feeder unit 104 from the upstream side to the downstream side and from the downstream side to the upstream side in the moving direction W1. That is, the extruding arm 124 reciprocates inside the feeder unit 104 along an extending direction (horizontal direction) of the feeder unit 104.

[0014]

The combustion chamber 108 includes a fire grate 126 (stoker) into which the extruded solid fuel Fg extruded into the combustion chamber 108 via the inlet 122 falls. The fire grate 126 corresponds to a floor portion of the combustion chamber 108. The fire grate 126 is configured to move the solid fuel Fg on the fire grate 126 in a direction away from the inlet 122 (from the upstream side to the downstream side in the moving direction W1). In addition, the combustion chamber 108 includes a drying region 128, a combustion region 130, and a post-combustion region 132 which are sequentially aligned from the upstream side to the downstream side in the moving direction W1. The drying region 128 dries the solid fuel Fg by using heat inside the combustion chamber 108. The combustion region 130 raises a flame 131 to combust the solid fuel Fg. The post-combustion region 132 completely combusts burnout which is not burned out in the combustion region 130. The solid fuel Fg which is dried, combusted, and post-combusted

in the combustion chamber 108 turns into ash 135, and is discharged outward of the incinerator equipment 100.

[0015]

The air supply device 112 is configured to supply primary air used for combusting the solid fuel Fg and secondary air used for reducing concentration of unburnt gas such as carbon monoxide generated by combusting the solid fuel Fg to the combustion chamber 108. In the exemplary form illustrated in Fig. 1, the air supply device 112 includes an air supply pipe 136 and a blower 138 provided in the air supply pipe 136. A portion of the air flowing through the air supply pipe 136 is supplied as the primary air from the fire grate 126 to a lower portion of the combustion chamber 108 via a first flow control valve 140, and a remaining portion of the air is supplied as the secondary air to an upper portion of the combustion chamber 108 from a side wall of the combustion chamber 108 via a second flow control valve 142. The air supply device 112 functions as a secondary air supply device that supplies the secondary air to the upper portion of the combustion chamber 108. In the exemplary form illustrated in Fig. 1, the air supply device 112 is configured to supply the primary air to each of the drying region 128, the combustion region 130, and the post-combustion region 132 of the combustion chamber 108.

[0016]

Each of the heat recovery steam generator 114, the desuperheater tower 116, the dust collector 118, and the stack 120 is provided in a flue 144 of the incinerator equipment 100 through which exhaust gas 143 generated by combusting the solid fuel Fg circulates. The exhaust gas 143 circulates in the order of the heat recovery steam generator 114, the desuperheater tower 116, the dust collector 118, and the stack 120. The heat recovery steam generator 114 generates steam from heat energy of the exhaust gas 143. The desuperheater tower 116 lowers a temperature of the exhaust gas 143 passing through the heat recovery steam generator 114. The dust collector 118 collects flying ash contained in the exhaust gas 143 passing through the desuperheater tower 116. The stack 120 exhausts the exhaust gas 143 passing through the dust collector 118 to the outside of the incinerator equipment 100. The steam generated by the heat recovery steam generator 114 may be configured to be supplied to a steam turbine (not illustrated).

[0017]

(Configuration of Control Device)

A control device 4 applied to the incinerator equipment 100 described above is a control device for the incinerator equipment 100 having the combustion chamber 108

that transports the incineration object while combusting the incineration object, and the extruding device 110 that supplies the incineration object to the combustion chamber 108. The control device 4 includes the following units as a functional configuration including a combination of a computer, hardware such as peripheral devices of the computer, and software such as a program executed by the computer. That is, the control device 4 includes an image information acquisition unit 41, an image information recognition unit 42, a supply state determination unit 43, a combustion air amount control unit 44, a feeder control unit 45, and an excessive supply detection unit 46, a protruding amount detection unit 47, a model learning unit 48, and a storage unit 49. In addition, the storage unit 49 stores a plurality of trained models 491 and a plurality of image information 492.

[0018]

The image information acquisition unit 41 periodically acquires image information including an image signal indicating a feeder vicinity region which is a region including the feeder unit 104 captured by an imaging device 2. In the present embodiment, the image information may include an image signal indicating a captured image, information indicating an image captured date and time of the image signal, and information indicating a total stroke

length (total extruding length of the feeder) of the extruding arm 124 at time of imaging. The total stroke length of the extruding arm 124 is a total value of lengths of the extruding arm 124 moved from the upstream to the downstream in the moving direction W1, when a starting point is based on a time point at which excessive supply (also referred to as "falling-off") of the incineration object occurs. For example, the feeder vicinity region is a region including a front surface Fr of the solid fuel Fg as a region of interest.

[0019]

The imaging device 2 is configured to capture an infrared image (thermal image) of the solid fuel Fg before the solid fuel Fg accumulated in the feeder unit 104 of the incinerator equipment 100 falls into the combustion chamber 108. The infrared image of the solid fuel Fg captured by the imaging device 2 is transmitted to the control device 4 on a real time basis. In the exemplary form illustrated in Fig. 1, the imaging device 2 is provided in a furnace bottom 145 of the combustion chamber 108 located on the downstream side in the moving direction W1 with respect to the post-combustion region 132 of the combustion chamber 108 so that the imaging device 2 captures the infrared image of the front surface Fr facing the combustion chamber 108 out of the surface of the solid fuel Fg before the solid fuel Fg

falls into the combustion chamber 108. The imaging device 2 can capture the infrared image of the front surface Fr of the solid fuel Fg protruding from the inlet 122 of the combustion chamber 108. In addition, when the infrared image of the front surface Fr of the solid fuel Fg can be captured, the imaging device 2 may be provided at positions other than the furnace bottom 145 of the combustion chamber 108.

[0020]

In addition, for example, the imaging device 2 is an infrared camera, and detects infrared rays in a predetermined wavelength region having small radiation from the flame 131. In this case, a range of the predetermined wavelength region is 2 μm or larger and 5 μm or smaller, for example. In order to capture the infrared image of the front surface Fr of the solid fuel Fg while further suppressing influence of the flame 131, the range of the predetermined wavelength region is 3.8 μm or larger and 4.2 μm or smaller. A target wavelength region to be captured as the infrared image is 0.8 μm to 1,000 μm . When necessary, an operation using only some wavelengths can be performed by causing the wavelengths to pass through a bandpass filter in this wavelength region.

[0021]

In addition, the imaging device 2 is not limited to

the infrared camera as long as the infrared image of the front surface Fr of the solid fuel Fg can be captured over the flame 131. In some embodiments, the imaging device 2 includes a visible light camera and a filter device that limits a transmitted wavelength incident on the visible light camera to a predetermined wavelength region.

[0022]

The image information recognition unit 42 recognizes whether or not the solid fuel Fg in the feeder vicinity region is in a state of protruding to the combustion chamber 108, based on the image information acquired by the image information acquisition unit 41. In the present embodiment, the image information recognition unit 42 uses the trained model 491 to recognize whether or not the solid fuel Fg in the feeder vicinity region is in the state of protruding to the combustion chamber 108. In the present embodiment, the image information recognition unit 42 recognizes whether or not the solid fuel Fg is in the state of protruding to the combustion chamber 108 for each division region in which the feeder vicinity region is divided into a plurality of regions. In this case, the trained model 491 is trained for each division region.

[0023]

For example, the trained model 491 is a deep learning model, and is a model trained in advance through supervised

training by using at least the image information as an explanatory variable to determine protruding, non-protruding, and poor visibility of the solid fuel Fg as objective variables. For example, the trained model 491 inputs at least the image information as the explanatory variable, and outputs protruding, non-protruding, and the poor visibility of the solid fuel Fg as the objective variables. For example, in the trained model 491, a neural network is set as an element, and a weighting coefficient between neurons in each layer of the neural network is optimized by machine learning so that a desired solution is output for a large number of input data. For example, the trained model 491 includes a combination of a program for executing an operation from an input to an output and a weighting coefficient (parameter) used for the operation. In addition, for example, the trained model 491 is trained for each division region in which the infrared image captured by the imaging device 2 is divided into any desired regions.

[0024]

Fig. 3 illustrates an example of an infrared image 201 captured by the imaging device 2. The image information recognition unit 42 divides the infrared image 201 into three regions, a left region RL, a central region RC, and a right region RR, in a direction orthogonal to the moving

direction W1 (referred to as an X1-direction), and classifies each division region into the protruding, the non-protruding, or the poor visibility. In an example illustrated in Fig. 3, the central region RC is classified as the protruding, and the left region RL and the right region RR are classified as the non-protruding. For example, the poor visibility corresponds to an image captured when ash is interposed between the imaging device 2 and the feeder vicinity region. In the present embodiment, the number of division regions is three, but is not limited to three. The solid fuel Fg is uniformly pushed by the extruding device 110, but does not uniformly fall into the furnace due to entangled dust. In addition, when the solid fuel Fg falls, dust in the back may be entangled and fall together, and a surface of the dust may not be uniform. Therefore, a plurality of regions of interest are provided.

[0025]

The trained model 491 can be a determination model using the deep learning in which each of the division regions is classified as the protruding, the non-protruding, or the poor visibility, based on the image information. Meanwhile, in order to prepare the determination model, training may be performed by using operation data such as the total stroke length together as the explanatory variable. As the image information, the image information 492 during

an actual operation may be used, or the image information 492 in the past may be used.

[0026]

The supply state determination unit 43 determines that there is a prediction that the solid fuel Fg is excessively supplied (falling-off) to the combustion chamber 108, when it is continuously recognized for a predetermined time that the solid fuel Fg is in a state of protruding to the combustion chamber 108. In addition, the supply state determination unit 43 determines that there is the prediction that the solid fuel Fg is excessively supplied to the combustion chamber 108, at least when it is continuously recognized for a predetermined time that the solid fuel Fg is in the state of protruding to the combustion chamber 108 in the plurality of division regions. Furthermore, when the image information recognition unit 42 recognizes whether or not the solid fuel Fg is in the state of protruding to the combustion chamber 108 by using the trained model 491 that uses at least the image information as the explanatory variable to determine the protruding, the non-protruding, and the poor visibility of the solid fuel Fg as the objective variables, the supply state determination unit 43 determines as follows. That is, the supply state determination unit 43 determines that there is the prediction that the solid fuel Fg is excessively

supplied to the combustion chamber 108, at least when it is continuously recognized for a predetermined time that the solid fuel Fg is in the state of protruding to the combustion chamber 108, and the extruding device 110 is pushing the solid fuel Fg.

[0027]

For example, in determining the falling-off prediction, the supply state determination unit 43 determines the prediction, based on whether or not all of the following conditions are satisfied. (Condition 1) Protruding in two or more division regions out of three division regions, based on the image information divided into three regions (Condition 2) Occurring continuously for five seconds (Condition 3) Feeder operation is pushing For example, a detection time is set to continue for a predetermined time (for example, 60 seconds). The detection time is a waiting time until the subsequent prediction determination is performed when the falling-off (excessive supply) does not actually occur after the conditions for the prediction determination are satisfied. When the falling-off (excessive supply) actually occurs after the conditions for the prediction determination are satisfied, the subsequent prediction determination can be immediately performed. For example, the predetermined time can be adjusted in accordance with one average pushing time.

[0028]

In the present embodiment, the supply state determination unit 43 determines that there is the prediction that the solid fuel Fg is excessively supplied to the combustion chamber 108, when it is continuously recognized for a predetermined time that the solid fuel Fg is in the state of protruding to the combustion chamber 108, and an excessive supply occurrence probability based on the total stroke length (total extruding length) of the extruding device 110 is equal to or greater than a predetermined threshold value. Fig. 5 illustrates an example of the excessive supply occurrence probability based on the total stroke length of the extruding device 110. Fig. 5 illustrates an example of a falling-off occurrence probability with respect to the total stroke length by setting a horizontal axis as the total stroke length and a vertical axis as the falling-off occurrence probability. In an example illustrated in Fig. 5, mostly, when the total stroke length is L1, the occurrence probability is 10%. When the total stroke length is L2, the occurrence probability is 40%. When the total stroke length is L3, the occurrence probability is 70%. When the total stroke length is L4, the occurrence probability is 90%. A solid line indicates a case where the falling-off occurs while the feeder is pushed, and a chain line indicates a case

where the falling-off occurs while the feeder is moving rearward or stopped. An example (plant) illustrated in Fig. 5 is an example in which a general stroke length per stroke is controlled to be approximately between L2 and L3.

[0029]

In the present embodiment, even when all of the conditions of the prediction determination described above are satisfied, the supply state determination unit 43 determines no prediction indicating excessive supply, when the excessive supply occurrence probability based on the total stroke length of the extruding device 110 is smaller than a predetermined threshold value (for example, 70%). For example, the excessive supply occurrence probability can be approximated by a quadratic function in which the total stroke length is set as a parameter, or can be obtained by using a map that defines a correspondence relationship between the total stroke length and the excessive supply occurrence probability. In confirming the present embodiment in an actual machine, the falling-off does not always occur after the prediction is detected. Therefore, as illustrated in Fig. 5, the falling-off occurrence probability with respect to the total stroke length of the feeder is calculated, and the occurrence probability is also used for the prediction determination. In this manner, accuracy in the prediction determination is further improved.

[0030]

For example, the threshold value with respect to the excessive supply occurrence probability may be changed by the supply state determination unit 43 at every predetermined time in accordance with an operation status during the operation. The falling-off occurrence probability varies depending on dust quality (dryness, shape, or hardness). Therefore, for example, the threshold value can be automatically or manually changed, based on an actual value of a detection rate and a correct answer rate (wrong answer rate). For example, the control for suppressing the generation of carbon monoxide during the prediction detection (to be described later) is performed by increasing the supply of the secondary air before the falling-off occurs during the prediction detection. In this case, when the falling-off actually occurs, the generation of carbon monoxide can be suppressed by preventing incomplete combustion by the increased supply of oxygen. However, when the falling-off does not actually occur, oxygen is excessive, thereby causing a possibility that the generation of nitrogen oxides may increase. Therefore, the threshold value may be changed in accordance with an actual operation status by keeping a balance between a demand for carbon monoxide reduction and an increase in a possibility of nitrogen oxide generation. Here, information indicating

the operation status is not limited to information indicating a generation amount of carbon monoxide and information indicating a generation amount of nitrogen oxide, and for example, may include information indicating dust quality, temperature, or humidity. In this case, the threshold value with respect to the excessive supply occurrence probability is a value changed based on information relating to an actual combustion state of the incineration object, which includes at least the information indicating the generation amount of carbon monoxide and information indicating the generation amount of nitrogen oxide. Since the threshold value is changed in this way, for example, an upper limit value with regard to the generation amount of carbon monoxide and an upper limit value with regard to the generation amount of nitrogen oxide can be accurately managed. Fig. 6 illustrates a relationship between a wrong answer rate and the detection rate of the prediction determination when the threshold value is changed in a case where the prediction determination based on image recognition and a comparison between the excessive supply occurrence probability based on the total stroke length and the threshold value are combined. The wrong answer rate is a ratio of the number of times at which the falling-off does not occur with respect to the total number of times of the prediction

determination. The detection rate is a ratio of the number of times at which the falling-off can be predicted with respect to the number of times at which the falling-off occurs. When the threshold value decreases, the detection rate increases, but the wrong answer rate also increases. When the threshold value increases, the wrong answer rate decreases, but the detection rate also decreases.

[0031]

The combustion air amount control unit 44 controls the air supply device 112 to change the supply amount of the combustion air, based on a determination result of the prediction of the excessive supply by the supply state determination unit 43. For example, according to this control, it is possible to suppress a rapid increase in carbon monoxide which occurs when the falling-off occurs. For example, the combustion air amount control unit 44 can increase concentration of oxygen inside the furnace by performing control to increase the supply amount of the secondary combustion air, when the supply state determination unit 43 determines the prediction of the excessive supply. In this manner, a rapid increase in concentration of CO can be suppressed.

[0032]

The feeder control unit 45 changes at least one of an operation speed or a stroke of the extruding device 110,

based on a determination result of the prediction of the excessive supply by the supply state determination unit 43. For example, when the supply state determination unit 43 determines the prediction of the excessive supply, the feeder control unit 45 controls the extruding device 110 to slow down the operation speed of the extruding device 110 and to shorten the stroke (moving stroke of the extruding arm 124). According to this control, a time is gained (postponed) until the subsequent falling-off occurs. Even when the falling-off occurs, it is not necessary to stop a refuse feeding equipment. Therefore, fuel supply can be continued, and a decrease in the amount of evaporation can be suppressed.

[0033]

Both the control by the combustion air amount control unit 44 and the control by the feeder control unit 45 may be performed, or only one control may be performed. In addition, the control by the combustion air amount control unit 44 and the control by the feeder control unit 45 when the prediction of the excessive supply is determined will be referred to as prediction time control.

[0034]

The excessive supply detection unit 46 detects the occurrence of the excessive supply by monitoring brightness of the infrared image of the front surface Fr of the solid

fuel Fg, based on a plurality of the infrared images acquired by the image information acquisition unit 41. Fig. 7 is a graph illustrating the brightness of the infrared image of the front surface Fr of the solid fuel Fg before the solid fuel Fg falls into the combustion chamber 108, in which the vertical axis indicates the brightness and the horizontal axis indicates a time. Times t1 and t2 are times when the excessive supply actually occurs. As illustrated in Fig. 7, when the excessive supply actually occurs at times t1 and t2, the brightness of the infrared image of the front surface Fr of the solid fuel Fg is significantly reduced. Therefore, the occurrence of the excessive supply can be quickly detected by monitoring the brightness of the infrared image of the front surface Fr of the solid fuel Fg. When the excessive supply detection unit 46 detects the occurrence of the excessive supply, the excessive supply detection unit 46 instructs the extruding device 110 to stop an operation of the extruding arm 124 via the feeder control unit 45. When receiving the instruction from the feeder control unit 45, the extruding device 110 stops the operation of the extruding arm 124. In this manner, the supply of the solid fuel Fg to the combustion chamber 108 is stopped.

[0035]

In addition, when the excessive supply detection unit

46 detects the occurrence of the excessive supply, the excessive supply detection unit 46 increases the amount of the secondary air to be supplied to the combustion chamber 108 from the air supply device 112 (secondary air supply device) via the combustion air amount control unit 44.

[0036]

As illustrated in Fig. 8, the protruding amount detection unit 47 detects a protruding length L_r of the solid fuel F_g protruding from the inlet 122 of the combustion chamber 108 toward the combustion chamber 108. In an exemplary form illustrated in Fig. 8, as the protruding length L_r , the protruding amount detection unit 47 detects a size between the inlet 122 of the combustion chamber 108 and a portion $Fr1$ located on the most downstream side of the front surface Fr of the solid fuel F_g in the moving direction $W1$. For example, the protruding amount detection unit 47 detects the protruding length L_r for each division region, based on the imaging information of a protruding amount detection imaging device 28 which can image the solid fuel F_g from above.

[0037]

The model learning unit 48 performs image processing such as pattern recognition on the infrared image acquired by the image information acquisition unit 41 for each division region, and recognizes whether or not the

visibility is poor. When the visibility is poor, the model learning unit 48 classifies the division region as poor visibility. In addition, when the model learning unit 48 does not recognize the infrared image acquired by the image information acquisition unit 41 as the poor visibility, the model learning unit 48 classifies the partial region as the protruding or the non-protruding, based on the protruding length L_r detected by the protruding amount detection unit 47 for each division region. Then, the model learning unit 48 stores a recognition result as the image information 492, and for example, when a predetermined amount of the image information 492 is accumulated, the model learning unit 48 re-learns the trained model 491 by using the image information 492.

[0038]

(Operation Example of Control Device)

Next, an operation example of the control device 4 will be described with reference to Fig. 4. For example, a process illustrated in Fig. 4 is repeatedly performed at an interval of one second. When the process illustrated in Fig. 4 starts, the control device 4 determines whether or not the prediction time control is performed (S1). When the prediction time control is not performed (S1: NO), the image information acquisition unit 41 images the inside of the furnace with the imaging device 2 (infrared camera),

and acquires the image information (S2). Next, the image information recognition unit 42 divides the image in the feeder vicinity region into a mesh (S3). Next, the image information recognition unit 42 determines the protruding, the non-protruding, or the poor visibility by using the deep learning determination model for each division region (S4). Next, the supply state determination unit 43 determines the falling-off prediction (S5).

[0039]

The supply state determination unit 43 determines that there is the prediction (S5: Yes) when all of the above-described (Condition 1) to (Condition 3) are satisfied, and determines that there is no prediction when any one of the above-described conditions is not satisfied (S5: No). When it is determined that there is the prediction (S5: Yes), the supply state determination unit 43 determines whether or not the falling-off occurrence probability based on the total stroke length is equal to or greater than a predetermined threshold value (S6). When the value is equal to or greater than the threshold value (S6: Yes), the combustion air amount control unit 44 and the feeder control unit 45 start the prediction time control (S7). Next, the control device 4 determines whether or not a completion condition of the prediction time control is satisfied (S8).

[0040]

For example, the completion condition of the prediction time control is satisfied when the excessive supply detection unit 46 detects that the falling-off actually occurs, or when a predetermined continuous time (for example, 60 seconds) elapses without the falling-off occurrence after the prediction time control starts. When the completion condition of the prediction time control is satisfied (S8: Yes), the control device 4 completes the prediction time control, and proceeds to the actual falling-off control, or simply completes the prediction time control (S9).

[0041]

While the prediction time control is performed (S1: Yes), the control device 4 determines whether or not the completion condition of the prediction time control is satisfied (S8). In addition, when the prediction time control is completed (S9), when there is no prediction in determining the falling-off prediction (S5: No), when the value is not equal to or greater than the threshold value (S6: No), or when the completion condition of the prediction time control is not satisfied (S8: No), the control device 4 completes a process illustrated in Fig. 4.

[0042]

Fig. 9 illustrates an example of an operation pattern when the prediction detection is satisfied. For example,

time T1 is five seconds, and for example, time T2 is 60 seconds. When pushing of the feeder starts at time t11, Condition 1, Condition 3, and the threshold value determination are satisfied at time t12, and time T1 further elapses, the prediction detection occurs at time t13, and at time TC1 until time t14 at which the falling-off occurs, the prediction time control is performed. In addition, when pushing of the feeder starts at time t11, Condition 1, Condition 3, and the threshold value determination are satisfied at time t22, and time T1 further elapses, the prediction detection occurs at time t23, and at time TC2 until time t25 at which the falling-off occurs, the prediction time control is performed. In this case, at time t24, the feeder is moving rearward from the pushing. In addition, when pushing of the feeder starts at time t11, Condition 1, Condition 3, and the threshold value determination are satisfied at time t22, and time T1 further elapses, the prediction detection occurs at time t23, and at time TC3 until time t32 at which the falling-off occurs, the prediction time control is performed. In this case, at time t24, the feeder is moving rearward from the pushing. In addition, at time t31, the feeder is stopped.

[0043]

(Operational Effects)

As described above, according to the present

embodiment, it is possible to improve a delay in the control corresponding to a change in the supply amount of the combustion object such as excessively supplied waste.

[0044]

(Other Embodiments)

Hitherto, the embodiment of the present disclosure has been described in detail with reference to the drawings. However, specific configurations are not limited to the above-described embodiment, and design changes within the scope not departing from the concept of the present disclosure are also included.

In the above-described embodiment, the image recognition process is performed by using the trained model 491. However, the present invention is not limited thereto, and for example, an optical flow may be used, or a cubic higher-order local auto-correlation (CHLAC) method may be used.

In addition, when the supply state determination unit 43 detects the prediction, the combustion air amount control unit 44 may open Over Fire Air (OFA) in advance to solve an air shortage and prevent an increase in the concentration of CO. On the other hand, as a countermeasure against an increase in NOx, a damper opening degree of the post-combustion region 132 may be minimized. In addition, when the feeder control unit 45 detects the prediction in a

falling-off target, the feeder control unit 45 may reduce a stoker speed, and may gain a time until the subsequent occurrence. In this manner, fluctuations in the amount of evaporation due to the continuous falling-off may be suppressed.

[0045]

<Computer Configuration>

Fig. 10 is a schematic block diagram illustrating a configuration of a computer according to at least one embodiment.

A computer 90 includes a processor 91, a main memory 92, a storage 93, and an interface 94.

The above-described control device 4 is mounted on the computer 90. An operation of each processing unit described above is stored in the storage 93 in a form of a program. The processor 91 reads the program from the storage 93, develops the program in the main memory 92, and performs the above-described processing in accordance with the program. In addition, the processor 91 secures a storage area corresponding to each storage unit described above in the main memory 92 in accordance with the program.

[0046]

The program may partially realize functions fulfilled by the computer 90. For example, the program may cause the functions to be fulfilled in combination with another

program already stored in the storage or in combination with another program installed on another device. In another embodiment, in addition to the above-described configuration or in place of the above-described configuration, the computer may include a custom large scale integrated circuit (LSI) such as a programmable logic device (PLD). 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 realized by the processor may be partially or entirely realized by the integrated circuit.

[0047]

Examples of the storage 93 include a hard disk drive (HDD), a solid state drive (SSD), a magnetic disk, an optical magnetic disk, a compact disc read only memory (CD-ROM), and a digital versatile disc read only memory (DVD-ROM), and a semiconductor memory. The storage 93 may be internal media directly connected to a bus of the computer 90, or external media connected to the computer 90 via the interface 94 or a communication line. In addition, in a case where this program is distributed to the computer 90 via the communication line, the computer 90 receiving the distribution may develop the program in the main memory 92, and may perform the above-described processing. In at least

one embodiment, the storage 93 is a non-temporary tangible storage medium.

[0048]

<Additional Notes>

The control device 4 of the incinerator equipment described in each embodiment is understood as follows, for example.

[0049]

(1) According to a first aspect, there is provided the control device 4 for incinerator equipment having the furnace body that transports the incineration object while combusting the incineration object, and the feeder that supplies the incineration object to the furnace body. The control device includes the image information acquisition unit 41 that periodically acquires the image information including the inlet 122 of the furnace body, which is connected to the end portion of the feeder, the image information recognition unit 42 that recognizes whether or not the incineration object in the inlet 122 is in a state of protruding to the furnace body, based on the image information, and the supply state determination unit 43 that determines that there is a prediction that the incineration object is excessively supplied to the furnace body, when it is continuously recognized for a predetermined time that the incineration object is in a state protruding to the

furnace body. According to the present aspect and each of the following aspects, it is possible to improve a delay in the control corresponding to a change in the supply amount of the combustion object such as excessively supplied waste.

[0050]

(2) According to a second aspect of the control device 4 for incinerator equipment, in the control device 4 for incinerator equipment according to the aspect (1) above, the image information acquisition unit 41 may acquire the image information including the inlet 122 and at least a portion of the inner wall of the drying region.

[0051]

(3) According to a third aspect of the control device 4 for incinerator equipment, in the control device 4 for incinerator equipment according to the aspect (1) or (2) above, the supply state determination unit 43 may determine that there is the prediction that the incineration object is excessively supplied to the furnace body, when it is continuously recognized for a predetermined time that the incineration object is in a state of protruding to the furnace body, and the excessive supply occurrence probability based on the total extruding length of the feeder is equal to or greater than a predetermined threshold value.

[0052]

(4) According to a fourth aspect of the control device 4 for incinerator equipment, in the control device 4 for incinerator equipment according to the aspect (3) above, the threshold value may be a value that is changed, based on the information relating to the actual combustion state of the incineration object, which includes at least the information indicating the generation amount of carbon monoxide and the information indicating the generation amount of nitrogen oxide.

[0053]

(5) According to a fifth aspect of the control device 4 for incinerator equipment, in the control device 4 for incinerator equipment according to the aspects (1) to (4) above, the image information recognition unit 42 may recognize whether or not the incineration object is in a state of protruding to the furnace body for each division region in which the inlet 122 is divided into a plurality of regions. The supply state determination unit 43 may determine that there is the prediction that the incineration object is excessively supplied to the furnace body, at least when it is continuously recognized for a predetermined time that the incineration object is in a state of protruding to the furnace body in a plurality of the division regions.

[0054]

(6) According to a sixth aspect of the control device

4 for incinerator equipment, in the control device 4 for incinerator equipment according to the aspects (1) to (5) above, the image information recognition unit 42 may recognize whether or not the incineration object is in a protruding state by using the trained model 491 that uses at least the image information as the explanatory variable to determine the protruding, the non-protruding, and the poor visibility of the incineration object as the objective variables. The supply state determination unit 43 may determine that there is the prediction that the incineration object is excessively supplied to the furnace body, at least when it is continuously recognized for a predetermined time that the incineration object is in a state of protruding to the furnace body, and the feeder is pushing the incineration object.

[0055]

(7) According to a seventh aspect of the control device 4 for incinerator equipment, in the control device 4 for incinerator equipment according to the aspects (1) to (6) above, at least one of the combustion air amount control unit that changes the supply amount of the combustion air, based on the determination result of the prediction of the excessive supply, and the feeder control unit the changes at least one of the operation speed or the stroke of the feeder, based on the determination result of the prediction

of the excessive supply.

[Industrial Applicability]

[0056]

According to a control device for the incinerator equipment of the present disclosure, it is possible to improve a delay in control corresponding to a change in a supply amount of a combustion object such as waste.

[Reference Signs List]

[0057]

100: Incinerator equipment

108: Combustion chamber

110: Extruding device

4: Control device

41: Image information acquisition unit

42: Image information recognition unit

43: Supply state determination unit

44: Combustion air amount control unit

45: Feeder control unit

49: Storage unit

491: Trained model

492: Image information

CLAIMS

[Claim 1]

A control device for incinerator equipment having a furnace body that transports an incineration object while combusting the incineration object, and a feeder that supplies the incineration object to the furnace body, the control device comprising:

an image information acquisition unit that periodically acquires image information including an inlet of the furnace body, which is connected to an end portion of the feeder;

an image information recognition unit that recognizes whether or not the incineration object in the inlet is in a state of protruding to the furnace body, based on the image information; and

a supply state determination unit that determines that there is a prediction that the incineration object is excessively supplied to the furnace body, when it is continuously recognized for a predetermined time that the incineration object is in a state of protruding to the furnace body.

[Claim 2]

The control device for incinerator equipment according

to Claim 1,

wherein the image information acquisition unit acquires the image information including the inlet and at least a portion of an inner wall of a drying region.

[Claim 3]

The control device for incinerator equipment according to Claim 1 or 2,

wherein the supply state determination unit determines that there is the prediction that the incineration object is excessively supplied to the furnace body, when it is continuously recognized for a predetermined time that the incineration object is in a state of protruding to the furnace body, and an excessive supply occurrence probability based on a total extruding length of the feeder is equal to or greater than a predetermined threshold value.

[Claim 4]

The control device for incinerator equipment according to Claim 3,

wherein the threshold value is a value that is changed, based on information relating to an actual combustion state of the incineration object, which includes at least information indicating a generation amount of carbon monoxide and information indicating a generation amount of

nitrogen oxide.

[Claim 5]

The control device for incinerator equipment according to any one of Claims 1 to 4,

wherein the image information recognition unit recognizes whether or not the incineration object is in a state of protruding to the furnace body for each division region in which the inlet is divided into a plurality of regions, and

the supply state determination unit determines that there is the prediction that the incineration object is excessively supplied to the furnace body, at least when it is continuously recognized for a predetermined time that the incineration object is in a state of protruding to the furnace body in at least a plurality of the division regions.

[Claim 6]

The control device for incinerator equipment according to any one of Claims 1 to 5,

wherein the image information recognition unit recognizes whether or not the incineration object is in a protruding state by using a trained model that uses at least the image information as an explanatory variable to determine protruding, non-protruding, and poor visibility

of the incineration object as objective variables, and

the supply state determination unit determines that there is the prediction that the incineration object is excessively supplied to the furnace body, at least when it is continuously recognized for a predetermined time that the incineration object is in a state of protruding to the furnace body, and the feeder is pushing the incineration object.

[Claim 7]

The control device for incinerator equipment according to any one of Claims 1 to 6, further comprising:

at least one of a combustion air amount control unit that changes a supply amount of combustion air, based on a determination result of the prediction of the excessive supply, or a feeder control unit that changes at least one of an operation speed or a stroke of the feeder, based on a determination result of the prediction of the excessive supply.