DESCRIPTION

Title of Invention

COMBUSTION FACILITY STATE IDENTIFICATION DEVICE, STATE IDENTIFICATION METHOD, AND PROGRAM

[Technical Field]

[0001]

The present disclosure relates to a combustion apparatus state identification device, a state identification method, and a program.

The present application claims priority with respect to Japanese Patent Application No. 2019-228238 filed in Japan on December 18, 2019, the contents of which are incorporated herein by reference.

[Background Art]

[0002]

Patent Document 1 discloses a waste incinerator technology for sufficiently coping with a change in combustion state, a change in flame, and so on by extracting a combustion region from an image taken by a camera from a lower side in a combustion chamber and detecting the combustion state of the combustion chamber.

[Citation List]

[Patent Document]

[0003]

[Patent Document 1] Japanese Patent No. 5755171

[Summary of Invention]

[Technical Subject]

[0004]

The state of a flame that burns an incineration object in a combustion facility changes depending on the situation of combustion of the incineration object in a feeder and a drying stage preceding the generation of the flame. However, in a captured image, the incineration object in the feeder and the drying stage is blocked by the flame, and thus it is difficult to grasp the combustion state in the feeder and the drying stage.

The present disclosure has been made to solve the above subject, and an object of the present disclosure is to provide a combustion apparatus state identification device, a state identification method, and a program.

[Subject to be solved]

[0005]

A combustion facility state identification device according to the present disclosure is a state identification device identifying a combustion state of a combustion facility including a furnace main body defining a treatment space, a fire grate transporting an incineration object in a transport direction in the

treatment space, and a feeder supplying the incineration object to the treatment space, the treatment space being partitioned into a plurality of sections in the transport direction, the combustion facility state identification device including: an image acquisition unit acquiring a treatment image as an image of the feeder and the sections; and a state identification unit identifying a combustion state of each of the feeder and the sections based on the treatment image.

[0006]

A state identification method according to the present disclosure is a state identification method of a state identification device identifying a combustion state of a combustion facility including a furnace main body defining a treatment space, a fire grate transporting an incineration object in a transport direction in the treatment space, and a feeder supplying the incineration object to the treatment space, the treatment space being partitioned into a plurality of sections in the transport direction, the state identification method including: a step of acquiring a treatment image as an image of the feeder and the sections; and a step of identifying a combustion state of each of the feeder and the sections based on the treatment image.

[0007]

A program according to the present disclosure is a program causing a computer of a state identification device identifying a combustion state of a combustion facility including a furnace main body defining a treatment space, a fire grate transporting an incineration object in a transport direction in the treatment space, and a feeder supplying the incineration object to the treatment space, the treatment space being partitioned into a plurality of sections in the transport direction, to execute: a step of acquiring a treatment image as an image of the feeder and the sections; and a step of identifying a combustion state of each of the feeder and the sections based on the treatment image.

[Advantageous Effects of Invention]

[0008]

According to the combustion apparatus state identification device, the state identification method, and the program of the present disclosure, it is possible to grasp the combustion states in the feeder and the sections of the combustion facility.

[Brief Description of Drawings]

[0009]

Fig. 1 is a diagram illustrating the configuration of a combustion facility according to an embodiment of the present disclosure.

Fig. 2 is a schematic block diagram illustrating the configuration of a state identification device according to an embodiment of the present disclosure.

Fig. 3 is a flowchart illustrating the operation of a state control device according to an embodiment of the present disclosure.

Fig. 4 is a schematic block diagram illustrating the configuration of the state identification device according to an embodiment of the present disclosure.

Fig. 5 is a schematic block diagram illustrating the configuration of a computer according to at least one embodiment.

[Description of Embodiments]

[0010]

<First Embodiment>

<<Configuration of Combustion Apparatus>>

Hereinafter, the configuration of a combustion facility 100 according to a first embodiment will be described. The combustion facility 100 according to the first embodiment is a facility for incinerating waste as an incineration object 400. Examples of the combustion facility 100 include a waste incinerator stoker furnace and a biomass fluidized bed boiler. The combustion facility 100 according to the first embodiment is a waste incinerator stoker furnace.

[0011]

Fig. 1 is a diagram illustrating the configuration of the combustion facility 100 according to the first embodiment. The combustion facility 100 includes a stoker furnace 1, a waste heat recovery boiler 8, a temperature reduction tower 9, a dust collector 11, a chimney 12, and a state identification device 300.

[0012]

The stoker furnace 1 is a furnace where the incineration object 400 is burned while being transported. Examples of the incineration object 400 include waste and biomass. The incineration object 400 in Fig. 1 is waste. Exhaust gas is generated from the stoker furnace 1 as the incineration object 400 is burned by the stoker furnace 1. This exhaust gas is sent to the waste heat recovery boiler 8 provided in the upper portion of the stoker furnace 1.

[0013]

The waste heat recovery boiler 8 performs heat exchange between the exhaust gas and water to heat the water and generate steam. This steam is used in external equipment (not illustrated). The exhaust gas that has passed through the waste heat recovery boiler 8 is cooled by the temperature reduction tower 9 and then sent to the dust collector 11. After soot and dust removal at the dust collector 11, the exhaust gas is discharged into the

atmosphere through the chimney 12.

[0014]

Next, the configuration of the stoker furnace 1 will be described. As illustrated in Fig. 1, the stoker furnace 1 has a furnace main body 10, a furnace 7 extending upward from the furnace main body 10, a hopper 3 temporarily storing the incineration object 400, a feeder 31 supplying the incineration object 400 from the hopper 3 into the furnace main body 10, and a stoker 6 provided in the bottom portion of the furnace main body 10. In addition, the stoker furnace 1 has a discharge chute 13 discharging the incineration object 400 to the outside after incineration, a wind box 2 provided below the stoker 6, a clinker roller 210 moving the incineration object 400 to the discharge chute 13, and a camera 220 capturing a treatment image of the furnace main body 10.

[0015]

In addition, the stoker furnace 1 has a blower B1 sending air into a primary air line L1 and a secondary air line L2, the primary air line L1 supplying the air to the wind box 2, and the secondary air line L2 supplying the air to the furnace 7.

[0016]

The stoker 6 is configured by a plurality of fire grates 61. The fire grate 61 is divided into a fixed fire

grate 61A and a movable fire grate 61B. The fixed fire grate 61A is the fire grate 61 that is fixed. The movable fire grate 61B is the fire grate 61 that stirs the incineration object 400 on the fire grate 61 by operating in a transport direction +Da and a transport reverse direction -Da at a constant speed. The transport direction +Da is from the hopper 3 toward the discharge chute 13. The transport reverse direction -Da is opposite to the transport direction Da.

[0017]

A treatment space V for burning the incineration object 400 is formed in the furnace main body 10. In this treatment space V, the incineration object 400 is transported by the stoker 6 in the transport direction +Da from the feeder 31 toward the discharge chute 13. After the combustion, the incineration object 400 is discharged to the outside through the discharge chute 13. In the present embodiment, the stoker 6 is provided horizontally. The stoker 6 according to another embodiment may be provided so as to be inclined with respect to a horizontal plane.

[0018]

The furnace main body 10 is designed to be divided into a drying stage 21, a combustion stage 22, and a post-combustion stage 23 in this order from the upstream side

in the transport direction +Da. The drying stage 21, the combustion stage 22, and the post-combustion stage 23 partition the treatment space V in the transport direction Da. The drying stage 21 is a section for drying the incineration object 400 supplied from the hopper 3 prior to combustion. The combustion stage 22 and the post-combustion stage 23 are sections for burning the incineration object 400 that is dry. In the combustion stage 22, a flame F is generated by the pyrolysis gas that is generated from the incineration object 400. In the post-combustion stage 23, the fixed carbon of the incineration object 400 is burned, and thus the flame F is not generated. In other words, the flame F resulting from combustion is mainly formed above the combustion stage 22.

[0019]

The furnace 7 extends upward from the upper portion of the furnace main body 10. The exhaust gas in the treatment space V is sent to the waste heat recovery boiler 8 through the furnace 7. The primary air line L1 connects the blower B1 and the wind box 2. By driving the blower B1, air is supplied to the wind box 2 through the primary air line L1. The wind box 2 supplies air from below the fire grate 61. The secondary air line L2 connects the blower B1 and the inside of the furnace 7. Air for combustion is supplied into the furnace 7 from

above the fire grate 61 through the secondary air line L2. The wind box 2 forms the bottom surface of the treatment space V. A plurality of the wind boxes 2 are arranged in the transport direction Da.

[0020]

The clinker roller 210 rotates to move the incineration object 400 from the post-combustion stage 23 to the discharge chute 13. The clinker roller 210 rotates every time set by the state identification device 300.

[0021]

The camera 220 has a visible camera and an infrared camera. A treatment image taken by the camera 220 shows the feeder 31, the drying stage 21, the combustion stage 22, and the post-combustion stage 23. The treatment image generated by the camera 220 shows a bright flame generated from the incineration object 400. The infrared camera is capable of capturing a flame transmission image and a temperature distribution image. The wavelength of infrared rays measured by the infrared camera is different between the flame transmission image and the temperature image. The infrared camera receives infrared rays having a wavelength that allows flame transmission and captures the flame transmission image. The infrared camera receives infrared rays having a wavelength different from that of the flame transmission image and captures the

temperature distribution image.

[0022]

The state identification device 300 acquires a treatment image from the camera 220 and identifies the brightness and so on to identify the combustion state of each of the feeder 31, the drying stage 21, the combustion stage 22, and the post-combustion stage 23 and control the speed of the fire grate 61 and the amount of air supplied by the wind box 2. The state identification device 300 includes an image acquisition unit 310, a brightness identification unit 320, a point identification unit 330, a temperature identification unit 340, a state identification unit 350, and a recommendation proposal unit 360. The state identification device 300 is connected to the combustion facility 100 by wire or wirelessly.

[0023]

The image acquisition unit 310 acquires a treatment image from the camera 220.

The brightness identification unit 320 identifies the brightness of each of the feeder 31, the drying stage 21, the combustion stage 22, and the post-combustion stage 23 based on the treatment image acquired by the image acquisition unit 310. Specifically, the brightness identification unit 320 identifies the brightness by the

following operation.

[0024]

The brightness identification unit 320 receives treatment images acquired from the camera 220 by the image acquisition unit 310 and taken by the visible camera and the infrared camera. In the following description, the treatment image taken by the visible camera is referred to as a visible image and the treatment image taken by the infrared camera is referred to as an infrared image. The infrared image is divided into a flame transmission image and a temperature distribution image. The position of the camera 220 is fixed, and thus the regions showing the feeder 31, the drying stage 21, the combustion stage 22, and the post-combustion stage 23 in the treatment image taken by the camera 220 are identifiable.

[0025]

The flame F is in the combustion stage 22. Accordingly, in the visible image, the post-combustion stage 23 is mainly shown in the lower portion of the visible image and the flame F is mainly shown in the upper portion of the visible image. The feeder 31 and the drying stage 21 are blocked by the flame F and hardly appear in the visible image. On the other hand, the infrared camera of the camera 220 sees through the flame F, and thus the post-combustion stage 23 is photographed in

the lower portion of the flame perspective image, the combustion stage 22 is photographed in the middle portion of the flame perspective image, and the feeder 31 and the drying stage 21 are photographed in the upper portion of the flame perspective image.

[0026]

The brightness identification unit 320 identifies brightness related to the feeder 31, the drying stage 21, the combustion stage 22, and the post-combustion stage 23 based on the visible image and the flame perspective image. In other words, the brightness identification unit 320 identifies the brightness of each pixel in the region showing the post-combustion stage 23 and the brightness of each pixel in the region showing the flame F in the visible image.

[0027]

In addition, the brightness identification unit 320 adjusts the contrast and brightness of the visible image using preset numerical values and then binarizes the identified brightness based on a preset binarization threshold. The brightness identification unit 320 divides the visible image into a plurality of meshes. Subsequently, the brightness identification unit 320 classifies the brightness of each mesh into a bright mesh and a dark mesh by comparison between a preset

classification threshold and the average value or sum of the brightness binarized in each mesh. For example, in a case where the total brightness in one mesh is equal to or higher than the preset classification threshold, the mesh is classified as a bright mesh.

[0028]

The treatment image at the position where the flame F is shows high brightness attributable to the flame F. Accordingly, the state identification device 300 is capable of grasping the position and shape of the flame F in the visible image by binarizing the visible image and identifying the position of the bright mesh as described above.

[0029]

The brightness identification unit 320 identifies the brightness of the feeder 31 and the drying stage 21 in the upper portion of the flame perspective image. The brightness identification unit 320 calculates the average value and standard deviation of the brightness of each of the regions showing the feeder 31 and the drying stage 21 in the flame perspective image.

[0030]

In the flame perspective image, a higher brightness is shown at a higher temperature. In a case where the flame F is in the feeder 31, the brightness of the region

showing the feeder 31 is high. Accordingly, the state identification device 300 is capable of determining with the brightness whether or not the flame F is in the feeder 31.

[0031]

The temperature of the incineration object 400 that is dried in the drying stage 21 is higher than the temperature of the incineration object 400 that is not dried. Accordingly, the state identification device 300 is capable of grasping the degree of drying of the incineration object 400 with the brightness of the region showing the drying stage 21 in the flame perspective image. In other words, in a case where the region showing the drying stage 21 in the flame perspective image shows high brightness, it can be seen that the temperature of the incineration object 400 in the drying stage 21 is high and the incineration object 400 is sufficiently dried. In a case where the region showing the drying stage 21 in the flame perspective image shows low brightness, it can be seen that the temperature of the incineration object 400 in the drying stage 21 is low and the incineration object 400 is not sufficiently dried.

[0032]

In a case where the standard deviation of the brightness in the region showing the drying stage 21 in

the flame perspective image is high, the temperature of the incineration object 400 in the drying stage 21 varies, and thus it can be seen that the amount of the incineration object 400 in the drying stage 21 is large and the incineration object 400 is highly deposited in the height direction. In a case where the standard deviation of the brightness in the region showing the drying stage 21 in the flame perspective image is low and the incineration object 400 is deposited low in the height direction, it can be seen that the temperature of the incineration object 400 in the drying stage 21 does not vary and the amount of the incineration object 400 in the drying stage 21 is small.

[0033]

The point identification unit 330 identifies a burnout point Z, which is the rear end in the transport direction Da of the flame F caused by the combustion of the incineration object 400, based on the bright mesh and the dark mesh of the visible image identified by the brightness identification unit 320. Specifically, the point identification unit 330 identifies the burnout point Z by the following operation.

[0034]

The point identification unit 330 receives the data divided into meshes by the brightness identification unit

320 identifying the brightness of the treatment image and identifies the position of the lowermost bright mesh in the treatment image. The burnout point Z is identified by identifying the distance between the bright mesh and the point where the feeder 31 and the drying stage 21 are connected as a reference. For example, the identified burnout point is 2.5 M in a case where the distance is 2.5 M.

[0035]

The temperature identification unit 340 identifies the temperature of the post-combustion stage 23 based on the temperature distribution image of the camera 220 acquired from the image acquisition unit 310. For example, the temperature identification unit 340 identifies whether a part indicating a temperature exceeding a preset threshold is positioned in the lower portion, the middle portion, or the upper portion in the treatment image of the post-combustion stage 23.

[0036]

The state identification unit 350 identifies the state of combustion based on the brightness of the visible image and the brightness of the flame perspective image identified by the brightness identification unit 320. In the present embodiment, the combustion state is one of “stable combustion”, “non-uniform combustion”, “early

combustion", "feeder combustion", "drying defect", "burnout defect", and "boundary defect".

[0037]

"Non-uniform combustion" means a state where the combustion in the furnace width direction is non-uniform in the combustion stage 22. "Early combustion" means a state where the generation of the flame F is completed in the front half portion of the combustion stage 22. "Feeder combustion" means a state where the incineration object 400 is in the process of combustion on the feeder 31. "Drying defect" means a state where the incineration object 400 supplied to the drying stage 21 is not in the process of drying and the layer height of the incineration object 400 in the drying stage 21 becomes excessive. "Burnout defect" means a state where the flame F continues to be generated in the post-combustion stage 23. "Boundary defect" means a state where the field of view in the furnace is obstructed and it is difficult to confirm the state of combustion of the incineration object 400.

[0038]

The state identification unit 350 associates the combustion state with the brightness state of the treatment image in the combustion state in advance and identifies the combustion state by collating the brightness of the treatment image identified by the

brightness identification unit 320 with the relationship. An example of the relationship between the brightness and the combustion state will be described later.

[0039]

The recommendation proposal unit 360 proposes to a user of the combustion facility 100 a recommended operation of the speed of the fire grate 61 or the amount of air supplied from the wind box 2 based on the combustion state identified by the state identification unit 350, the burnout point Z identified by the point identification unit 330, and the temperature identified by the temperature identification unit 340. For example, the recommendation proposal unit 360 collates the combustion state, the burnout point Z, and the temperature with a table in which the combustion state, the burnout point Z, the temperature, and the recommended operation are associated to identify and propose the recommended operation. Examples of recommended operation include a recommended speed of the fire grate 61 and a recommended amount of air supplied from the wind box 2.

[0040]

For example, in a case where the temperature in the post-combustion stage 23 identified by the temperature identification unit 340 is lower than a preset reference temperature, the recommendation proposal unit 360 proposes

a recommended operation to the effect of the wind box 2 of the post-combustion stage 23 increasing the amount of air supplied to the post-combustion stage 23 from the current amount.

[0041]

<<Description of State Data>>

As described above, the state identification unit 350 identifies the combustion state based on the state data in which the combustion state and the brightness state of the treatment image are associated with each other. Information held by the state data will be described below.

[0042]

In association with the combustion state of "non-uniform combustion", the state data holds a state where the ratio of bright mesh is equal to or lower than a non-uniformity threshold (e.g. 50%) in a partial region on the lower side of the flame F region of the visible image (e.g. 3/13 on the lower side). In other words, in a case where the bright mesh ratio is equal to or lower than a non-uniformity threshold in a partial region on the lower side of the region showing the flame F, the state identification unit 350 identifies the combustion state as "non-uniform combustion".

[0043]

In the case of uniform combustion in the combustion stage 22, the flame F is generated in a wide region of the combustion stage 22 and the bright mesh ratio exceeds the non-uniformity threshold in the partial region on the lower side of the region showing the flame F. In the case of non-uniform combustion in the combustion stage 22, the flame F is generated only in a region that is a part of the combustion stage 22 and the bright mesh ratio is below the non-uniformity threshold in the partial region on the lower side of the region showing the flame F. Accordingly, the state identification unit 350 is capable of identifying the combustion state of non-uniform combustion by the above operation.

[0044]

In association with the combustion state of "early combustion", the state data holds a state where the bright mesh ratio is equal to or lower than an early combustion threshold (e.g. 10%) in the right or left side region of the flame F region of the visible image. In other words, in a case where the bright mesh ratio is equal to or lower than an early combustion threshold in the right or left side region of the region showing the flame F, the state identification unit 350 identifies the combustion state as "early combustion".

[0045]

As illustrated in Fig. 1, the camera 220 is on the post-combustion stage 23 side. Accordingly, as the position of the flame F becomes closer to the drying stage 21, that is, when early combustion occurs, the width of the flame F decreases in perspective and the bright mesh ratio decreases in the right or left side region of the region showing the flame F. Accordingly, the early combustion state can be identified by the ratio of the bright mesh in the right or left side region of the region showing the flame F.

[0046]

The state data associates the combustion state with "feeder combustion" to hold a state where the average value of the brightness is equal to or higher than a feeder combustion threshold in the region showing the feeder 31 in the flame perspective image. In other words, in a case where the average value of the brightness is equal to or higher than a feeder combustion threshold in the region showing the feeder 31, the state identification unit 350 identifies the combustion state as "feeder combustion". In other words, the state identification unit 350 identifies the combustion state of the feeder 31.

[0047]

When the incineration object 400 is burned, an increase in temperature occurs and the brightness of the

corresponding region rises. Accordingly, a case where the average value of the brightness is equal to or higher than the feeder combustion threshold in the region showing the feeder 31 indicates that the incineration object 400 is in the process of combustion in the feeder and corresponds to “feeder combustion”.

[0048]

The state data associates the combustion state with “drying defect” to hold a case where the value of brightness equal to or lower than drying defect threshold 1 is equal to or higher than drying defect-related threshold 1 or a state where the value of brightness equal to or lower than drying defect threshold 2 is equal to or higher than drying defect-related threshold 2 and the standard deviation of the brightness is equal to or higher than drying defect-related threshold 3 at the part of the flame perspective image showing the drying stage 21. In other words, the state identification unit 350 identifies the combustion state as “drying defect” in a case where the value of brightness equal to or lower than drying defect threshold 1 is equal to or higher than drying defect-related threshold 1 or in a case where the value of brightness equal to or lower than drying defect threshold 2 is equal to or higher than drying defect-related threshold 2 and the standard deviation of the brightness

is equal to or higher than drying defect-related threshold 3 at the part showing the drying stage 21. Drying defect threshold 1 is lower than drying defect threshold 2. In other words, the state identification unit 350 identifies the combustion state of the drying stage 21.

[0049]

In the event of insufficient drying in the drying stage 21, the temperature is low with the incineration object 400 having moisture and the value of brightness equal to or lower than drying defect threshold 1 increases. In addition, in the event of insufficient drying in the drying stage 21, the value of brightness equal to or lower than drying defect threshold 2 increases, the incineration object 400 that is sufficiently dried and high in brightness and the incineration object 400 that is not sufficiently dried and low in brightness are mixed, and thus the standard deviation of brightness increases.

[0050]

The state data associates the combustion state with "burnout defect" to hold a state where the bright mesh is equal to or higher than a burnout defect threshold (e.g. 10%) in the region showing the post-combustion stage 23 in the visible image in which the bright and dark meshes are identified by the brightness identification unit 320. In other words, in a case where the bright mesh is equal to

or higher than a burnout defect threshold in the region showing the post-combustion stage 23, the state identification unit 350 identifies the combustion state as “burnout defect”.

[0051]

When the incineration object 400 is burned in the post-combustion stage 23, post-combustion as the combustion of the fixed carbon of the incineration object 400 in the post-combustion stage 23 is not sufficiently performed. Such a state is also called a burnout defect. When the incineration object 400 is burned in the post-combustion stage 23, the flame F is generated in the post-combustion stage 23 and the brightness increases. Accordingly, in a case where the bright mesh is equal to or higher than the burnout defect threshold in the region showing the post-combustion stage 23, it can be grasped that the combustion state is “burnout defect”.

[0052]

The state data associates the combustion state with “poor visibility” to hold a state where the bright mesh ratio changes by a poor visibility threshold or more within reference time (e.g. 5 seconds) in the partial region on the lower side of the flame F region (e.g. 3/13 on the lower side) in the visible image in which the bright and dark meshes are identified by the brightness

identification unit 320. Alternatively, the state data associates the combustion state with “poor visibility” to regard “poor visibility” as the combustion state in a case where the average value of brightness is equal to or lower than an average value threshold or in a case where the value of brightness variance is equal to or higher than variance threshold 1 (e.g. 1000) or in a case where the value of brightness variance is equal to or lower than variance threshold 2 (e.g. 80) in the combustion stage 22 region of the flame perspective image. In other words, the state identification unit 350 identifies the combustion state as “poor visibility” in the above case.

[0053]

The visibility of the treatment space V of the combustion facility 100 may be poor due to, for example, the scattering of the incineration object 400. In such a case, the brightness of the combustion stage 22 significantly changes in a short time as a result of the scattering of the incineration object 400 in the combustion stage 22. Alternatively, the average value of the brightness in the entire region of the combustion stage 22 becomes equal to or less than a preset value as a result of the scattering of the incineration object 400. Alternatively, the value of brightness variance in the combustion stage 22 becomes equal to or higher than

variance threshold 1 as a result of the partial scattering of the incineration object 400 in a wide region of the combustion stage 22 or the value of brightness variance in the combustion stage 22 becomes equal to or lower than variance threshold 2 by the incineration object 400 covering a wide region of the combustion stage 22.

[0054]

In a case where the combustion state does not correspond to any of "non-uniform combustion", "early combustion", "feeder combustion", "drying defect", "burnout defect", and "poor visibility", the state identification unit 350 identifies the combustion state as "stable combustion".

[0055]

<<Operation of State Identification Device>>

Hereinafter, the operation of the state identification device 300 will be described. Fig. 3 is a flowchart illustrating the operation of the state identification device 300.

[0056]

The image acquisition unit 310 acquires the treatment image from the visible camera and the infrared camera of the camera 220 (step S1). In other words, the image acquisition unit 310 acquires the visible image, the flame perspective image, and the temperature distribution

image from the camera 220.

The brightness identification unit 320 identifies the brightness of the visible image and the brightness of the flame perspective image based on the visible image and the flame perspective image acquired by the image acquisition unit 310 in step S1 and calculates the average value and the standard deviation of the brightness of the flame perspective image (step S2).

[0057]

The state identification unit 350 identifies the combustion state of the combustion facility 100 by collating the brightness identified by the brightness identification unit 320 in step S2 and the average value and the standard deviation calculated by the brightness identification unit 320 in step S2 with the state data (step S3). In other words, the state identification unit 350 identifies whether the combustion state is "stable combustion", "non-uniform combustion", "early combustion", "feeder combustion", "drying defect", "burnout defect", or "poor visibility".

[0058]

The point identification unit 330 identifies the burnout point Z based on the brightness of the visible image identified by the brightness identification unit 320 in step S2 (step S4).

The temperature identification unit 340 receives the temperature distribution image acquired by the image acquisition unit 310 and identifies the temperature of the post-combustion stage 23 (step S5).

The recommendation proposal unit 360 proposes a recommended operation of the speed of the fire grate 61 or the amount of air supplied by the wind box 2 based on the combustion state identified in step S3, the burnout point Z identified in step S4, and the temperature identified in step S5 (step S6).

[0059]

As a result of the above operation, a user of the combustion facility 100 can grasp the combustion state in each of the feeder 31, the drying stage 21, the combustion stage 22, and the post-combustion stage 23 of the combustion facility 100.

[0060]

<<Actions and Effects>>

The state identification device 300 of the combustion facility 100 according to the present disclosure is the state identification device 300 identifying the combustion state of the combustion facility 100 including the furnace main body 10 defining the treatment space V, the fire grate 61 transporting the incineration object 400 in the transport direction Da in

the treatment space V, and the feeder 31 supplying the incineration object 400 to the treatment space V. The treatment space V is partitioned into a plurality of sections in the transport direction Da. The state identification device 300 includes the image acquisition unit 310 acquiring the treatment image as an image of the feeder 31 and the sections and the state identification unit 350 identifying the combustion state of each of the feeder 31 and the sections based on the treatment image.

[0061]

A user of the state identification device 300 can grasp the combustion state in the feeder 31 and the sections of the combustion facility 100.

[0062]

In addition, the image acquisition unit 310 of the state identification device 300 of the combustion facility 100 acquires the treatment image taken by the visible camera and the infrared camera.

[0063]

Since the state identification device 300 acquires the treatment image taken by the visible camera and the infrared camera, it is possible to acquire the treatment image even regarding a region blocked by, for example, the flame F in the treatment space V. As a result, a user of the state identification device 300 can grasp the

combustion state in the region of the feeder 31 and the drying stage 21 of the combustion facility 100 that is blocked by the flame F or the like.

[0064]

In addition, the sections of the state identification device 300 are partitioned into the drying stage 21, the combustion stage 22, and the post-combustion stage 23 from the upstream in the transport direction Da. The treatment image is an image showing the feeder 31, the drying stage 21, the combustion stage 22, and the post-combustion stage 23. The state identification unit 350 identifies the combustion state of each of the feeder 31, the drying stage 21, the combustion stage 22, and the post-combustion stage 23.

[0065]

A user of the state identification device 300 can grasp the combustion states in the feeder 31, the drying stage 21, the combustion stage 22, and the post-combustion stage 23 of the combustion facility 100.

[0066]

In addition, the brightness identification unit 320 identifies the brightness of an image associated with each of the feeder 31, the drying stage 21, the combustion stage 22, and the post-combustion stage 23 based on the treatment image and the state identification unit 350

identifies the combustion state based on the brightness.

[0067]

Since the state identification device 300 identifies the brightness of the treatment image, a user of the state identification device 300 can grasp the position of the flame F and can grasp the combustion state of the incineration object 400 based on the brightness.

[0068]

In addition, the state identification device 300 includes the point identification unit 330 identifying the burnout point Z, which is the rear end in the transport direction of the flame F caused by the combustion of the incineration object 400, based on the brightness, the temperature identification unit 340 identifying the temperature of the post-combustion stage 23 based on the treatment image, and the recommendation proposal unit 360 proposing a recommended operation of the combustion facility 100 based on the identified combustion state, burnout point Z, and temperature.

[0069]

As a result, a user of the state identification device 300 can receive the proposal of a recommended operation associated with the combustion state identified by the state identification device 300 and can operate the combustion facility 100 with greater ease.

[0070]

In addition, the combustion facility 100 includes the wind box 2 supplying air from below the fire grate 61. The recommended operation of the state identification device 300 is an operation related to the speed of the fire grate 61 or the amount of air supplied from the wind box 2.

[0071]

As a result, a user of the state identification device 300 can receive the proposal of a recommended operation that is an operation related to the speed of the fire grate 61 or the amount of air supplied from the wind box 2 identified by the state identification device 300 and can operate the combustion facility 100 with greater ease.

[0072]

In addition, the combustion state of the state identification device 300 is a state indicating any of the stable combustion, non-uniform combustion, early combustion, feeder combustion, drying defect, burnout defect, and boundary defect.

[0073]

The state identification device 300 identifies the combustion state, which is a state indicating any of the stable combustion, non-uniform combustion, early

combustion, feeder combustion, drying defect, burnout defect, and boundary defect. As a result, a user of the state identification device 300 can grasp the combustion state of the incineration object 400.

[0074]

<Second Embodiment>

Hereinafter, the combustion facility 100 according to a second embodiment will be described. In the configuration of the state identification device 300 according to the second embodiment, a model generation unit 370 and a model storage unit 380 are added to the configuration of the state identification device 300 according to the first embodiment.

[0075]

The model generation unit 370 generates a trained model trained by supervised learning using a data set of an input sample including the brightness of the drying stage 21 and an output sample including the combustion state of the drying stage 21 and records the trained model in the model storage unit 380. For example, the model generation unit 370 uses the brightness value of the visible image as the input sample. In addition, the model generation unit 370 uses a value associated with whether or not the combustion state is “drying defect” as the output sample. The model generation unit 370 trains the

trained model by a convolutional neural network (CNN) method using a data set in which the brightness value is an input sample and the value representing the combustion state is an output sample. The trained model is a relational expression in which the brightness value, the combustion state value, and a weight are associated.

[0076]

The model storage unit 380 stores the trained model generated by the model generation unit 370. Examples of the model storage unit 380 include on-premise and cloud storages.

[0077]

As in the case of the state identification unit 350 in the first embodiment, the state identification unit 350 in the second embodiment identifies the combustion state as “stable combustion”, “non-uniform combustion”, “early combustion”, “feeder combustion”, “drying defect”, “burnout defect”, or “poor visibility”. Regarding the above combustion states other than “drying defect”, the state identification unit 350 identifies the combustion state in the same manner as the state identification unit 350 according to the first embodiment. Regarding “drying defect”, the state identification unit 350 according to the second embodiment inputs the brightness identified by the brightness identification unit 320 to the trained

model stored in the model storage unit 380 and identifies whether or not the drying defect is “drying defect” that is the combustion state of drying stage 21.

[0078]

The camera 220 requires an infrared camera in a case where the model generation unit 370 generates the trained model. On the other hand, the camera 220 does not require an infrared camera in a case where the state identification unit 350 identifies the combustion state after the trained model is generated. In this case, the combustion state of the drying stage 21 can be grasped based on the treatment image of the brightness taken by the visible camera.

[0079]

<<Actions and Effects>>

The state identification device 300 of the combustion facility 100 according to the present disclosure includes the model storage unit 380 storing the trained model trained by supervised learning using the data set of the input sample including the brightness of an image associated with the drying stage 21 and the output sample including the combustion state of the drying stage 21. The state identification unit 350 inputs the brightness to the trained model to identify the combustion state of the drying stage 21.

[0080]

Since the state identification device 300 stores the trained model corresponding to the combustion state, a user of the state identification device 300 can grasp the combustion state of the drying stage 21 based on the trained model.

[0081]

<Other Embodiments>

Although one embodiment has been described in detail with reference to the drawings, the specific configuration is not limited to the above description and various design changes and the like can be made.

[0082]

Although the state identification unit 350 in the above embodiment identifies the combustion state of "feeder combustion" by the flame perspective image of the camera 220, the feeder combustion may be identified based on the visible image. In this case, the state identification unit 350 receives the visible image in which the bright mesh and the dark mesh are identified by the brightness identification unit 320 and identifies that the combustion state is "feeder combustion" in a case where the ratio of the bright mesh in the region showing the middle portion of the flame F is equal to or lower than a middle portion threshold (e.g. 70%) or in a case

where the ratio of the bright mesh in the region showing the upper portion of the flame F is equal to or higher than an upper portion threshold (e.g. 50%). Although the feeder 31 is behind the flame F with respect to the camera 220, in a case where combustion has occurred in the feeder 31, the combustion results in an increase in brightness and the brightness of the middle portion of the flame F or the upper portion of the flame F corresponding to the place of the feeder 31 increases.

[0083]

Fig. 5 is a schematic block diagram illustrating the configuration of a computer according to at least one embodiment.

A computer 1100 includes a processor 1110, a main memory 1120, a storage 1130, and an interface 1140.

The state identification device 300 described above is mounted on the computer 1100. The operation of each of the above processing units is stored in the storage 1130 in the form of a program. The processor 1110 reads a program from the storage 1130, loads the program into the main memory 1120, and executes the above processing in accordance with the program. In addition, the processor 1110 secures a storage region corresponding to each of the above storage units in the main memory 1120 in accordance with the program.

[0084]

The program may be one for realizing some of the functions of the computer 1100. For example, the program may exert a function in combination with another program already stored in the storage 1130 or in combination with another program mounted on another device. In another embodiment, 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, some or all of the functions realized by the processor 1110 may be realized by the integrated circuit.

[0085]

Examples of the storage 1130 include a magnetic disk, a magneto-optical disk, and a semiconductor memory. The storage 1130 may be internal media directly connected to the bus of computer 1100 or external media connected to the computer via the interface 1140 or a communication line. In addition, in a case where this program is distributed to the computer 1100 via a communication line, the distributed computer 1100 may load the program into the main memory 1120 and execute the above processing. In

at least one embodiment, the storage 1130 is a non-temporary tangible storage medium.

[0086]

In addition, the program may be one for realizing some of the functions described above. Further, the program may be a so-called difference file (difference program) that realizes the above function in combination with another program already stored in the storage 1130.

[0087]

<Additional Notes>

The state identification device 300 of the combustion facility 100 described in each embodiment is, for example, grasped as follows.

[0088]

(1) A state identification device 300 of a combustion facility 100 according to the present disclosure is a state identification device 300 identifying a combustion state of a combustion facility 100 including a furnace main body 10 defining a treatment space V, a fire grate 61 transporting an incineration object 400 in a transport direction Da in the treatment space V, and a feeder 31 supplying the incineration object 400 to the treatment space V, the treatment space V being partitioned into a plurality of sections in the transport direction Da, the state identification device 300

including: an image acquisition unit 310 acquiring a treatment image as an image of the feeder 31 and the sections; and a state identification unit 350 identifying a combustion state of each of the feeder 31 and the sections based on the treatment image.

[0089]

A user of the state identification device 300 can grasp the combustion state in the feeder 31 and the sections of the combustion facility 100.

[0090]

(2) The image acquisition unit 310 of the state identification device 300 of the combustion facility 100 acquires the treatment image taken by a visible camera and an infrared camera.

[0091]

Since the state identification device 300 acquires the treatment image taken by the visible camera and the infrared camera, it is possible to acquire the treatment image even regarding a region blocked by, for example, the flame F in the treatment space V. As a result, a user of the state identification device 300 can grasp the combustion state in the region of the feeder 31 and the drying stage 21 of the combustion facility 100 that is blocked by the flame F or the like.

[0092]

(3) The sections of the state identification device 300 are partitioned into a drying stage 21, a combustion stage 22, and a post-combustion stage 23 from an upstream in the transport direction Da, the treatment image is an image showing the feeder 31, the drying stage 21, the combustion stage 22, and the post-combustion stage 23, and the state identification unit 350 identifies a combustion state of each of the feeder 31, the drying stage 21, the combustion stage 22, and the post-combustion stage 23.

[0093]

A user of the state identification device 300 can grasp the combustion states in the feeder 31, the drying stage 21, the combustion stage 22, and the post-combustion stage 23 of the combustion facility 100.

[0094]

(4) The state identification device 300 further includes a brightness identification unit 320 identifying a brightness of an image associated with each of the feeder 31, the drying stage 21, the combustion stage 22, and the post-combustion stage 23 based on the treatment image, in which the state identification unit 350 identifies the combustion state based on the brightness.

[0095]

Since the state identification device 300 identifies the brightness of the treatment image, a user of the state

identification device 300 can grasp the position of the flame F and can grasp the combustion state of the incineration object 400 based on the brightness.

[0096]

(5) The state identification device 300 further includes: a point identification unit 330 identifying a burnout point Z as a rear end in the transport direction of a flame F caused by combustion of the incineration object 400 based on the brightness; a temperature identification unit 340 identifying a temperature of the post-combustion stage 23 based on the treatment image; and a recommendation proposal unit 360 proposing a recommended operation of the combustion facility 100 based on the identified combustion state, burnout point Z, and temperature.

[0097]

As a result, a user of the state identification device 300 can receive the proposal of a recommended operation associated with the combustion state identified by the state identification device 300 and can operate the combustion facility 100 with greater ease.

[0098]

(6) The combustion facility 100 includes a wind box 2 supplying air from below the fire grate 61, and the recommended operation of the state identification device

300 is an operation related to a speed of the fire grate 61 or the amount of air supplied from the wind box 2.

[0099]

As a result, a user of the state identification device 300 can receive the proposal of a recommended operation that is an operation related to the speed of the fire grate 61 or the amount of air supplied from the wind box 2 identified by the state identification device 300 and can operate the combustion facility 100 with greater ease.

[0100]

(7) The combustion state of the state identification device 300 is a state indicating any of stable combustion, non-uniform combustion, early combustion, feeder combustion, a drying defect, a burnout defect, and a boundary defect.

[0101]

The state identification device 300 identifies the combustion state, which is a state indicating any of the stable combustion, non-uniform combustion, early combustion, feeder combustion, drying defect, burnout defect, and boundary defect. As a result, a user of the state identification device 300 can grasp the combustion state of the incineration object 400.

[0102]

(8) The state identification device 300 of the combustion facility 100 according to the present disclosure includes a model storage unit 380 storing a trained model trained by supervised learning using a data set of an input sample including the brightness of an image associated with the drying stage 21 and an output sample including the combustion state of the drying stage 21, and the state identification unit 350 inputs the brightness to the trained model to identify the combustion state of the drying stage 21.

[0103]

Since the state identification device 300 stores the trained model corresponding to the combustion state, a user of the state identification device 300 can grasp the combustion state of the drying stage 21 based on the trained model.

[0104]

(9) A state identification method according to the present disclosure is a state identification method of a state identification device 300 identifying a combustion state of a combustion facility 100 including a furnace main body 10 defining a treatment space V, a fire grate 61 transporting an incineration object 400 in a transport direction Da in the treatment space V, and a feeder 31 supplying the incineration object 400 to the treatment

space V, the treatment space V being partitioned into a plurality of sections in the transport direction Da, the state identification method including: a step of acquiring a treatment image as an image of the feeder 31 and the sections; and a step of identifying a combustion state of each of the feeder 31 and the sections based on the treatment image.

[0105]

A user of the state identification method can grasp the combustion state in the feeder 31 and the sections of the combustion facility 100.

[0106]

(10) A program according to the present disclosure is a program causing a computer of a state identification device 300 identifying a combustion state of a combustion facility 100 including a furnace main body 10 defining a treatment space V, a fire grate 61 transporting an incineration object 400 in a transport direction Da in the treatment space V, and a feeder 31 supplying the incineration object 400 to the treatment space V, the treatment space V being partitioned into a plurality of sections in the transport direction Da, to execute: a step of acquiring a treatment image as an image of the feeder and the sections; and a step of identifying a combustion state of each of the feeder and the sections based on the

treatment image.

[0107]

A user of the program can grasp the combustion state in the feeder 31 and the sections of the combustion facility 100.

[Industrial Applicability]

[0108]

According to the combustion apparatus state identification device, the state identification method, and the program of the present disclosure, it is possible to grasp the combustion states in the feeder and the sections of the combustion facility.

[Reference Signs List]

[0109]

1 stoker furnace

2 wind box

3 hopper

4 gas circulation portion

6 stoker

7 furnace

8 waste heat recovery boiler

9 temperature reduction tower

10 furnace main body

11 dust collector

12 chimney

13 discharge chute

21 drying stage

22 combustion stage

23 post-combustion stage

31 feeder

61 fire grate

61A fixed fire grate

61B movable fire grate

100 combustion facility

300 state identification device

400 incineration object

1100 computer

1110 processor

1120 main memory

1130 storage

1140 interface

L1 primary air line

L2 secondary air line

B1 blower

F flame

Z burnout point

Claims

[Claim 1]

A state identification device identifying a combustion state of a combustion facility including a furnace main body defining a treatment space, a fire grate transporting an incineration object in a transport direction in the treatment space, and a feeder supplying the incineration object to the treatment space, the treatment space being partitioned into a plurality of sections in the transport direction, the combustion facility state identification device comprising:

an image acquisition unit acquiring a treatment image as an image of the feeder and the sections; and

a state identification unit identifying a combustion state of each of the feeder and the sections based on the treatment image.

[Claim 2]

The combustion facility state identification device according to Claim 1, wherein the image acquisition unit acquires the treatment image taken by a visible camera and an infrared camera.

[Claim 3]

The combustion facility state identification device according to Claim 1 or 2, wherein

the sections are partitioned into a drying stage, a combustion stage, and a post-combustion stage from an upstream in the transport direction,

the treatment image is an image showing the feeder, the drying stage, the combustion stage, and the post-combustion stage, and

the state identification unit identifies a combustion state of each of the feeder, the drying stage, the combustion stage, and the post-combustion stage.

[Claim 4]

The combustion facility state identification device according to Claim 3, further comprising a brightness identification unit identifying a brightness of an image associated with each of the feeder, the drying stage, the combustion stage, and the post-combustion stage based on the treatment image, wherein

the state identification unit identifies the combustion state based on the brightness.

[Claim 5]

The combustion facility state identification device according to Claim 4, further comprising a model storage

unit storing a trained model trained by supervised learning using a data set of an input sample including the brightness of the drying stage and an output sample including the combustion state of the drying stage, wherein

the state identification unit inputs the brightness to the trained model to identify the combustion state of the drying stage.

[Claim 6]

The combustion facility state identification device according to Claim 4 or 5, further comprising:

a point identification unit identifying a burnout point as a rear end in the transport direction of a flame caused by combustion of the incineration object based on the brightness;

a temperature identification unit identifying a temperature of the post-combustion stage based on the treatment image; and

an operation proposal unit proposing a recommended operation of the combustion facility based on the identified combustion state, burnout point, and temperature.

[Claim 7]

The combustion facility state identification device according to Claim 6, wherein

the combustion facility includes a wind box supplying air from below the fire grate, and

the recommended operation is an operation related to a speed of the fire grate or the amount of air supplied from the wind box.

[Claim 8]

The combustion facility state identification device according to any one of Claims 1 to 7, wherein the combustion state is a state indicating any of stable combustion, non-uniform combustion, early combustion, feeder combustion, a drying defect, a burnout defect, and a boundary defect.

[Claim 9]

A state identification method of a state identification device identifying a combustion state of a combustion facility including a furnace main body defining a treatment space, a fire grate transporting an incineration object in a transport direction in the treatment space, and a feeder supplying the incineration object to the treatment space, the treatment space being partitioned into a plurality of sections in the transport

direction, the state identification method comprising:

a step of acquiring a treatment image as an image of the feeder and the sections; and

a step of identifying a combustion state of each of the feeder and the sections based on the treatment image.

[Claim 10]

A program causing a computer of a state identification device identifying a combustion state of a combustion facility including a furnace main body defining a treatment space, a fire grate transporting an incineration object in a transport direction in the treatment space, and a feeder supplying the incineration object to the treatment space, the treatment space being partitioned into a plurality of sections in the transport direction, to execute:

a step of acquiring a treatment image as an image of the feeder and the sections; and

a step of identifying a combustion state of each of the feeder and the sections based on the treatment image.