

DESCRIPTION

Title of Invention

HEAT RECOVERY BOILER SYSTEM CONTROL DEVICE, HEAT RECOVERY BOILER SYSTEM CONTROL METHOD, AND PROGRAM

[Technical Field]

[0001]

The present disclosure relates to a heat recovery boiler system control device, a heat recovery boiler system control method, and a program.

[Background Art]

[0002]

In the furnace and the flue gas duct of boiler furnaces and incinerators such as waste incinerator boilers, soda recovery boilers, and coal-fired boilers, chlorine, heavy metals, sulfur, vanadium, and the like are contained in fuels such as coal and waste, and corrosion of metal materials such as a boiler superheater tube may occur. However, particularly in the case of the waste incinerator boiler, it is difficult to predict the life of the boiler superheater tube or the like in advance because the variation in fuel properties is large.

[0003]

For example, Patent Document 1 below discloses corrosion detection means for detecting corrosion of a metal part of a boiler, corrosion environment monitoring means for monitoring a corrosion environment of the boiler based on information from the corrosion detection means and detecting that the corrosion environment is harsh, and a heat recovery plant that estimates a factor by which the corrosion environment has

become harsh when the corrosion environment of the boiler is harsh, based on at least one of a processing amount of an incinerator, an amount of combustion air supplied to the incinerator, an amount of steam generated in the boiler, and an amount of heat generated in the boiler, determines a measure for mitigating the corrosion environment, and controls an operation of the incinerator such that the corrosion environment is mitigated, based on the determined measure.

[Citation List]

[Patent Document]

[0004]

[Patent Document 1] Japanese Patent No. 5767486

[Summary of Invention]

[0005]

However, in the heat recovery plant described in Patent Document 1, since the operation of the combustion furnace is controlled, there is a disadvantage that the operation performance of the heat recovery plant may be deteriorated (such as not reaching the planned processing amount and a decrease in the heat recovery efficiency). The present disclosure has been made in view of the above-described subjects, and an object of the present disclosure is to provide a heat recovery boiler system control device, a heat recovery boiler system control method, and a program capable of monitoring a corrosion state in real time and suppressing corrosion.

[Subject to be solved]

[0006]

In order to solve the above-described subjects and achieve the object, a heat recovery boiler system according to the present disclosure includes: an acquisition unit that acquires a first measurement value indicating measurement data of an ultrasonic

sensor and a second measurement value indicating measurement data of a two-electrode sensor; an estimation unit that estimates at least one of a wall thinning amount of a probe and melting of adhered ash of the probe, based on at least one of the first measurement value and the second measurement value; a determination unit that determines an operation command for a process with respect to the adhered ash, based on an estimation result of the estimation unit; and an operation control unit that controls an operation of at least one of a water spraying device that lowers a gas temperature and an ash removal device that removes the adhered ash, as processes with respect to the wall thinning and the adhered ash, based on a determination result of the determination unit.

[0007]

In order to solve the above-described subjects and achieve the object, a heat recovery boiler system control method according to the present disclosure includes: a step of acquiring a first measurement value indicating measurement data of an ultrasonic sensor and a second measurement value indicating measurement data of a two-electrode sensor; a step of estimating at least one of a wall thinning amount of a probe and melting of adhered ash of the probe, based on at least one of the first measurement value and the second measurement value; a step of determining an operation command for a process with respect to the adhered ash, based on an estimation result; and a step of controlling an operation of at least one of a water spraying device that lowers a gas temperature and an ash removal device that removes the adhered ash, as processes with respect to the wall thinning and the adhered ash, based on a determination result.

[0008]

In order to solve the above-described subjects and achieve the object, a program according to the present disclosure causes a computer to execute: a step of acquiring a first measurement value indicating measurement data of an ultrasonic sensor and a

second measurement value indicating measurement data of a two-electrode sensor; a step of estimating at least one of a wall thinning amount of a probe and melting of adhered ash of the probe, based on at least one of the first measurement value and the second measurement value; a step of determining an operation command for a process with respect to the adhered ash, based on an estimation result; and a step of controlling an operation of at least one of a water spraying device that lowers a gas temperature and an ash removal device that removes the adhered ash, as processes with respect to the wall thinning and the adhered ash, based on a determination result.

[0009]

According to the present disclosure, it is possible to provide a heat recovery boiler system control device, a heat recovery boiler system control method, and a program capable of monitoring a corrosion state in real time and suppressing corrosion.

[Brief Description of Drawings]

[0010]

Fig. 1 is a schematic diagram showing a configuration example of a heat recovery boiler system according to the present disclosure.

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

Fig. 3 is a diagram showing an example of information stored in an operation data storage unit according to the present disclosure.

Fig. 4 is a diagram showing an example of a time-series change in a first measurement value according to the present disclosure.

Fig. 5 is a diagram showing an example of a time-series change in a second measurement value according to the present disclosure.

Fig. 6 is a diagram showing an example of information stored in a model storage

unit according to the present disclosure.

Fig. 7 is a flowchart showing a flow of a first aspect of a heat recovery boiler system control method and a program according to the present disclosure.

Fig. 8 is a flowchart showing a flow of a second aspect of the heat recovery boiler system control method and the program according to the present disclosure.

Fig. 9 is a flowchart showing a flow of a third aspect of the heat recovery boiler system control method and the program according to the present disclosure.

[Description of Embodiments]

[0011]

Hereinafter, an embodiment according to the present disclosure will be described in detail with reference to the drawings. The present disclosure is not limited to the embodiment described below.

[0012]

(Configuration of Heat Recovery Boiler System)

Fig. 1 is a schematic diagram showing a configuration example of a heat recovery boiler system 10 according to the present disclosure. As shown in Fig. 1, the heat recovery boiler system 10 according to the present disclosure includes an incinerator 200 and a boiler furnace 300, and includes a high-temperature corrosion monitoring probe 310 (310A, 310B, 310C), an ash removal device 320 (320A, 320B, 320C), a heat exchanger 330 (330A, 330B, 330C), and a water spraying device 340 inside the boiler furnace 300.

[0013]

In the incinerator 200, the fuel is supplied from the fuel supply device 202, and the fuel is combusted in the furnace. The incinerator 200 combusts waste, black liquor, coal, petroleum, biomass, asphalt, and the like as fuel to generate a combustion gas G.

In the present embodiment, the incinerator for incinerating the object is used, but the present embodiment can be applied to a combustion furnace that combusts fuel. The incinerator in Fig. 1 schematically shows a stoker-type incinerator. The incinerator 200 may be realized by a pulverized coal-fired combustion furnace, an oil/gas-fired combustion furnace, a stoker-type incinerator, a fluidized bed-type incinerator, a shaft-type gasification and melting furnace, a fluidized bed-type gasification and melting furnace, a kiln-type gasification and melting furnace, or the like. The combustion gas G from the incinerator 200 is supplied to the inside of the boiler furnace 300 and the heat is recovered from the combustion gas G by superheating the steam circulating inside the heat exchanger 330.

[0014]

In the boiler furnace 300, various heat exchangers 330 are disposed, and heat is recovered from the combustion gas G generated in the incinerator 200. For example, the heat exchanger 330 such as an evaporator, a superheater, or an economizer that recovers heat from the combustion gas G to the water is disposed in the boiler furnace 300. The combustion gas G flowing into the boiler furnace 300 comes into contact with the heat exchangers 330, so that heat is transferred from the combustion gas G to the heat transport medium flowing through the heat exchangers 330.

[0015]

A high-temperature corrosion monitoring probe 310 (hereinafter, referred to as a "probe") includes a thin ultrasonic sensor and a two-electrode sensor, and detects a wall thinning amount of the probe 310 and a molten state of adhered ash. As shown in Fig. 1, the probe 310 is provided on the upstream side of the combustion gas G of the heat exchanger 330. The probe 310 is manufactured to simulate the heat transfer tube of the heat exchanger 330. Therefore, the wall thinning amount of the probe 310 and

the molten state of the adhered ash may be regarded as the wall thinning amount of the heat transfer tube of the corresponding heat exchanger 330 and the molten state of the adhered ash. The thin ultrasonic sensor provided on one side in the thickness direction of the probe 310 includes a piezoelectric element, and transmits ultrasonic waves by applying a high-frequency voltage to the piezoelectric element to cause the piezoelectric element to vibrate at a high frequency, thereby transmitting the ultrasonic waves to the inside of the probe 310, receiving a reflected wave of the ultrasonic waves from an end portion on the side opposite to the probe 310 in which the piezoelectric element is provided, and calculating a wall thickness based on a time interval until the reflected wave is received. The two-electrode sensor provided in the probe 310 detects the melting of the adhered ash by measuring a current value in a case where a conductive liquid is generated by the melting of the adhered ash adhered between electrodes that are not electrically connected to each other.

[0016]

Since the normal ultrasonic sensor is too large for a narrow place such as the inside of the probe 310, the ultrasonic sensor may be difficult to install. In addition, the normal ultrasonic sensor has a problem in heat resistance. Further, in a case where the probe 310 is installed in the corrosion environment exposed to the high-temperature combustion gas G, a problem arises in that the probe 310 does not satisfy sufficient durability to withstand long-term operation. On the other hand, a plurality of locations can be easily measured by the thin ultrasonic sensor according to the present application. In addition, the two-electrode sensor has a simple structure, excellent durability, and does not cause adhesion like a large number of electrodes. In addition, in the case of the two-electrode sensor, when the thickness of the adhered ash increases, it can be grasped that the contact area between the adhered ash and the electrode increases and

the resistance decreases, and there is a possibility that a lot of information related to the phenomenon can be acquired even with a simple structure.

[0017]

The ash removal device 320 is a device that removes coal or ash adhered to the heat transfer tube of the heat exchanger 330 of the boiler furnace 300. As shown in Fig. 1, the ash removal device 320 is provided on the upstream side of the combustion gas G of the heat exchanger 330. The ash removal device 320 may be, for example, a shock pulse type soot blower. The shock pulse type soot blower fills the inside of the soot blower with a combustible gas, generates a shock wave by the explosion of the combustible gas, and performs ash removal by the shock wave. By using the shock pulse type soot blower, it is possible to eliminate the need to use the steam generated in the boiler furnace 300 for ash removal. In this manner, since it is possible to reduce steam loss as compared with a case where an ash removal device using the steam generated in the boiler furnace 300 is normally used, it is possible to increase the heat recovery efficiency of the heat recovery boiler system 10.

[0018]

The heat exchanger 330 recovers heat from the combustion gas G to the heat transport medium. A plurality of the heat exchangers 330 are provided in the boiler furnace 300. The heat exchanger 330 may be, for example, an evaporator, a superheater, an economizer, or the like. In these cases, the heat is recovered by using water as a heat transport medium and transferring the heat of the combustion gas G from the heat transfer tube by heat conduction or heat transfer through the water flowing inside the heat transfer tube constituting the heat exchanger 330.

[0019]

The water spraying device 340 is provided on the upstream side of the gas flow

with respect to the heat exchanger 330, sprays water into the boiler furnace 300 to cool the gas, and decreases the gas temperature when the combustion gas G reaches the heat exchanger 330. The water spraying device 340 may be configured with, for example, a spraying nozzle, a heat-resistant hose, and a pump unit. In Fig. 1, an example is shown in which the spraying nozzle of the water spraying device 340 is provided to protrude from the side surface of the incinerator 200 in the left-right direction on the paper surface. However, the spraying nozzle may be provided to protrude from the side surface of the incinerator 200 in the front direction on the paper surface and the side surface of the incinerator 200 in the rear direction on the paper surface. In addition, the heat-resistant hose may be suspended from the upper surface of the incinerator 200, an spraying unit in which the spraying nozzle is attached and which is connected to the heat-resistant hose may be provided inside the incinerator 200, and water may be sprayed from the spraying nozzle toward the side surface side of the incinerator 200 from the central portion of the incinerator 200. In addition, the spraying port of the spraying nozzle may be provided to be open on a wall surface forming a side surface of the incinerator 200, and the spraying nozzle may not protrude into the incinerator 200.

[0020]

Then, as shown in Fig. 1, the probe 310, the ash removal device 320, and the water spraying device 340 are connected to a control device 100. These apparatuses connected to the control device 100 operate based on a signal transmitted by the control device 100. Hereinafter, the control device 100 will be described.

[0021]

(Configuration of Control Device)

The control device 100 manages the heat recovery boiler system 10, and integrates and controls various apparatuses and devices constituting the heat recovery

boiler system 10. The configuration of the control device 100 will be described with reference to Fig. 2. Fig. 2 is a diagram showing a configuration example of the control device according to the present disclosure. The control device 100 includes a communication unit 110, a storage unit 120, a control unit 130, an input unit 140, and a display unit 150.

[0022]

The communication unit 110 transmits and receives information from various apparatuses and devices constituting the heat recovery boiler system 10. The communication unit 110 may be realized by, for example, various dedicated wired lines or wireless communication with security measures.

[0023]

The storage unit 120 is a storage device that stores various types of information such as a program used for processes of the control unit 130 and operation data of the heat recovery boiler system 10. For example, the storage unit 120 may be realized by a semiconductor memory element such as a random access memory (RAM), a read only memory (ROM), or a flash memory, or a combination of a hard disk, a solid state drive (SSD), an optical disk, or the like.

[0024]

The storage unit 120 includes an operation data storage unit 121 and a model storage unit 122. Different types of information are stored in the operation data storage unit 121 and the model storage unit 122. Hereinafter, an example of the information stored in the storage units will be described.

[0025]

The operation data storage unit 121 stores various measurement values generated in accordance with the operation of the heat recovery boiler system 10 and

information related to the operation status. Here, an example of the information stored in the operation data storage unit 121 will be described with reference to Fig. 3.

[0026]

Fig. 3 is a diagram showing an example of the information stored in the operation data storage unit according to the present disclosure. As shown in Fig. 3, the operation data storage unit 121 stores information related to various environmental conditions and items related to the operation, which affect corrosion, such as "measurement date and time", "first measurement value", "second measurement value", "pressure value", and "temperature value", in association with each other.

[0027]

The "measurement date and time" is information indicating the date and time when various measurement values are measured. The "first measurement value" is information indicating a measurement value of the thin ultrasonic sensor. The "second measurement value" is information indicating a measurement value of the two-electrode sensor. The "pressure value" is information indicating a measurement value of the pressure measurement equipment. The "temperature value" is information indicating a measurement value of the temperature measurement equipment.

[0028]

That is, in Fig. 3, the first measurement value "FMD#1", the second measurement value "SMD#1", the pressure value "PD#1", and the temperature value "TD#1" measured at the measurement date and time "TM#1" are stored in association with each other.

[0029]

The information stored in the operation data storage unit 121 is not limited to information related to items such as "measurement date and time", "first measurement

value", "second measurement value", "pressure value", and "temperature value", and for example, data related to the operation of the heat recovery boiler system 10, such as a combustion chamber temperature, a superheater (SH) inlet gas temperature, a processing amount, and an evaporation amount, may be stored. Further, data in which the actual wall thinning amount of the superheater is regularly measured may be stored in association with the storage data. Accordingly, when the combustion chamber temperature or the SH inlet gas temperature is high, it is clear that the calorific value of the waste as the fuel is high in the first place. Further, when the corrosion rate is also high, it is easier to determine the removal of the medium or the water spraying.

[0030]

Here, the time-series changes in the first measurement value and the second measurement value will be described with reference to Figs. 4 and 5, respectively. Fig. 4 is a diagram showing a time-series change in measurement values of the thin ultrasonic sensor according to the present disclosure. The horizontal axis of Fig. 4 indicates the operation time of the heat recovery boiler system 10 using a unit of month. The vertical axis of Fig. 4 indicates a time-series change in the wall thickness of the probe 310 estimated using the first measurement value. As shown in Fig. 4, it can be seen that the wall thickness of the probe 310 tends to decrease as the operation time elapses.

[0031]

A time-series change in the second measurement value will be described with reference to Fig. 5. Fig. 5 is a diagram showing a time-series change in measurement values of the two-electrode sensor according to the present disclosure. The horizontal axis of Fig. 5 indicates the operation time of the heat recovery boiler system 10 using a unit of month. The vertical axis of Fig. 5 indicates an inter-electrode current as the second measurement value. As shown in Fig. 5, in a case where a current is measured

between the two electrodes, for example, the gas temperature rises due to a change in the quality of the waste, the surface temperature of the probe 310 rises accordingly, and the adhered ash is heated, and it is estimated that the adhered ash has melted. In addition, it is also possible to estimate the relationship between the melting of the adhered ash and the tendency of the wall thinning by collating the timing when the amount of decrease in the probe wall thickness shown in the graph shown in Fig. 4 increases. In this way, by using the measurement value of the two-electrode sensor, it is possible to estimate a change in the properties of the waste put into the incinerator 200 or the molten state of the adhered ash. For example, in a case where waste containing a large amount of chlorine, such as plastic, is combusted, the corrosion rate increases due to a rise in the combustion chamber temperature and an increase in the adhesion amount or the melting amount. In addition, in a case where waste containing a large amount of lead (Pb), zinc (Zn), and copper (Cu) is combusted, the melting amount increases, the corrosion rate increases, and other changes are small. In addition, in a case where the calorie fluctuates greatly, such as in plastic, the fluctuation in the combustion chamber temperature is large, the adhesion amount is large, the melting amount fluctuates, and the corrosion rate is high. In addition, in a case where the calorie fluctuates greatly, such as in waste with a large amount of moisture, the fluctuation in the combustion chamber temperature is large, and the fluctuation in the melting amount is large. By using the measurement value of the two-electrode sensor, it is possible to estimate a change in the properties of the waste as described above, which is put into the incinerator 200.

[0032]

The operation data storage unit 121 may store information related to any other operation data without being limited to information related to items such as

"measurement date and time", "first measurement value", "second measurement value", "pressure value", and "temperature value".

[0033]

The model storage unit 122 stores a plurality of models. Fig. 6 is a diagram showing an example of information stored in the model storage unit according to the present disclosure.

[0034]

In the example shown in Fig. 6, the model storage unit 122 stores information related to items such as "model ID" and "model data" in association with each other.

[0035]

The "model ID" is an identifier for identifying the machine learning model, and is represented by a string, a number, or the like. The "model data" indicates model data of the machine learning model. For example, the "model data" stores data for a model that outputs various types of operation assistance information, information related to a corrosion state, and the like when operation data is input. For example, the machine learning model may be a neural network, a Bayesian network, a support vector machine, a soft sensor, or the like.

[0036]

That is, in Fig. 4, a model identified by a model ID "M#1" indicates a machine learning model M#1. In addition, the model data "MDT#1" indicates the model data of the machine learning model M#1.

[0037]

Here, in a case where the machine learning model is a neural network, the model data "MDT#1" includes, for example, various types of information such as connection information indicating how nodes included in each of a plurality of layers constituting

the neural network are connected to each other and a connection coefficient multiplied by a numerical value input and output between the connected nodes.

[0038]

The model storage unit 122 may store information related to any other machine learning model without being limited to information related to items such as "model ID" and "model data".

[0039]

The control unit 130 is a controller that manages and controls the control device 100. The control unit 130 is realized by a central processing unit (CPU), a micro processing unit (MPU), or the like executing various programs stored in the storage unit 120 using a RAM as a work region. In addition, for example, the control unit 130 may be realized by an integrated circuit such as an application specific integrated circuit (ASIC) or a field programmable gate array (FPGA).

[0040]

The control unit 130 includes an acquisition unit 131, an estimation unit 132, a determination unit 133, an operation control unit 134, and an operation control unit 135. The control unit 130 realizes these units by reading out the program from the storage unit 120 and executing the program. That is, these units are realized by a set of processes described by the program. The control unit 130 executes these processes in accordance with the description of the program. The control unit 130 may execute the process with one CPU or may include a plurality of the CPUs and may execute these processes with the plurality of CPUs.

[0041]

The acquisition unit 131 acquires the first measurement value indicating the measurement data of the thin ultrasonic sensor and the second measurement value

indicating the measurement data of the two-electrode sensor. For example, the acquisition unit 131 may acquire the first measurement value and the second measurement value from the thin ultrasonic sensor and the two-electrode sensor, respectively, via the measurement line connected to the communication unit 110. When the acquisition unit 131 acquires the first measurement value and the second measurement value, the acquisition unit 131 stores the acquired first measurement value and second measurement value in the operation data storage unit 121 of the storage unit 120.

[0042]

The estimation unit 132 estimates at least one of the wall thinning state of the probe 310 and the corrosion state of the probe 310 based on at least one of the first measurement value and the second measurement value. For example, the estimation unit 132 estimates the wall thinning amount of the probe 310 based on the first measurement value. Here, the wall thinning amount of the probe 310 means the wall thinning amount of the probe 310 which is a dummy superheater tube. Since the probe 310 simulates the superheater tube, the wall thinning amount of the probe 310 is considered to be a value approximating the wall thinning amount of the superheater. The first measurement value indicating the measurement data of the thin ultrasonic sensor indicates the wall thickness of the probe 310. Therefore, the wall thinning amount of the probe 310 can be estimated by subtracting the wall thickness of the probe 310 indicated by the first measurement value from the initial value of the wall thickness of the probe 310. In addition, the estimation unit 132 may estimate a predicted value of the wall thinning amount using a model obtained by machine learning a database in which the first measurement value is accumulated.

[0043]

In addition, for example, the estimation unit 132 estimates the corrosion state of the probe 310 based on the second measurement value. The second measurement value indicating the measurement data of the two-electrode sensor indicates a current value flowing between the two electrodes in a case where the melting of the adhered ash has occurred. Therefore, it is considered that the larger the current value indicated by the second measurement value, the more likely it is that a molten substance having low electric resistance is generated. In addition, it is considered that the longer the time during which the current value indicated by the second measurement value flows, the larger the amount of the molten substance generated by the melting of the adhered ash is, and the current continuously flows between the two electrodes. The estimation unit 132 estimates the molten state of the adhered ash of the probe 310 based on the second measurement value based on such estimation. In addition, the estimation unit 132 may estimate the prediction of the molten state of the adhered ash using a model obtained by machine learning a database in which the second measurement value is accumulated. In addition, the estimation unit 132 may estimate a predicted value of the wall thinning amount by training the correlation between the wall thinning amount of the probe and the melting of the adhered ash.

[0044]

The determination unit 133 determines an operation command for a process with respect to the adhered ash based on an estimation result of the estimation unit 132. That is, the determination unit 133 determines an operation command for at least one of the water spraying device 340, the ash removal device 320, and the incinerator 200. That is, the determination unit 133 determines whether or not to operate at least one of the water spraying device 340, the ash removal device 320, and the incinerator 200, or an operation command including a transition of an operation state, based on the wall

thinning amount and the corrosion state estimated by the estimation unit 132. That is, the operation command is a command signal indicating an operation instruction for these devices and apparatuses.

[0045]

For example, the determination unit 133 determines whether or not the wall thinning amount estimated by the estimation unit 132 is equal to or larger than a predetermined value or whether or not the molten substance is in a molten state for a relatively long time, and in a case where the wall thinning amount is equal to or larger than the predetermined value, the determination unit 133 determines to operate the water spraying device 340. Here, the predetermined value is a preset setting value that serves as a determination criterion for the operation of the water spraying device 340. For example, the predetermined value may be a value set arbitrarily by statistical processing based on data accumulated by the operation results of the heat recovery boiler system 10. Alternatively, the predetermined value may be a value set arbitrarily based on a rule of thumb constructed by many years of experience by the operation worker of the heat recovery boiler system 10. In addition, the predetermined value may be set to different values for each probe 310. Since there is a possibility that the target recovery heat amount of the boiler may not be satisfied due to the water spraying, in that case, the recovery heat amount may be adjusted by increasing the processing amount and creating a state where the operation temperature is raised.

[0046]

In addition, the determination unit 133 determines to operate the ash removal device 320 in a case where the melting of the adhered ash estimated by the estimation unit 132 has occurred or in a case where the progress of the wall thinning rate is faster than the normal state. For example, in a case where the estimation unit 132 estimates

that the melting of the adhered ash of the probe 310 has occurred based on the second measurement value, the determination unit 133 determines to operate the ash removal device 320 corresponding to the probe 310 in which the melting of the adhered ash is estimated to have occurred.

[0047]

In addition, in a case where the estimation unit 132 estimates that the melting of the adhered ash in the plurality of probes 310 has occurred, the determination unit 133 determines to lower the temperature of the incinerator 200 within a range in which there is no problem in operation or to lower the gas temperature by water spraying of the water spraying device 340. Here, the number of the plurality of probes 310 may be set to any number based on the past operation results of the heat recovery boiler system 10 having a similar configuration. For example, in a case where three heat exchangers 330 are provided in the boiler furnace 300 of the heat recovery boiler system 10, one probe 310 is provided corresponding to each of the heat exchangers 330, and a total of three probes 310 are provided, when the melting of the adhered ash is estimated in two or more probes 310, which is half or more, it may be determined to lower the temperature of the incinerator 200 within a range in which there is no problem in operation or to lower the gas temperature by water spraying of the water spraying device 340.

[0048]

In addition, the determination unit 133 may, in addition to detecting a molten status of the adhered ash by an ON or OFF response, evaluate a molten salt corrosion risk time from an integral of the number of times the adhered ash melted and a melting time of the adhered ash, and determine an operation of the ash removal device 320 or the water spraying device 340 using an evaluation result. That is, the evaluation may be performed using the parameter itself or the evaluation may be performed in

combination with other parameters. For example, the evaluation may be performed in accordance with a correlation between the wall thinning amount of the probe 310 and the molten salt corrosion risk time. In addition, the evaluation may be performed in accordance with a correlation between the wall thickness measurement result (regular inspection) of the actual heat transfer tube and the molten salt corrosion risk time.

[0049]

In addition, the determination unit 133 may detect (monitor) the wall thinning amount of the heat transfer tube and the increase status of the melting amount of the adhered ash, estimate a corrosion progress degree of an entire heat recovery facility based on a detection result, and determine the operation based on the corrosion progress degree. The operation of the ash removal device 320 and the water spraying device 340 may be determined by the following steps. That is, the ultrasonic sensor and the two-electrode sensor of the probe 310 monitor the wall thinning amount of the heat transfer tube and the increase status of the melting amount of the adhered ash to estimate the corrosion progress degree of the entire heat recovery facility. Then, in a case where the corrosion progress degree is large, the corrosion temperature environment is reduced by spraying water to the upstream side of the heat recovery facility. It is preferable to use the spray water as the in-plant wastewater. The corrosion progress degree may be determined by considering detection results of a plurality of sensors in the same probe or different probes. In addition to the data acquired by the probe 310, the operation conditions of the boiler (fuel properties, air ratio, evaporation amount, and the like) and the wall thickness measurement result (regular inspection result) of the actual heat transfer tube may also be taken into account. Accordingly, it is possible to estimate a corrosion rate distribution based on the relationship between the corrosion rate and the operation condition and a factor thereof. Alternatively, it is also possible to evaluate

and update the estimation result of the corrosion rate distribution of the heat transfer tubes in the furnace.

[0050]

The operation control unit 134 controls the operation of the process with respect to the adhered ash based on the determination result of the determination unit 133. That is, the operation control unit 134 controls the operation of at least one of the water spraying device 340 and the ash removal device 320. For example, in a case where the determination unit 133 determines to operate the water spraying device 340 based on the fact that the wall thinning amount is equal to or larger than the predetermined value, the operation control unit 134 performs control to operate the water spraying device 340. In this manner, it is possible to reduce the corrosion temperature environment.

[0051]

In addition, in a case where the determination unit 133 determines to operate corresponding ash removal device 320 based on the estimation that the melting of the adhered ash has occurred, the operation control unit 134 performs control to operate the corresponding ash removal device 320. Since the plurality of probes 310 are provided, by operating the ash removal device 320 corresponding to the probe 310 in which the melting of the adhered ash has occurred, it is possible to remove the adhered ash adhered to the heat transfer tube of the heat exchanger 330 in which the melting of the adhered ash is estimated to have occurred.

[0052]

The operation control unit 135 controls the operation of the incinerator 200 based on the determination result of the determination unit 133. The operation control unit 135 performs control to lower the operation temperature of the incinerator 200 in a case where the determination unit 133 determines to lower the temperature of the

incinerator 200 within a range in which there is no problem in operation or to lower the gas temperature by water spraying of the water spraying device 340, based on the estimation that the melting of the adhered ash has occurred in the plurality of probes 310. For example, in a case where the incinerator 200 is a stoker-type incinerator, control is performed to reduce the amount of air blown from the blower or to reduce the amount of waste to be put into the incinerator 200.

[0053]

The input unit 140 receives an operation of the heat recovery boiler system 10 from the operation worker. The input unit 140 may be realized by various input devices such as a mouse or a keyboard. In addition, the input unit 140 may be realized by a dedicated operation panel in which a plurality of switches are combined. The heat recovery boiler system 10 is operated in accordance with an operation input to the input unit 140 from the operation worker.

[0054]

The display unit 150 is a display device that displays various types of information such as operation information and an operation status of the heat recovery boiler system 10. The display unit 150 receives information to be displayed from the control unit 130 and displays various types of information based on the received information. In this manner, the operation worker of the heat recovery boiler system 10 can grasp the operation status and make a decision or determination on the operation of various apparatuses according to the operation status. The display unit 150 may be realized by a display device such as a liquid crystal display, an organic electro luminescence (EL) display, or a micro light emitting diode (LED) display. The display unit 150 may be realized by combining a plurality of display devices for the purpose of enabling the operation worker to instantly grasp a large amount of information.

[0055]

(Heat Recovery Boiler System Control Method and Configuration of Program)

Next, a control method of the heat recovery boiler system 10 and a program according to the present disclosure will be described with reference to Figs. 7 to 9.

[0056]

(First Aspect)

Fig. 7 is a flowchart showing a flow of a first aspect of the heat recovery boiler system control method and the program according to the present disclosure. A control method of the heat recovery boiler system 10 of the first aspect will be described with reference to Fig. 7.

[0057]

First, the control device 100 acquires measurement data including the first measurement value indicating the measurement data of the thin ultrasonic sensor and the second measurement value indicating the measurement data of the two-electrode sensor (step S1). Next, the control device 100 estimates at least one of the wall thinning amount of the probe 310 and the melting of the adhered ash of the probe 310 based on at least one of the first measurement value and the second measurement value (step S2). Next, the control device 100 determines whether or not the wall thinning amount is equal to or larger than a predetermined value (step S3). Next, in a case where the wall thinning amount is equal to or larger than a predetermined value (step S3: Yes), the control device 100 performs control to operate the water spraying device 340 (step S4). In a case where the wall thinning amount is not equal to or larger than the predetermined value (step S3: No), the control device 100 ends the process. These processes may be described in a program to be executed by a computer included in the control device 100, and the processes may be executed by the computer by the program.

[0058]

Accordingly, it is possible to control the operation of the ash removal device 320 in accordance with the wall thinning amount and the melting of the adhered ash. Therefore, it is possible to appropriately execute the operation of the ash removal device 320 in accordance with the monitoring of the probe 310.

[0059]

(Second Aspect)

Fig. 8 is a flowchart showing a flow of a second aspect of the heat recovery boiler system control method and the program according to the present disclosure. A control method of the heat recovery boiler system 10 of the second aspect will be described with reference to Fig. 8.

[0060]

In the control method of the heat recovery boiler system 10 of the second aspect, the same processes as the processes from step S1 to step S2 of the control method of the heat recovery boiler system 10 according to the first aspect are executed from step S10 to step S20. Next, the control device 100 determines whether or not the melting of the adhered ash has occurred (step S30). In a case where it is determined that the melting of the adhered ash has occurred (step S30: Yes), the control device 100 operates the ash removal device 320 (step S40). In a case where it is determined that the melting of the adhered ash has not occurred (step S30: No), the control device 100 ends the process. These processes may be described in a program to be executed by a computer included in the control device 100, and the processes may be executed by the computer by the program.

[0061]

Accordingly, in a case where the adhered ash has melted, the ash removal device

320 can be operated. Therefore, it is possible to appropriately execute the operation of the ash removal device 320 in accordance with the monitoring of the probe 310.

[0062]

(Third Aspect)

Fig. 9 is a flowchart showing a flow of a third aspect of the heat recovery boiler system control method and the program according to the present disclosure. A control method of the heat recovery boiler system 10 of the third aspect will be described with reference to Fig. 9.

[0063]

In the control method of the heat recovery boiler system 10 of the third aspect, the same processes as the processes from step S1 to step S2 of the control method of the heat recovery boiler system 10 according to the first aspect are executed from step S100 to step S200. Next, the control device 100 determines whether or not the wall thinning amount of the probe 310 is equal to or larger than a predetermined value at a plurality of locations (step S300). In a case where the wall thinning amount of the plurality of probes 310 is equal to or larger than the predetermined value (step S300: Yes), the control device 100 performs control to lower the operation temperature (step S400). In a case where the wall thinning amount of the plurality of probes 310 is not equal to or larger than the predetermined value (step S300: No), the control device 100 ends the process. These processes may be described in a program to be executed by a computer included in the control device 100, and the processes may be executed by the computer by the program.

[0064]

Accordingly, when the melting of the adhered ash has occurred in the plurality of probes 310, it is possible to perform an operation of lowering the operation

temperature. Therefore, it is possible to reduce the risk of high-temperature corrosion due to exposure to a high-temperature environment.

[0065]

(Configuration and Effect)

The present disclosure discloses the following invention. The present disclosure is not limited to the following.

(1) A heat recovery boiler system control device including: an acquisition unit 131 that acquires a first measurement value indicating measurement data of an ultrasonic sensor and a second measurement value indicating measurement data of a two-electrode sensor; an estimation unit 132 that estimates at least one of a wall thinning amount of a probe 310 and melting of adhered ash of the probe 310, based on at least one of the first measurement value and the second measurement value; a determination unit 133 that determines an operation command of at least one of a water spraying device and an ash removal device, as a process with respect to the adhered ash, based on an estimation result of the estimation unit 132; and an operation control unit 134 that controls an operation for the process with respect to the adhered ash, based on a determination result of the determination unit 133.

[0066]

According to this configuration, it is possible to provide a control device capable of monitoring a corrosion state in real time and suppressing corrosion. According to this configuration, by controlling any one of the water spraying device 340, the ash removal device 320, and the combustion furnace, the reduction process and the removal process of the adhered ash can be appropriately executed.

[0067]

(2) The heat recovery boiler system control device according to (1), in which in

a case where the wall thinning amount of the probe 310 estimated by the estimation unit 132 is equal to or larger than a predetermined value, the determination unit 133 determines to operate a water spraying device 340 corresponding to a probe 310 of which a wall thinning amount is estimated to be equal to or larger than the predetermined value.

[0068]

According to this configuration, in a case where the wall thinning of the probe 310 is progressed, the corrosion temperature environment can be reduced by operating the water spraying device 340.

[0069]

(3) The heat recovery boiler system control device according to (1) or (2), in which in a case where the estimation unit 132 estimated that the adhered ash of the probe 310 has melted, the determination unit 133 determines to operate an ash removal device 320 corresponding to a probe 310 in which the melting of the adhered ash has occurred.

[0070]

According to this configuration, in a case where the melting of the adhered ash is estimated, the adhered ash can be removed by operating the ash removal device 320 corresponding to the probe 310 in which the melting of the adhered ash has occurred. Therefore, it is possible to provide the control device 100 for the heat recovery boiler system 10 capable of suppressing corrosion.

[0071]

(4) The heat recovery boiler system control device according to any one of (1) to (3), in which in a case where the estimation unit 132 estimated that the adhered ash has melted in a plurality of the probes, the determination unit 133 determines to lower an operation temperature of a combustion furnace, and the heat recovery boiler system

control device further includes: an operation control unit 135 that controls an operation of the combustion furnace, based on the determination result of the determination unit 133.

[0072]

According to this configuration, in a case where the melting of the adhered ash has occurred in the plurality of probes 310, it is possible to perform an operation of lowering the operation temperature of the combustion furnace. Therefore, it is possible to provide the control device 100 for the heat recovery boiler system 10 capable of suppressing corrosion.

[0073]

(5) The heat recovery boiler system control device according to any one of (1) to (4), in which the determination unit 133 detects a molten status of the adhered ash by an ON or OFF response, evaluates a molten salt corrosion risk time from an integral of the number of times the adhered ash melted and a melting time of the adhered ash, and determines an operation of the ash removal device 320 or the water spraying device 340 using an evaluation result.

[0074]

According to this configuration, it is possible to provide the heat recovery boiler system 10 capable of monitoring a corrosion state in real time and suppressing corrosion.

[0075]

(6) The heat recovery boiler system control device according to any one of (1) to (5), in which the determination unit 133 detects a wall thinning amount of a heat transfer tube and an increase status of a melting amount of the adhered ash, estimates a corrosion progress degree of an entire heat recovery facility based on a detection result, and determines an operation of the ash removal device or the water spraying device

based on the corrosion progress degree.

[0076]

According to this configuration, it is possible to provide the heat recovery boiler system 10 capable of monitoring a corrosion state in real time and suppressing corrosion.

[0077]

(7) A heat recovery boiler system control method including: a step of acquiring a first measurement value indicating measurement data of an ultrasonic sensor and a second measurement value indicating measurement data of a two-electrode sensor; a step of estimating at least one of a wall thinning amount of a probe 310 and melting of adhered ash of the probe 310, based on at least one of the first measurement value and the second measurement value; a step of determining an operation command for a process with respect to the adhered ash, based on an estimation result; and a step of controlling an operation of at least one of a water spraying device and an ash removal device, as the process with respect to the adhered ash, based on a determination result.

[0078]

According to this configuration, it is possible to provide the control method of the heat recovery boiler system 10 capable of monitoring a corrosion state in real time and suppressing corrosion.

[0079]

(8) A program for a heat recovery boiler system causing a computer to execute: a step of acquiring a first measurement value indicating measurement data of an ultrasonic sensor and a second measurement value indicating measurement data of a two-electrode sensor; a step of estimating at least one of a wall thinning amount of a probe 310 and melting of adhered ash of the probe 310, based on at least one of the first measurement value and the second measurement value; a step of determining an

operation command for a process with respect to the adhered ash, based on an estimation result; and a step of controlling an operation of at least one of a water spraying device and an ash removal device, as the process with respect to the adhered ash, based on a determination result.

[0080]

According to this configuration, it is possible to provide a program capable of monitoring a corrosion state in real time and suppressing corrosion.

[0081]

Although the embodiments according to the present disclosure have been described above, the embodiments are not limited by the contents of the embodiments. In addition, the above-described components include those that can be easily assumed by those skilled in the art, those that are substantially the same, and those that are within a so-called equivalent range. Further, the above-described components can be combined as appropriate. Furthermore, various omissions, replacements, or modifications of the above-described components can be made without departing from the concept of the above-described embodiments.

[Reference Signs List]

[0082]

10: heat recovery boiler system

100: control device

110: communication unit

120: storage unit

121: operation data storage unit

122: model storage unit

130: control unit

131: acquisition unit
132: estimation unit
133: determination unit
134: operation control unit
135: operation control unit
140: input unit
150: display unit
200: incinerator
300: boiler furnace
310: high-temperature corrosion monitoring probe (probe)
320: ash removal device
330: heat exchanger

Claims

[Claim 1]

A heat recovery boiler system control device comprising:

an acquisition unit that acquires a first measurement value indicating measurement data of an ultrasonic sensor and a second measurement value indicating measurement data of a two-electrode sensor;

an estimation unit that estimates an amount of wall thinning of a probe and melting of adhered ash of the probe, using a model obtained by machine learning a database in which at least one of the first measurement value and the second measurement value is accumulated;

a determination unit that determines an operation command for a process with respect to the wall thinning and the adhered ash, based on an estimation result of the estimation unit; and

an operation control unit that controls an operation of at least one of a water spraying device and an ash removal device, as the process with respect to the wall thinning and the adhered ash, based on a determination result of the determination unit,

in a case where the amount of wall thinning of the probe estimated by the estimation unit is equal to or larger than a predetermined value, the determination unit determines to operate a water spraying device or an ash removal device, which corresponds to the probe and is provided on an upstream side of a gas flow, and

in a case where the estimation unit estimates that the adhered ash of the probe has melted, the determination unit determines to operate a water spraying device or an ash removal device, which is provided on an upstream side of a gas flow with respect to the probe.

[Claim 2]

The heat recovery boiler system control device according to Claim 1, wherein

in a case where the estimation unit estimated that the adhered ash has melted in a plurality of the probes, the determination unit determines to lower an operation temperature of a combustion furnace, and

the heat recovery boiler system control device further comprises: an operation control unit that controls an operation of the combustion furnace, based on the determination result of the determination unit.

[Claim 3]

The heat recovery boiler system control device according to Claim 1, wherein the determination unit detects a molten status of the adhered ash by an ON or OFF response, evaluates a molten salt corrosion risk time from an integral of the number of times the adhered ash melted and a melting time of the adhered ash, and determines an operation of the ash removal device or the water spraying device using an evaluation result.

[Claim 4]

The heat recovery boiler system control device according to Claim 1, wherein the determination unit detects a wall thinning amount of a heat transfer tube and an increase status of a melting amount of the adhered ash, estimates a corrosion progress degree of an entire heat recovery facility based on a detection result, and determines an operation of the ash removal device or the water spraying device based on the corrosion progress degree.

[Claim 5]

A heat recovery boiler system control method comprising:
a step of acquiring a first measurement value indicating measurement data of an ultrasonic sensor and a second measurement value indicating measurement data of a two-electrode sensor;
a step of estimating an amount of wall thinning of a probe and melting of adhered ash of the probe, using a model obtained by machine learning a database in which at least one of the first measurement value and the second measurement value is accumulated;
a step of determining an operation command for a process with respect to the wall thinning and the adhered ash, based on an estimation result; and
a step of controlling an operation of at least one of a water spraying device and an ash removal device, as the process with respect to the wall thinning and the adhered ash, based on a determination result,
the step of determining includes,
in a case where the amount of wall thinning of the probe estimated at the step of estimating is equal to or larger than a predetermined value, determining to operate a water

spraying device or an ash removal device, which corresponds to the probe and is provided on an upstream side of a gas flow, and

in a case where it is estimated at the step of estimating that the adhered ash of the probe has melted, determining to operate a water spraying device or an ash removal device, which is provided on an upstream side of a gas flow with respect to the probe.

[Claim 6]

A program causing a computer to execute:

a step of acquiring a first measurement value indicating measurement data of an ultrasonic sensor and a second measurement value indicating measurement data of a two-electrode sensor;

a step of estimating an amount of wall thinning of a probe and melting of adhered ash of the probe, using a model obtained by machine learning a database in which at least one of the first measurement value and the second measurement value is accumulated;

a step of determining an operation command for a process with respect to the wall thinning and the adhered ash, based on an estimation result; and

a step of controlling an operation of at least one of a water spraying device and an ash removal device, as the process with respect to the wall thinning and the adhered ash, based on a determination result,

the step of determining includes,

in a case where the amount of wall thinning of the probe estimated at the step of estimating is equal to or larger than a predetermined value, determining to operate a water spraying device or an ash removal device, which corresponds to the probe and is provided on an upstream side of a gas flow, and

in a case where it is estimated at the step of estimating that the adhered ash of the probe has melted, determining to operate a water spraying device or an ash removal device, which is provided on an upstream side of a gas flow with respect to the probe.