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(71) Applicant: **JFE Steel Corporation**
Tokyo 100-0011 (JP)

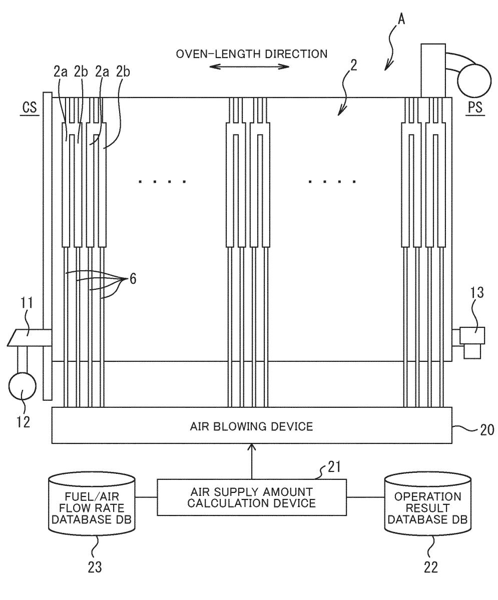
(72) Inventors:
- **KAWASHIMA Tomoyuki**
  Tokyo 100-0011 (JP)
- **IKEDA Norimasa**
  Tokyo 100-0011 (JP)
- **HIGASHI Yuki**
  Tokyo 100-0011 (JP)
- **OKADA Jun**
  Tokyo 100-0011 (JP)
- **OZAWA Noriko**
  Tokyo 100-0011 (JP)

(74) Representative: **Grünecker Patent- und Rechtsanwälte**
PartG mbB
Leopoldstraße 4
80802 München (DE)

(54) **COKE OVEN, METHOD FOR REGULATING TEMPERATURE DISTRIBUTION IN COKE OVEN, METHOD FOR OPERATING COKE OVEN, AND METHOD FOR PRODUCING COKE**

(57) There are provided a coke oven, a method for regulating a temperature distribution in the coke oven, a method for operating the coke oven, and a method for producing coke, which can regulate the temperature distribution in the oven-length direction in a combustion chamber by supplying air in an appropriate supply amount to flues with a reduced combustion temperature of the combustion chamber. A coke oven (A) includes: an air blowing device (20) connected, in an operation with one fuel supply system and an air supply system in a combustion chamber (2), to the other fuel supply system to supply air to each of flues (2a), (2b) by diverting the other fuel supply system; and an air supply amount calculation device (21) configured to calculate an air flow rate shortage for each of the flues (2a), (2b) based on a measured temperature in each of the flues (2a), (2b) in the combustion chamber (2). The air blowing device (20) supplies air in an amount corresponding to the air flow rate shortage calculated by the air supply amount calculation device (21) to the flues (2a), (2b) having the air flow rate shortage.

FIG. 6



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Description

Technical Field

[0001] The present invention relates to a coke oven, a method for regulating a temperature distribution in the coke oven, a method for operating the coke oven, and a method for producing coke.

Background Art

[0002] One of technologies of improving the combustion of a coke oven is a multi-stage combustion technology of lowering the flame temperature and reducing NOx, which is a technology of supplying about 80 to 90% of air required for complete combustion in a lower part of a combustion chamber and supplying air in an amount corresponding to a shortage in an upper part of the combustion chamber, thereby achieving complete combustion as a whole (see PTL 1) .

[0003] As a structure of supplying air to the upper part for multi-stage combustion, a structure is mentioned in which an air supply path is formed in a partition wall between combustion chambers subdivided in the oven-length direction, and air is supplied to the combustion chambers on one side from the supply path. However, bricks constituting the combustion chambers are prone to deterioration particularly in a part close to a coke oven port, and therefore the formation of the above-described supply path is desired to be prevented only in a partition wall partitioning the outside of the oven positioned at the endmost in the oven-length direction. Therefore, a blowoff port of the supply path formed in the partition wall between the combustion chamber positioned at the endmost in the oven-length direction and the combustion chamber adjacent thereto needs to be formed towards the side of the combustion chamber positioned at the endmost, i.e., towards the side of the coke oven port, and the subsequent blowoff ports are also necessarily directed towards the side of the coke oven port. Therefore, the blowoff ports are formed back-to-back on a coke side (CS) and a pusher side (PS) with the center in the oven-length direction as the boundary. Only in the partition wall positioned in the center in the oven-length direction, both the supply path of blowing off air to the coke side and the supply path blowing off air to the pusher side are provided.

[0004] The two supply paths provided in the center partition wall have a cross-sectional area smaller than that of the supply paths formed in the other partition walls to prevent deterioration of the strength of the partition wall. This has posed such a problem that the ventilation resistance of the two supply paths is large, so that pressure loss becomes correspondingly large, resulting in a reduction in the flow rate of air that can be supplied and a reduction in the combustion temperature, which lowering the combustion temperature of the center in the oven-length direction.

[0005] To solve this problem, PTL 2 describes a method for regulating a temperature distribution in a coke oven having two fuel supply systems capable of supplying fuel gas to each of combustion chambers subdivided in the oven-length direction and an air supply system capable of supplying air to each of the combustion chambers, in which, in an operation with one fuel supply system of the fuel supply systems and the air supply system, air is supplied by diverting the other fuel supply system to a predetermined combustion chamber positioned in the center in the oven-length direction, thereby regulating the temperature distribution in the oven-length direction of the combustion chamber.

Citation List

Patent Literatures

[0006]

PTL 1: JP 2001-81470 A
PTL 2: JP 2009-46536 A

Summary of Invention

Technical Problem

[0007] The bricks constituting the combustion chambers of the coke oven are deteriorated as described above, but this deterioration results in a decrease only in air ratios of the flues in the vicinity of the deteriorated bricks in some cases. More specifically, mortar applied between the brick and the brick is broken, so that volatile gas generated during dry distillation of coal flows from a carbonization chamber to the flue of the combustion chamber, causing the reduction in the air ratio and the reduction in the combustion temperature in some cases.

[0008] The reduction in the air ratio needs to be eliminated, because the reduction in the air ratio causes problems, such as the generation of dust of soot generated due to a reduction in the combustion efficiency caused by unburned fuel or pyrolysis and blockage of a gas flow path.

[0009] In this case, air is supplied to the flues positioned in the center in the oven-length direction according to the method for regulating the temperature distribution in the coke oven described in PTL 2, but the flues having the reduced combustion temperature and the reduced air ratio is not limited to the flues positioned in the center in the oven-length direction, and therefore air cannot be always supplied to the flues requiring the air supply. Further, the method for regulating the temperature distribution in the coke oven in PTL 2 does not describe the air supply amount to the flues, and therefore there is a risk that air in an excessive supply amount is blow into the flues positioned in the center in the oven-length direction, deteriorating the temperature distribution in the oven-length direction in the combustion chamber.

[0010] It is conceivable that air is blown uniformly to all of the flues in the entire combustion chamber to increase the air ratio of the flues having the reduced air ratio. However, this case results in a loss of energy because air is blown even to the flues not requiring the air supply.

[0011] Thus, the present invention has been made to solve the conventional problem. It is an object of the present invention to provide a coke oven, a method for regulating the temperature distribution in the coke oven, a method for operating the coke oven, and a method for producing coke, which can regulate the temperature distribution in the oven-length direction in a combustion chamber by supplying air in an appropriate supply amount to the flues with a reduced combustion temperature of the combustion chamber.

Solution to Problem

[0012] To achieve the above-described object, a coke oven according to one aspect of the present invention is a coke oven with a combustion chamber having a plurality of sets of two flues, two fuel supply systems capable of supplying fuel gas to each of the flues of the combustion chamber, and an air supply system capable of supplying air to each of the flues of the combustion chamber in the oven-length direction, including: an air blowing device connected, in an operation with one fuel supply system of the two fuel supply systems and the air supply system in the combustion chamber, to the other fuel supply system to supply air to each of the flues by diverting the other fuel supply system; and an air supply amount calculation device configured to calculate the air flow rate shortage for each of the flues based on the measured temperature in each of the flues in the combustion chamber, in which the air blowing device supplies air in an amount corresponding to the air flow rate shortage calculated by the air supply amount calculation device to the flues having the air flow rate shortage.

[0013] A method for regulating a temperature distribution in a coke oven according to another aspect of the present invention is a method for regulating the temperature distribution in a coke oven with a combustion chamber having a plurality of sets of two flues, two fuel supply systems capable of supplying fuel gas to each of the flues of the combustion chamber, and an air supply system capable of supplying air to each of the flues of the combustion chamber in the oven-length direction, including: an air supply amount calculation step of calculating the air flow rate shortage for each of the flues based on the measured temperature in each of the flues in the combustion chamber by the air supply amount calculation device; and an air blowing step of supplying air in an amount corresponding to the air flow rate shortage calculated in the air supply amount calculation step to the flues having the air flow rate shortage from an air blowing device connected, in an operation with one fuel supply system of the two fuel supply systems and the air supply system in the combustion chamber, to the other fuel supply system to supply air to each of the flues by diverting the other fuel supply system, regulating the temperature distribution in the oven-length direction of the combustion chamber.

[0014] A method for operating a coke oven according to another aspect of the present invention includes operating the coke oven by regulating the temperature distribution in the oven-length direction of the combustion chamber by the method for regulating the temperature distribution in the coke oven described above.

[0015] A method for producing coke according to another aspect of the present invention includes producing coke by operating the coke oven according to the method for operating the coke oven described above.

Advantageous Effects of Invention

[0016] The coke oven, the method for regulating the temperature distribution in the coke oven, the method for operating the coke oven, and the method for producing coke can provide a coke oven, a method for regulating the temperature distribution in the coke oven, a method for operating the coke oven, and a method for producing coke, which can regulate the temperature distribution in the oven-length direction in the combustion chamber by supplying air in an appropriate supply amount to the flues with a reduced combustion temperature of the combustion chamber.

Brief Description of Drawings

[0017]

FIGS. 1A and 1B illustrate the outline configurations of a coke oven, in which FIG. 1A is a cross-sectional view of the coke oven cut along the oven-length direction in a carbonization chamber and FIG. 1B is a cross-sectional view of the coke oven cut along the longitudinal direction of coke oven battery;

FIG. 2 is a view for illustrating the configuration of sets of two flues and regenerators in a combustion chamber;

FIG. 3 is a view for illustrating the outline configuration of air supply paths and blowoff ports;

FIG. 4 is a view for illustrating the configuration of an existing C gas supply system;

FIG. 5 is a view in which an air blowing device is connected to a vertical pipe of a C gas supply system to supply air to each of the flues by diverting the C gas supply system;

FIG. 6 is a view for illustrating the outline configuration of a coke oven according to one embodiment of the present invention, but FIG. 6 does not illustrate the regenerators and the carbonization chambers;

FIG. 7 is a view illustrating the outline configuration of an air blowing device in the coke oven illustrated in FIG. 6;

FIG. 8 is a view illustrating the outline configuration of an air supply amount calculation device in the coke oven illustrated in FIG. 6;

FIG. 9 is a flowchart for illustrating the processing flow for regulating a temperature distribution in the oven-length direction of the combustion chamber;

FIG. 10 is a flowchart for illustrating a detailed process flow of Step S1 (air supply amount calculation step) in the flowchart illustrated in FIG. 9;

FIG. 11 is a flowchart for illustrating a detailed process flow of Step S2 (air blowing step) in the flowchart illustrated in FIG. 9;

FIG. 12 is a graph illustrating one example of a temperature distribution in the oven-length direction of the combustion chamber (the temperature of flues in the center in the oven-length direction decreases by about 50°C) ;

FIG. 13 is a graph illustrating the relationship between the oven wall temperature estimated from the measured temperature in the flues in the center in the oven-length direction and the oven wall temperature estimated from the temperature of a calculation value in the flues in the center in the oven-length direction in the combustion chamber having the temperature distribution illustrated in FIG. 12;

FIG. 14 is a graph for illustrating changes with time of the oven bottom temperature in the flues in the center in the oven-length direction, changes with time of the flow rate of air supplied to the flues in the center in the oven-length direction, and changes with time of the CO concentration in the flues in the center in the oven-length direction for illustrating the effect when air in an amount corresponding to the air flow rate shortage is supplied to the flues in the center in the oven-length direction in the combustion chamber having the temperature distribution illustrated in FIG. 12; and

FIG. 15 is a view for illustrating a difference between odd and even numbers of gas blowing flues and exhausting flues in combustion chambers adjacent to each other in the longitudinal direction of coke oven battery.

Description of Embodiments

[0018] Embodiments of the present invention will now be described with reference to the drawings. The embodiments described below exemplify devices or methods for embodying the technical idea of the present invention, and the technical idea of the present invention does not specify the materials, shapes, structures, arrangement, and the like of constituent components to the materials, shapes, structures, arrangement, and the like described below. The drawings are schematic. Therefore, it should be noted that the relationship between the thickness and the planar dimension, ratio, and the like are different from the actual relationship, ratio, and the like. The drawings include portions different in mutual dimensional relationships and ratios.

[0019] FIG. 1 illustrates the outline configuration of a coke oven. In a coke oven A illustrated in FIGS. 1A and 1B, a plurality of carbonization chambers 1 and a plurality of combustion chambers 2 are alternately arranged along the longitudinal direction of coke oven battery, and a plurality of regenerators 3 is provided in the longitudinal direction of coke oven battery below the carbonization chambers 1 and the combustion chambers 2. Each combustion chamber 2 has a plurality of sets (16 sets in this embodiment) of two flues 2a, 2b (see FIG. 2) in the oven-length direction as illustrated in FIG. 6. With respect to the plurality of sets of the two flues 2a, 2b, the sets of the flues 2a, 2b are arranged at a predetermined pitch along the oven-length direction. The sets of the flues 2a, 2b extend in the vertical direction, and each have a hairpin structure in which the flues 2a, 2b are allowed to communicate with each other in top portions of the flues 2a, 2b as illustrated in FIGS. 2 and 6.

[0020] The regenerators 3 are divided in the oven-length direction, and the predetermined regenerator 3 is allowed to communicate with one set of the flues 2a, 2b of each combustion chamber 2. A bottom section of each regenerator 3 aligned in the oven-length direction is allowed to communicate with a sole flue 4 extending in the oven-length direction, and a nozzle plate 5 with an opening section is interposed between each regenerator 3 and the sole flue 4.

[0021] For one set of the flues 2a, 2b, a route for supplying fuel gas (M gas: mixed gas of coke oven gas and blast furnace gas) and air and a route for discharging exhaust gas from the one set of the flues 2a, 2b are individually formed. More specifically, the M gas and air are individually poured from one end on a coke side (CS) of the sole flues 4 different from each other, enter the regenerator 3 via the nozzle plate 5, followed by preheating therein, and then introduced into either one of one set of the flues 2a, 2b for combustion. Exhaust gas of the combustion is drawn down from the other one of the one set of the flues 2a, 2b to the regenerator 3, followed by heat recovery therein, enters the sole flue 4, and then exhausted from the other end on a pusher side (PS). The supply route of the M gas and air and the exhaust route of the exhaust gas are switched every predetermined time interval, and the preheating and the heat recovery are alternately performed in the regenerator 3.

[0022] To lower the flame temperature and reduce NOx, two-stage combustion is performed. In a first stage, air is supplied from the bottom sections of the flues 2a, 2b, and, in a second stage, an air supply path 2c is formed in a partition wall between the flues 2a, 2b and air is supplied from the supply path 2c to the flue 2a or 2b as illustrated in FIGS. 2 and 3. More specifically, the predetermined regenerator 3 is allowed to communicate with one supply path 2c, and air sent to this regenerator 3 is blown off to the flue 2a or 2b via the supply path 2c in the partition wall. However, bricks constituting the combustion chamber 2 are prone to deterioration particularly in a section close to a coke oven port, and therefore the formation of the supply path 2c is desired to be prevented only in the partition wall partitioning the outside of the oven positioned at the endmost in the oven-length direction. Therefore, as illustrated in FIG. 3, a blowoff port 2d of the supply path 2c formed in the partition wall between the flue 2a or 2b positioned at the endmost in the oven-length direction and the flue 2b or 2a adjacent to the flue 2a or 2b positioned at the endmost is formed towards the side of the flue 2a or 2b positioned at the endmost, i.e., towards the side of the coke oven port, and all of the subsequent blowoff ports 2d are also directed towards the side of the coke oven port. Thus, the blowoff ports 2d are formed back-to-back on the coke side (CS) and the pusher side (PS) with the center in the oven-length direction as the boundary. Only in the partition wall positioned in the center in the oven-length direction, both the supply path 2c performing blowing-off to the coke side and the supply path 2c performing blowing-off to the pusher side are provided. The combustion temperatures of the flues 2a, 2b depend on the flow rates of the M gas and the air supplied thereto, and therefore the combustion temperatures are regulated by regulating the flow rate of the fuel gas passing through the nozzle plate 5 by regulating the opening area of the nozzle plate 5.

[0023] On the other hand, a vertical pipe 6 supplying fuel gas (C Gas: coke oven gas) is allowed to communicate with the bottom section of each of the flues 2a, 2b. Each vertical pipe 6 is allowed to communicate with a distribution pipe 8 via a branch pipe 7, and a chip 9 capable of controlling the flow rate is provided in the middle of the branch pipe 7 as illustrated in FIG. 4. The C gas poured into the distribution pipe 8 does not pass through the regenerator 3, and is supplied directly to one of the flues 2a and 2b through the branch pipe 7 and the vertical pipe 6, so that combustion occurs in one of the flues 2a and 2b. Exhaust gas of the combustion is the same as that in the combustion of the M gas described above.

[0024] As described above, the coke oven A includes the M gas supply system and the C gas supply system (distribution pipe 8, branch pipe 7, and vertical pipe 6) capable of supplying the M gas and the C gas to each of the flues 2a, 2b of the combustion chamber 2 and the air supply system (including the supply path 2c) capable of supplying air to each of the flues 2a, 2b of the combustion chamber 2, and involves M gas combustion performed by the M gas and the air and C gas combustion performed by the C gas and the air. The coke oven A is operated by either one of the M gas combustion and the C gas combustion. However, the coke oven A is operated mainly by the M gas combustion.

[0025] When the coke oven A is operated by the M gas combustion, the C gas supply system is not used and is in a resting state, and therefore, to supply air in an appropriate supply amount to one or two or more of the flues 2a, 2b with the reduced combustion temperature among the plurality (32 sets in this embodiment) of flues 2a, 2b of the combustion chamber 2 by diverting the C gas supply system, an air blowing device 20 is connected to the vertical pipe 6 of the C gas supply system allowed to communicate with the plurality (32 sets in this embodiment) of flues 2a, 2b in the combustion chamber 2 as illustrated in FIG. 6. At this time, as illustrated in FIG. 5, the chip 9 of the branch pipe 7 allowed to communicate with each of the flues 2a, 2b is replaced with a blind chip 10. The branch pipe 7 is disconnected (separated) from the distribution pipe 8. When a flow path can be completely closed by the chip 9, there is no need to replace the chip 9 with the blind chip 10. Then, the air blowing device 20 is connected to the lower end of the vertical pipe 6 disconnected from the distribution pipe 8, enabling the air supply. In FIG. 6, the reference numeral 11 denotes an air inlet, the reference numeral 12 denotes an M gas supply pipe, and the reference numeral 13 denotes an exhaust port.

[0026] When there are the flues 2a, 2b having the air flow rate shortage calculated by an air supply amount calculation device 21 described below larger than a predetermined threshold α, the air blowing device 20 supplies air in an amount corresponding to the air flow rate shortage to the flues 2a, 2b having the air flow rate shortage larger than the predetermined threshold α, and includes a plurality (32 in this embodiment) of air blowing sections 20b supplying air to each of the flues 2a, 2b and an air-blowing control section 20a controlling the air blowing of the plurality of air blowing sections 20b as illustrated in FIG. 7.

[0027] Herein, the "predetermined threshold α" is set based on the air ratio. For example, when the air ratio is 0.8 or less, air in an amount corresponding to the air flow rate shortage is blown. For example, when the dry distillation heat quantity is set to 600 Mcal/t, the coal supply amount per one time to one combustion chamber is set to 30 t, the theoretical air amount (volume ratio) required for the complete combustion of the M gas is set to 1, the heat quantity of the M gas is set to 1.200 [Mcal/Nm^3], the air ratio of the design value of the coke oven is set to 1.2, a time required for one dry distillation is set to 17.5 hours, and the number of the flues on the fuel gas blowing side in one combustion chamber is set to 16 (= 32/2), the air amount per flue is 64 Nm^3/h, because Air blowing amount into one flue = Dry distillation heat quantity $\times$ Coal supply amount per one time into one combustion chamber/Heat quantity of M gas $\times$ Theoretical heat quantity $\times$ Air ratio of design value of coke oven/Time required for one dry distillation/Number of flues on fuel gas blowing side in one combustion chamber is established.

[0028] When there is the flue determined to have the air ratio of 0.75 in this example, air in an amount corresponding to Air-ratio blowing gas amount = Air blowing amount into one flue $\times$ (Air ratio of design value - Actual air ratio)/ Air ratio of design value $\approx$ 38.5 Nm^3/h is blown into the flues 2a, 2b determined to have a low air ratio (flues 2a, 2b determined to have the air flow rate shortage larger than the predetermined threshold α).

[0029] Each air blowing section 20b is connected to a common air pipe connected to an air supply source, and is configured to supply air in an amount corresponding to the air flow rate according to the opening degree of a valve provided in each air blowing section 20b to each of the flues 2a, 2b.

[0030] The air-blowing control section 20a is a computer system with an arithmetic processing function, and is configured to determine whether there are the flues 2a, 2b having the air flow rate shortage calculated by the air supply amount calculation device 21 larger than the predetermined threshold α, and, when there are the flues 2a, 2b having the air flow rate shortage larger than the predetermined threshold α, control the valve opening degree of the air blowing sections 20b supplying air to the flues 2a, 2b having the air flow rate shortage larger than the predetermined threshold α, and supply air in an amount corresponding to the air flow rate shortage to the flues 2a, 2b.

[0031] To the air blowing device 20, the air supply amount calculation device 21 is connected, the air supply amount calculation device 21 calculating the air flow rate shortage for each of the flues 2a, 2b based on the measured temperature in each of the flues 2a, 2b in the combustion chamber 2.

[0032] The air supply amount calculation device 21 includes an operation data acquisition section 21a, a first distribution flow rate estimation section 21b, a flue internal temperature acquisition section 21c, a second distribution flow rate estimation section 21d, an air flow rate shortage calculation section 21e, and an output section 21f as illustrated in FIG. 8. The air supply amount calculation device 21 is a computer system with an arithmetic processing function, and is configured to execute various dedicated computer programs stored in advance in hardware, thereby enabling the realization, on software, of the functions of the operation data acquisition section 21a, the first distribution flow rate estimation section 21b, the flue internal temperature acquisition section 21c, the second distribution flow rate estimation section 21d, the air flow rate shortage calculation section 21e, and the output section 21f.

[0033] Herein, the operation data acquisition section 21a acquires operation data stored in an operation result database 22 (see FIG. 6)). The operation result database 22 stores the operation data when coke oven operation was performed in the past. The operation data is result data in the coke oven operation, such as the total flow rate of the fuel gas supplied to the combustion chamber 2, the valve opening degree for supplying the fuel gas to each of the flues 2a, 2b, and a top pressure.

[0034] The first distribution flow rate estimation section 21b estimates the distribution flow rate of each of the fuel and the air to each of the flues 2a, 2b in the combustion chamber 2 based on the operation data acquired by the operation data acquisition section 21a. Specifically, the first distribution flow rate estimation section 21b estimates the distribution flow rate of each of the fuel and the air to each of the flues 2a, 2b from the total flow rate of the fuel gas supplied to the combustion chamber 2, the valve opening degree for supplying the fuel gas to each of the flues 2a, 2b, and the top pressure of the operation data acquired by the operation data acquisition section 21a.

[0035] The flue internal temperature acquisition section 21c acquires a calculation value of temperature in each of the flues 2a, 2b from the distribution flow rate of each of the fuel and the air to each of the flues 2a, 2b in the combustion chamber 2 estimated by the first distribution rate estimation section 21b and the relationship between temperature data in each of the flues 2a, 2b and the distribution flow rate of each of the fuel and the air in each of the flues 2a, 2b in the combustion chamber 2 stored in a fuel/air flow rate database 23. The fuel/air flow rate database 23 stores the relationship between the temperature data in each of the flues 2a, 2b and the distribution flow rate of each of the fuel and the air in each of flues 2a, 2b in the combustion chamber 2 obtained by carrying out a large number of combustion simulations according to the fuel amount, the air amount, the operation rate, and the like.

[0036] The second distribution flow rate estimation section 21d estimates the actual distribution flow rate of each of the fuel and the air in each of the flues 2a, 2b from temperature data in each of the flues 2a, 2b obtained by the measurement in each of the flues 2a, 2b in the combustion chamber 2 and the relationship between the temperature data in each of the flues 2a, 2b and the distribution flow rate of each of the fuel and the air in each of the flues 2a, 2b stored in the fuel/air flow rate database 23. The measured temperature data in each of the flues 2a, 2b is specifically data of a temperature distribution of the oven bottom of each of the flues 2a, 2b in the combustion chamber 2.

[0037] The air flow rate shortage calculation section 21e calculates the air flow rate shortage for each of the flues 2a, 2b in the combustion chamber 2 relative to the air ratio of the design value from the distribution flow rate of each of the fuel and the air to each of the flues 2a, 2b in the combustion chamber 2 estimated by the first distribution flow rate estimation section 21b and the actual distribution flow rate of each of the fuel and the air in each of the flues 2a, 2b estimated by the second distribution flow rate estimation section 21d. Herein, the air ratio of the design value is specifically set to about 1.2.

[0038] Further, the output section 21f outputs, to the air blowing device 20, the results of the calculation by the air flow rate shortage calculation section 21e, i.e., data of the air flow rate shortage for each of the flues 2a, 2b in the combustion chamber 2 calculated by the air flow rate shortage calculation section 21e.

[0039] When there are the flues 2a, 2b having the air flow rate shortage calculated by the air supply amount calculation device 21 larger than the predetermined threshold α as described above, the air blowing device 20 supplies air in an amount corresponding to the air flow rate shortage to the flues 2a, 2b having the large air flow rate shortage.

[0040] As described above, the coke oven A in this embodiment includes the air blowing device 20 connected, in an operation with one fuel supply system (M gas supply system) and the air supply system (including the supply path 2c) in the combustion chamber 2, to the other fuel supply system (C gas supply system) to supply air to each of the flues, 2a 2b by diverting the other fuel supply system (C gas supply system), and the air supply amount calculation device 21 calculating the air flow rate shortage for each of the flues 2a, 2b based on the measured temperature in each of the flues 2a, 2b in the combustion chamber 2. When there are the flues 2a, 2b having the air flow rate shortage calculated by the air supply amount calculation device 21 larger than the predetermined threshold α, the air blowing device 20 supplies air in an amount corresponding to the air flow rate shortage to the flues 2a, 2b having the air flow rate shortage larger than the predetermined threshold α.

[0041] Thus, the supply of air in an amount corresponding to the air flow rate shortage to the flues 2a, 2b with a reduced combustion temperature in the combustion chamber 2 increases the internal temperature of the flues 2a, 2b, uniformizing the temperature distribution in the oven-length direction in the combustion chamber 2, and the supply of air in an appropriate supply amount to the flues 2a, 2b with a reduced combustion temperature in the combustion chamber 2 enables the regulation of the temperature distribution in the oven-length direction in the combustion chamber 2.

[0042] According to the coke oven A in this embodiment, the air supply amount calculation device 21 includes the operation data acquisition section 21a acquiring the operation data of the combustion chamber 2 stored in the operation result database 22, and the first distribution flow rate estimation section 21b estimating the distribution flow rate of each of the fuel and the air to each of the flues 2a, 2b based on the operation data acquired by the operation data acquisition section 21a. Further, the coke oven A in this embodiment includes the second distribution flow rate estimation section 21d estimating the actual distribution flow rate of each of the fuel and the air in each of the flues 2a, 2b from the temperature data in each of the flues 2a, 2b obtained by the measurement in each of the flues 2a, 2b and the relationship between the temperature data in each of the flues 2a, 2b and the distribution flow rate of each of the fuel and the air in each of the flues 2a, 2b stored in the fuel/air flow rate database 23, and the air flow rate shortage calculation section 21e calculating the air flow rate shortage for each of the flues 2a, 2b relative to the air ratio of the design value from the distribution flow rate of each of the fuel and the air to each of the flues 2a, 2b estimated by the first distribution flow rate estimation section 21b and the actual distribution flow rate of each of the fuel and the air in each of the flues 2a, 2b estimated by the second distribution flow rate estimation section 21d.

[0043] This enables the calculation of the air flow rate shortage for each of the flues 2a, 2b in the combustion chamber 2 from the distribution flow rate of each of the fuel and the air to each of the flues 2a, 2b estimated based on the operation data of the coke oven operation in the past and the actual distribution flow rate of each of the fuel and the air in each of the flues 2a, 2b estimated from the temperature data in each of the flues 2a, 2b obtained by the measurement in each of the flues 2a, 2b.

[0044] When the different combustion chambers 2 in the longitudinal direction of coke oven battery are compared with each other, the same flues 2a, 2b are prone to deterioration in the case of the same coke oven battery. The design is such that, in the combustion chambers 2 adjacent to each other in the longitudinal direction of coke oven battery, odd and even numbers of the gas blowing flues 2a, 2b and the exhausting flues 2a, 2b are different from each other, and the gas blowing flues 2a, 2b and the exhausting flues 2a, 2b alternate every predetermined time interval. In view of this feature, the air blowing device 20, solenoid valves M1, M2, ..., M32, M33, and pipes P1, P2, ..., P32, P33 are preferably designed as follows as illustrated in FIG. 15.

[0045] As illustrated in FIG. 15, flues N1 in the combustion chambers i, iii v along the longitudinal direction of coke oven battery are connected to the air blowing device 20 by a pipe P1 in which a solenoid valve M1 is installed. The flues N1 of the combustion chambers ii, iv are connected to the air blowing device 20 by a pipe P2 in which a solenoid valve M2 is installed. Flues N2 of the combustion chambers i, iii, v along the longitudinal direction of coke oven battery are connected to the air blowing device 20 by the pipe P2 in which the solenoid valve M2 is installed. The flues N2 of the combustion chambers ii, iv are connected to the air blowing device 20 by a pipe P3 in which a solenoid valve M3 is installed. Repeating this in a similar configuration, flues N32 of the combustion chambers i, iii, v along the longitudinal direction of coke oven battery are connected to the air blowing device 20 by a pipe P32 in which a solenoid valve M32 is installed. The flues N32 of the combustion chambers ii, iv are connected to the air blowing device 20 by a pipe P33 in which a solenoid valve M33 is installed.

[0046] When the fuel and the air are blown from the flues N1, N3, N5, ..., N31 in the combustion chambers i, iii, v, the fuel and the air are blown from the flues N2, N4, ..., N32 in the combustion chambers ii, iv. In this case, the solenoid valves M1, M3, ..., M33 are opened and the solenoid valves M2, M4, ..., M32 are closed.

[0047] On the other hand, when the fuel and the air are blown from the flues N1, N3, N5, ..., N31 in the combustion chambers ii, iv, the fuel and the air are blown from the flues N2, N4, ..., N32 in the combustion chambers i, iii, v. In this case, the solenoid valves M2, M4, ..., M32 are opened and the solenoid valves M1, M3, ..., M33 are closed.

[0048] The solenoid valves marked with an X mark in FIG. 15 may be manual valves or automatic valves.

[0049] FIG. 15 illustrates the five combustion chambers i to v along the longitudinal direction of coke oven battery, and the description thereof is given above, but the number of the combustion chambers along the longitudinal direction of coke oven battery is not limited to five.

[0050] Next, a method for regulating the temperature distribution in the oven-length direction of the combustion chamber 2 is described with reference to FIGS. 9 to 11.

[0051] FIG. 9 illustrates the process flow in regulating the temperature distribution in the oven-length direction of the combustion chamber 2. To regulate the temperature distribution in the oven-length direction of the combustion chamber 2, first, in Step S1, the air supply amount calculation device 21 calculates the air flow rate shortage for each of the flues 2a, 2b based on the measured temperature in each of the flues 2a, 2b in the combustion chamber 2 (air supply amount calculation step) .

[0052] The details of the air supply amount calculation step are described with reference to FIG. 10. In the air supply amount calculation step, first, in Step S11, the operation data acquisition section 21a of the air supply amount calculation device 21 acquires the operation data stored in the operation result database 22 (operation data acquisition step). The operation data is the result data in the coke oven operation, such as the total flow rate of the fuel gas supplied to the combustion chamber 2, the valve opening degree for supplying the fuel gas to each of the flues 2a, 2b, and the top pressure.

[0053] Next, in Step S12, the first distribution flow rate estimation section 21b of the air supply amount calculation device 21 estimates the distribution flow rate of each of the fuel and the air to each of the flues 2a, 2b in the combustion chamber 2 based on the operation data acquired in Step S11 (operation data acquisition step) (first distribution flow rate estimation step). Specifically, the first distribution flow rate estimation section 21b estimates the distribution flow rate of each of the fuel and the air to each of the flues 2a, 2b from the total flow rate of the fuel gas supplied to the combustion chamber 2, the valve opening degree for supplying the fuel gas to each of the flues 2a, 2b, and the top pressure of the operation data acquired in Step S11 (operation data acquisition step).

[0054] Next, in Step S13, the flue internal temperature acquisition section 21c of the air supply amount calculation device 21 acquires a calculation value of the temperature in each of the flues 2a, 2b from the distribution flow rate of each of the fuel and the air to each of the flues 2a, 2b in the combustion chamber 2 estimated in Step S12 (first distribution rate estimation step) and the relationship between the temperature data in each of the flues 2a, 2b and the distribution flow rate of each of the fuel and the air in each of the flues 2a, 2b in the combustion chamber 2 stored in the fuel/air flow rate database 23 (temperature calculation value acquisition step). The fuel/air flow rate database 23 stores the relationship between the temperature data in each of the flues 2a, 2b and the distribution flow rate of each of the fuel and the air in each of flues 2a, 2b in the combustion chamber 2 obtained by carrying out a large number of combustion simulations according to the fuel amount, the air amount, the operation rate, and the like.

[0055] Next, in Step S14, the second distribution flow rate estimation section 21d of the air supply amount calculation device 21 estimates the actual distribution flow rate of each of the fuel and the air in each of the flues 2a, 2b from the temperature data in each of the flues 2a, 2b obtained by the measurement in each of the flues 2a, 2b in the combustion chamber 2 and the relationship between the temperature data in each of the flues 2a, 2b and the distribution flow rate of each of the fuel and the air in each of the flues 2a, 2b stored in the fuel/air flow rate database 23 (second distribution rate estimation step). The measured temperature data in each of the flues 2a, 2b is specifically data of a temperature distribution of the oven bottom of each of the flues 2a, 2b in the combustion chamber 2.

[0056] Next, in Step S15, the air flow rate shortage calculation section 21e of the air supply amount calculation device 21 calculates the air flow rate shortage for each of the flues 2a, 2b in the combustion chamber 2 relative to the air ratio of the design value from the distribution flow rate of each of the fuel and the air to each of the flues 2a, 2b in the combustion chamber 2 estimated in Step S12 (first distribution flow rate estimation step) and the actual distribution flow rate of each of the fuel and the air in each of the flues 2a, 2b estimated in Step S14 (second distribution flow rate estimation step) (air flow rate shortage calculation step). Herein, the air ratio of the design value is specifically set to about 1.2.

[0057] In the air flow rate shortage calculation step, finally, in Step S16, the output section 21f of the air supply amount calculation device 21 outputs, to the air blowing device 20, the data of the air flow rate shortage for each of the flues 2a, 2b in the combustion chamber 2 calculated in Step S15 (air flow rate shortage calculation step).

[0058] After the completion of the air flow rate shortage calculation step, when there are the flues 2a, 2b having the air flow rate shortage calculated in Step S1 (air supply amount calculation step) larger than the predetermined threshold α as described above, air in an amount corresponding to the air flow rate shortage is supplied from the air blowing device 20 to the flues 2a, 2b having the air flow rate shortage larger than the predetermined threshold α, regulating the temperature distribution in the oven-length direction of the combustion chamber 2 in Step S2 as illustrated in FIG. 9 (air blowing step).

[0059] The details of the air blowing step are described with reference to FIG. 11. In the air blowing step, first, in Step S21, the air-blowing control section 20a of the air blowing device 20 acquires the data of the air flow rate shortage for each of the flues 2a, 2b in the combustion chamber 2 calculated in Step S1 (air supply amount calculation step).

[0060] Next, in Step S22, the air-blowing control section 20a of the air blowing device 20 determines whether there are the flues 2a, 2b having the air flow rate shortage for each of the flues 2a, 2b in the combustion chamber 2 larger than the predetermined threshold α (determination step) .

[0061] Herein, the "predetermined threshold α" is set based on the air ratio. For example, when the air ratio is 0.8 or less, air in an amount corresponding to the shortage is blown. For example, when the dry distillation heat quantity is set to 600 Mcal/t, the coal supply amount per one time to one combustion chamber is set to 30 t, the theoretical air amount (volume ratio) required for the complete combustion of the M gas is set to 1, the heat quantity of the M gas is set to 1.200 [Mcal/Nm^3], the air ratio of the design value of the coke oven is set to 1.2, a time required for one dry distillation is set to 17.5 hours, and the number of the flues on the fuel gas blowing side in one combustion chamber is set to 16 (= 32/2), the air amount per flue is 64 Nm^3/h, because Air blowing amount into one flue = Dry distillation heat quantity $\times$ Coal supply amount per one time into one combustion chamber/Heat quantity of M gas $\times$ Theoretical heat quantity $\times$ Air ratio of design value of coke oven/Time required for one dry distillation/Number of flues on fuel gas blowing side in one combustion chamber is established.

[0062] When there are the flues determined to have the air ratio of 0.75 in this example, air in an amount corresponding to Air-ratio blowing gas amount = Air blowing amount into one flue $\times$ (Air ratio of design value - Actual air ratio)/ Air ratio of design value $\approx$ 38.5 Nm^3/h is blown into the flues 2a, 2b determined to have a low air ratio (flues 2a, 2b determined to have the air flow rate shortage larger than the predetermined threshold α).

[0063] When the determination result of Step S22 (determination step) is YES (when there are such flues 2a, 2b), the process shifts to Step S23. When the determination result is NO (where there are no such flues 2a, 2b), Step S2 (air blowing step) is ended.

[0064] In Step S23, the air-blowing control section 20a of the air blowing device 20 issues a command to supply air in an amount corresponding to the air flow rate shortage to the air blowing section 20b supplying air to the flues 2a, 2b having the air flow rate shortage larger than the predetermined threshold α. The air blowing section 20b supplies air in an amount corresponding to the air flow rate shortage to the flues 2a, 2b having the air flow rate shortage larger than the predetermined threshold α according to the command, and regulates the temperature distribution in the oven-length direction of the combustion chamber 2 (air supply step).

[0065] As described above, the method for regulating the temperature distribution in the coke oven in this embodiment includes the air supply amount calculation step (Step S1) of calculating the air flow rate shortage for each of the flues 2a, 2b based on the measured temperature in the flues 2a, 2b in the combustion chamber 2 by the air supply amount calculation device 21, and the air blowing step (Step S2) of, when there are the flues 2a, 2b having the air flow rate shortage calculated in the air supply amount calculation step larger than the predetermined threshold α, supplying air in an amount corresponding to the air flow rate shortage to the flues 2a, 2b having the air flow rate shortage larger than the predetermined threshold α from the air blowing device 20 connected, in the operation with the one fuel supply system (M gas supply system) of the fuel supply systems and the air supply system in the combustion chamber 2, to the other fuel supply system (C gas supply system) to supply air to each of the flues, 2a 2b by diverting the other fuel supply system (C gas supply system), regulating the temperature distribution in the oven-length direction of the combustion chamber 2.

[0066] Thus, the supply of air in an amount corresponding to the air flow rate shortage to the flues 2a, 2b with a reduced combustion temperature in the combustion chamber 2 increases the internal temperature of the flues 2a, 2b, uniformizing the temperature distribution in the oven-length direction in the combustion chamber 2, and the supply of air in an appropriate supply amount to the flues 2a, 2b with a reduced combustion temperature in the combustion chamber 2 enables the regulation of the temperature distribution in the oven-length direction in the combustion chamber 2.

[0067] According to the method for regulating the temperature distribution in the coke oven in this embodiment, the air supply amount calculation step (Step S1) includes the operation data acquisition step (Step S11) of acquiring the operation data of the combustion chamber 2 stored in the operation result database 22, and the first distribution flow rate estimation step (Step S12) of estimating the distribution flow rate of each of the fuel and the air to each of the flues 2a, 2b based on the operation data acquired in the operation data acquisition step (Step S11). Further, the air supply amount calculation step (Step S1) includes the second distribution flow rate estimation step (Step S14) of estimating the actual distribution flow rate of each of the fuel and the air in each of the flues 2a, 2b from the temperature data in each of the flues 2a, 2b obtained by the measurement in each of the flues 2a, 2b and the relationship between the temperature data in each of the flues 2a, 2b and the distribution flow rate of each of the fuel and the air in each of the flues 2a, 2b stored in the fuel/air flow rate database 23, and the air flow rate shortage calculation step (Step S15) of calculating the air flow rate shortage for each of the flues 2a, 2b relative to the air ratio of the design value from the distribution flow rate of each of the fuel and the air to each of the flues 2a, 2b estimated in the first distribution flow rate estimation step (Step S12) and the actual distribution flow rate of each of the fuel and the air in each of the flues 2a, 2b estimated in the second distribution flow rate estimation step (Step S14).

[0068] This enables the calculation of the air flow rate shortage for each of the flues 2a and 2b in the combustion chamber 2 from the distribution flow rate of each of the fuel and the air to each of the flues 2a, 2b estimated based on the operation data of the coke oven operation in the past and the actual distribution flow rate of each of the fuel and the air in each of the flues 2a, 2b estimated from the temperature data in each of the flues 2a, 2b obtained by the measurement in each of the flues 2a, 2b.

[0069] Then, the coke oven A is operated by regulating the temperature distribution in the oven-length direction of the combustion chamber 2 by the method for regulating the temperature distribution in the coke oven. Coke is produced by operating the coke oven A as described above. In the operation of the coke oven A and the production of coke, the supply of air in an amount corresponding to the air flow rate shortage to the flues 2a, 2b in the combustion chamber 2 with a reduced combustion temperature increases the internal temperature of such flues 2a, 2b, uniformizing the temperature distribution in the oven-length direction in the combustion chamber 2, and thus the temperature regulation in the oven-length direction in the combustion chamber 2 is achieved and excellent coke can be produced.

[0070] The embodiments of the present invention are described above, but the present invention is not limited thereto and can be variously modified and improved.

[0071] For example, in this embodiment, the air blowing device 20 (air blowing step: Step S2) regulates the temperature distribution in the oven-length direction of the combustion chamber 2 by supplying, when there are the flues 2a, 2b having the air flow rate shortage calculated by the air supply amount calculation device 21 (air supply amount calculation step: Step S1) larger than the predetermined threshold α, air in an amount corresponding to the air flow rate shortage to the flues 2a, 2b having the air flow rate shortage larger than the predetermined threshold α from the air blowing device 20. However, the air blowing device 20 (air blowing step: Step S2) may omit the determination (determination step: Step S22) by the air-blowing control section 20a whether there are the flues 2a, 2b having the air flow rate shortage larger than the predetermined threshold α for each of the flues 2a, 2b in the combustion chamber 2, and may regulate the temperature distribution in the oven-length direction of the combustion chamber 2 by supplying air in an amount corresponding to the air flow rate shortage calculated by the air supply amount calculation device 21 (air supply amount calculation step: Step S1) to the flues 2a, 2b which are short of the air flow rate, irrespective of the threshold value α.

[0072] Thus, the supply of air in an amount corresponding to the air flow rate shortage to the flues 2a, 2b with a reduced combustion temperature in the combustion chamber 2 increases the internal temperature of the flues 2a, 2b, uniformizing the temperature distribution in the oven-length direction in the combustion chamber 2, and the supply of air in an appropriate supply amount to the flues 2a, 2b with a reduced combustion temperature in the combustion chamber 2 enables the regulation of the temperature distribution in the oven-length direction in the combustion chamber 2.

[0073] Although the 16 sets of the 32 flues 2a, 2b are provided in the combustion chamber 2, two or more of the sets of the two flues 2a, 2b may be provided, and the number is not limited to the 16 sets of the 32 flues 2a, 2b.

[0074] The air blowing device 20 is connected to the vertical pipes 6 of the C gas supply system allowed to communicate with all of the 16 sets of 32 flues 2a, 2b in the combustion chamber 2 but are not necessarily connected to the vertical pipes 6 of the C gas supply system allowed to communicate with all of the 16 sets of 32 flues 2a, 2b in the combustion chamber 2 and may be connected to the vertical pipes 6 of the C gas supply system allowed to communicate with the flues 2a, 2b in the number equal to or less than 15 sets of 30 flues 2a, 2b in the combustion chamber 2.

[0075] Although the air supply amount calculation device 21 and the air blowing device 20 are connected, but a configuration may be acceptable in which the air supply amount calculation device 21 and the air blowing device 20 are disconnected, the calculation results of the air supply amount calculation device 21 are displayed on a display device (not illustrated), a worker enters the calculation results displayed on the display device into the air blowing device 20, and air in an amount corresponding to the air flow rate shortage is blown into the flues 2a, 2b having the air flow rate shortage larger than the predetermined threshold α or air in an amount corresponding to the air flow rate shortage is supplied to the flues 2a, 2b which are short of the air flow rate.

[0076] Although the supply amount calculation section 21 includes the flue internal temperature acquisition section 21c, the flue internal temperature acquisition section 21c may be omitted and Step S13 (temperature calculation value acquisition step) may be omitted.

EXAMPLES

[0077] To verify the effects of the present invention, air in an amount corresponding to the air flow rate shortage was supplied to the flues 2a, 2b in the center in the oven-length direction where a temperature reduction was noticeable in the combustion chamber 2 as in the temperature distribution in FIG. 12 from the vertical pipes 6 of the C gas supply system in the operation with the M gas combustion. At this time, the air flow rate shortage was calculated by the air supply amount calculation device 21 according to the air supply amount calculation step illustrated in FIG. 10, and air in an amount corresponding to the calculated air flow rate shortage was blown from the air blowing device 20.

[0078] FIG. 13 illustrates the relationship between the oven wall temperature estimated from the measured temperature in the flues 2a, 2b in the center in the oven-length direction in the combustion chamber 2 having the temperature distribution illustrated in FIG. 12 and the oven wall temperature estimated from the temperature of the calculation value in the flues 2a, 2b in the center in the oven-length direction (oven wall temperature estimated from the temperature of the calculation value in the flues 2a, 2b in the center in the oven-length direction acquired in Step S13). In the flues 2a, 2b in the center in the oven-length direction, the oven wall temperature estimated from the measured temperature is about 50°C lower than the oven wall temperature estimated from the temperature of the calculation value.

[0079] In the air supply amount calculation step, the air flow rate shortage for each of the flues 2a, 2b was calculated relative to the air ratio of the design value (1.2) in Step S15. The results were such that the flues 2a, 2b in the center in the oven-length direction had the air flow rate shortage relative to the air ratio of 1.2 was 40 Nm^3/h for and the air ratio of 0.7. In the air blowing device 20, the air ratio of 0.7 was lower than the predetermined threshold (air ratio of 0.8), and therefore air in an amount corresponding to the air flow rate shortage of 40 Nm^3/h was blown from the air blowing device 20 to the flues 2a, 2b in the center in the oven-length direction via the vertical pipe 6 of the C gas supply system in combustion. As a result, it was able to be confirmed that the temperature increased by about 40°C when the air was blown, and the CO indicating incomplete combustion, which had been confirmed before the air was blown, decreased to almost zero, and the air shortage was eliminated as illustrated in FIG. 14.

Reference Signs List

[0080]

1	carbonization chamber
2	combustion chamber
2a, 2b	flue
2c	supply path
2d	blowoff port
3	regenerator
4	sole flue
5	nozzle plate
6	vertical pipe
7	branch pipe
8	distribution pipe
9	chip
10	blind chip
20	air blowing device
20a	air-blowing control section
20b	air blowing section
21	air supply amount calculation device
21a	operation data acquisition section
21b	first distribution flow rate estimation section
21c	flue internal temperature acquisition section
21d	second distribution flow rate estimation section
21e	air flow rate shortage calculation section
21f	output section
22	operation result database
23	fuel/air flow rate database

Claims

1. A coke oven with a combustion chamber having a plurality of sets of two flues, two fuel supply systems capable of supplying fuel gas to each of the flues of the combustion chamber, and an air supply system capable of supplying air to each of the flues of the combustion chamber in an oven-length direction, comprising:

   an air blowing device connected, in an operation with one fuel supply system of the two fuel supply systems and the air supply system in the combustion chamber, to another fuel supply system to supply air to each of the flues by diverting the another fuel supply system; and
   an air supply amount calculation device configured to calculate an air flow rate shortage for each of the flues based on a measured temperature in each of the flues in the combustion chamber, wherein
   the air blowing device supplies air in an amount corresponding to the air flow rate shortage calculated by the air supply amount calculation device to the flues having the air flow rate shortage.

2. The coke oven according to claim 1, wherein the air blowing device is configured to supply, when there are the flues having the air flow rate shortage calculated by the air supply amount calculation device larger than a predetermined threshold, air in an amount corresponding to the air flow rate shortage to the flues having the air flow rate shortage larger than the predetermined threshold.

3. The coke oven according to claim 1 or 2, wherein the air supply amount calculation device includes:

   an operation data acquisition section configured to acquire operation data of the combustion chamber stored in an operation result database;
   a first distribution flow rate estimation section configured to estimate a distribution flow rate of each of fuel and air to each of the flues based on the operation data acquired by the operation data acquisition section;
   a second distribution flow rate estimation section configured to estimate an actual distribution flow rate of each of the fuel and the air in each of the flues from temperature data in each of the flues obtained by measurement in each of the flues and a relationship between the temperature data in each of the flues and the distribution flow rate of each of the fuel and the air in each of the flues stored in a fuel/air flow rate database; and
   an air flow rate shortage calculation section configured to calculate the air flow rate shortage for

each of the flues relative to an air ratio of a design value from the distribution flow rate of each of the fuel and the air to each of the flues estimated by the first distribution flow rate estimation section and the actual distribution flow rate of each of the fuel and the air in each of the flues estimated by the second distribution flow rate estimation section.

4. A method for regulating a temperature distribution in a coke oven with a combustion chamber having a plurality of sets of two flues, two fuel supply systems capable of supplying fuel gas to each of the flues of the combustion chamber, and an air supply system capable of supplying air to each of the flues of the combustion chamber in an oven-length direction, comprising:

an air supply amount calculation step of calculating an air flow rate shortage for each of the flues based on a measured temperature in each of the flues in the combustion chamber by an air supply amount calculation device; and
an air blowing step of supplying air in an amount corresponding to the air flow rate shortage calculated in the air supply amount calculation step to the flues having the air flow rate shortage from an air blowing device connected, in an operation with one fuel supply system of the two fuel supply systems and the air supply system in the combustion chamber, to another fuel supply system to supply air to each of the flues by diverting the another fuel supply system, regulating a temperature distribution in the oven-length direction of the combustion chamber.

5. The method for regulating a temperature distribution in a coke oven according to claim 4, wherein, in the air blowing step, when there are the flues having the air flow rate shortage calculated by the air supply amount calculation step larger than a predetermined threshold, air in an amount corresponding to the air flow rate shortage is supplied to the flues having the air flow rate shortage larger than the predetermined threshold from the air blowing device, regulating the temperature distribution in the oven-length direction of the combustion chamber.

6. The method for regulating a temperature distribution in a coke oven according to claim 4 or 5, wherein the air supply amount calculation step includes:

an operation data acquisition step of acquiring operation data of the combustion chamber stored in an operation result database;
a first distribution flow rate estimation step of estimating a distribution flow rate of each of fuel and air to each of the flues based on the operation data acquired in the operation data acquisition step;
a second distribution flow rate estimation step of estimating an actual distribution flow rate of each of the fuel and the air in each of the flues from temperature data in each of the flues obtained by measurement in each of the flues and a relationship between the temperature data in each of the flues and the distribution flow rate of each of the fuel and the air in each of the flues stored in a fuel/air flow rate database; and
an air flow rate shortage calculation step of calculating the air flow rate shortage for each of the flues relative to an air ratio of a design value from the distribution flow rate of each of the fuel and the air to each of the flues estimated in the first distribution flow rate estimation step and the actual distribution flow rate of each of the fuel and the air in each of the flues estimated in the second distribution flow rate estimation step.

7. A method for operating a coke oven comprising:
operating a coke oven by regulating a temperature distribution in an oven-length direction of a combustion chamber by the method for regulating the temperature distribution in a coke oven according to any one of claims 4 to 6.

8. A method for producing coke comprising:
producing coke by operating a coke oven by the method for operating a coke oven according to claim 7.

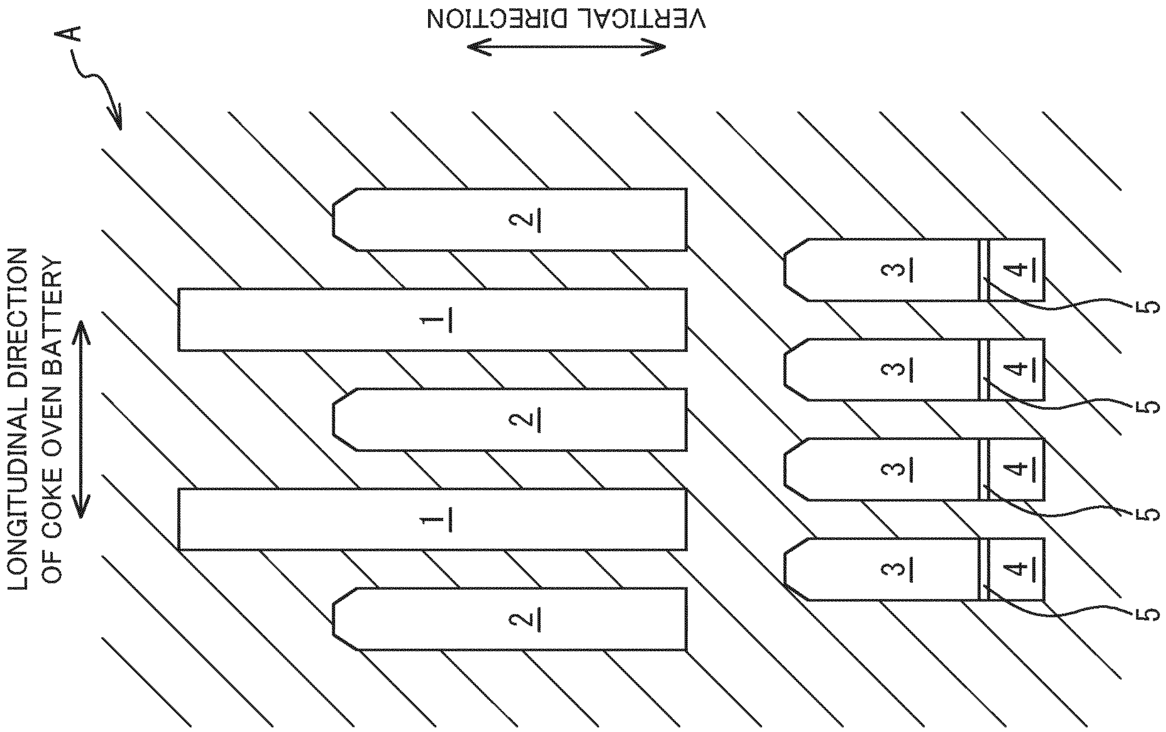

A
VERTICAL DIRECTION
LONGITUDINAL DIRECTION
OF COKE OVEN BATTERY
1
2
3
4
5

FIG. 1B

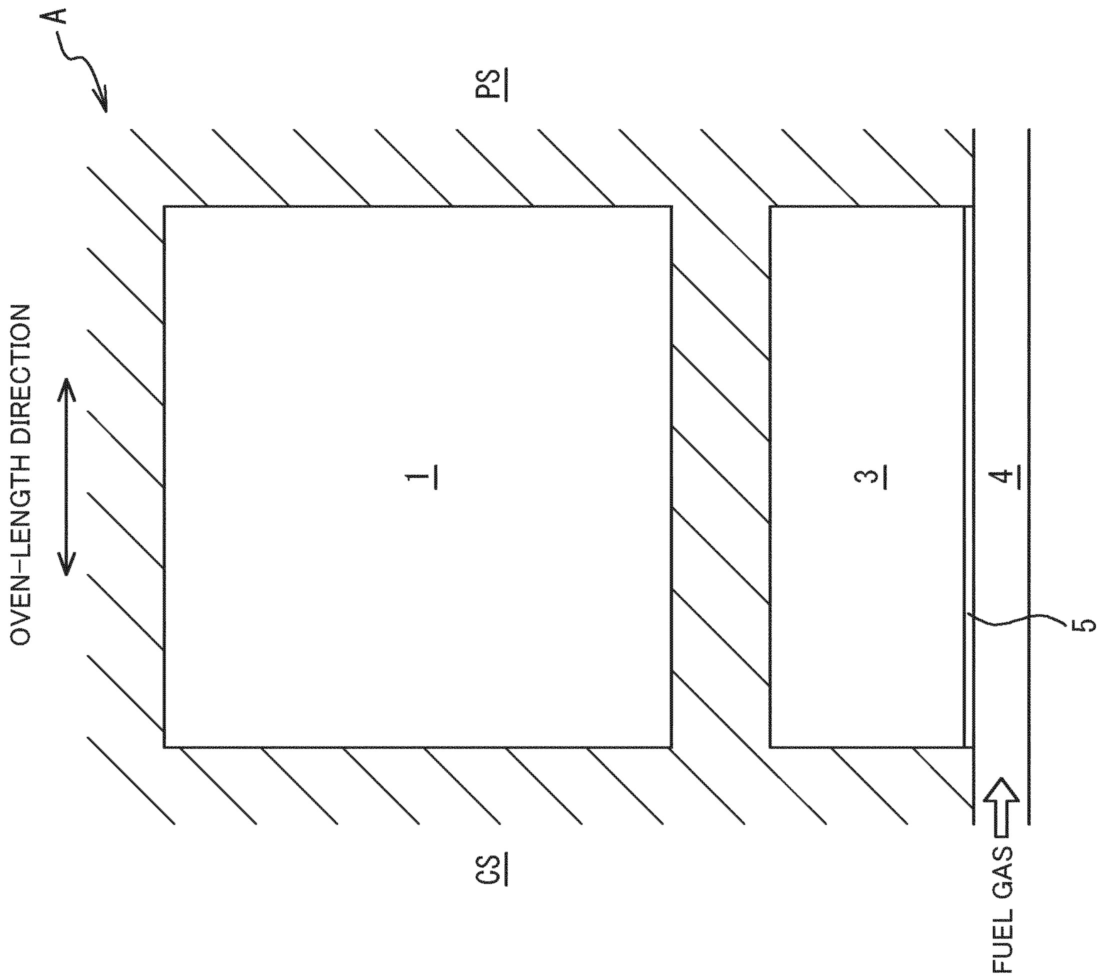

A
PS
OVEN-LENGTH DIRECTION
1
3
4
5
CS
FUEL GAS

FIG. 1A

FIG. 2

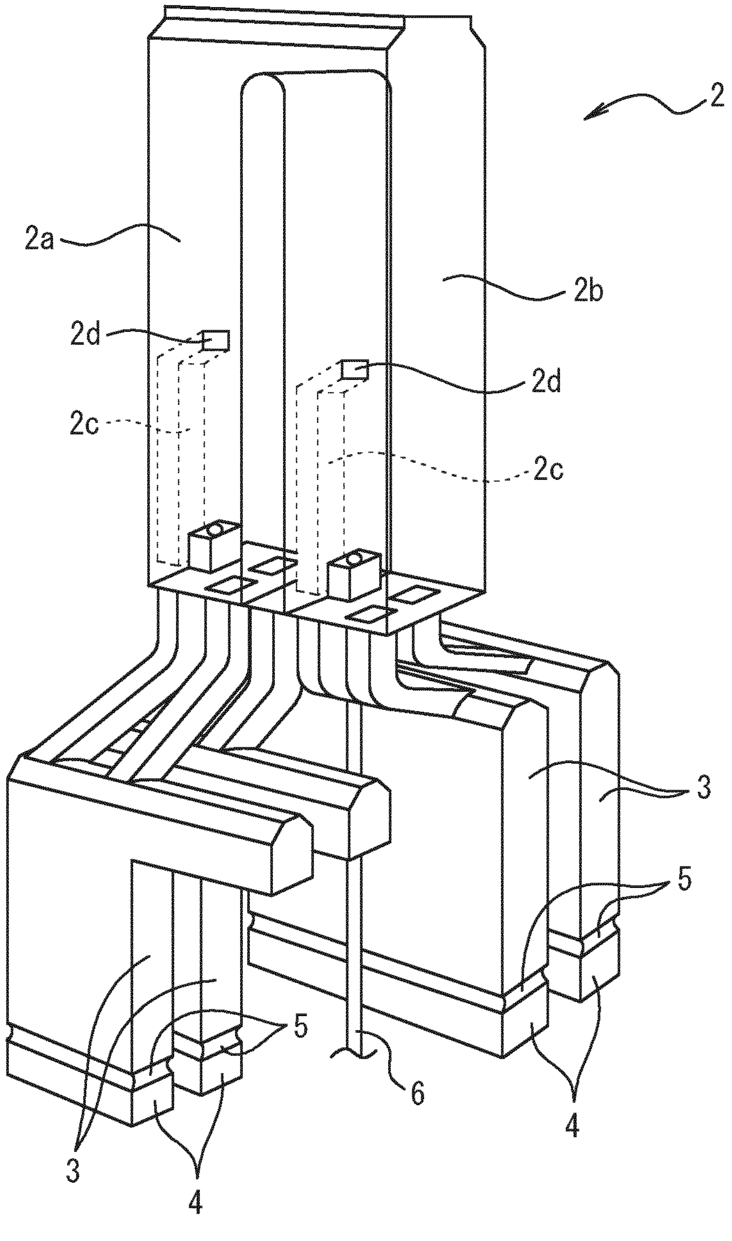


FIG. 3A

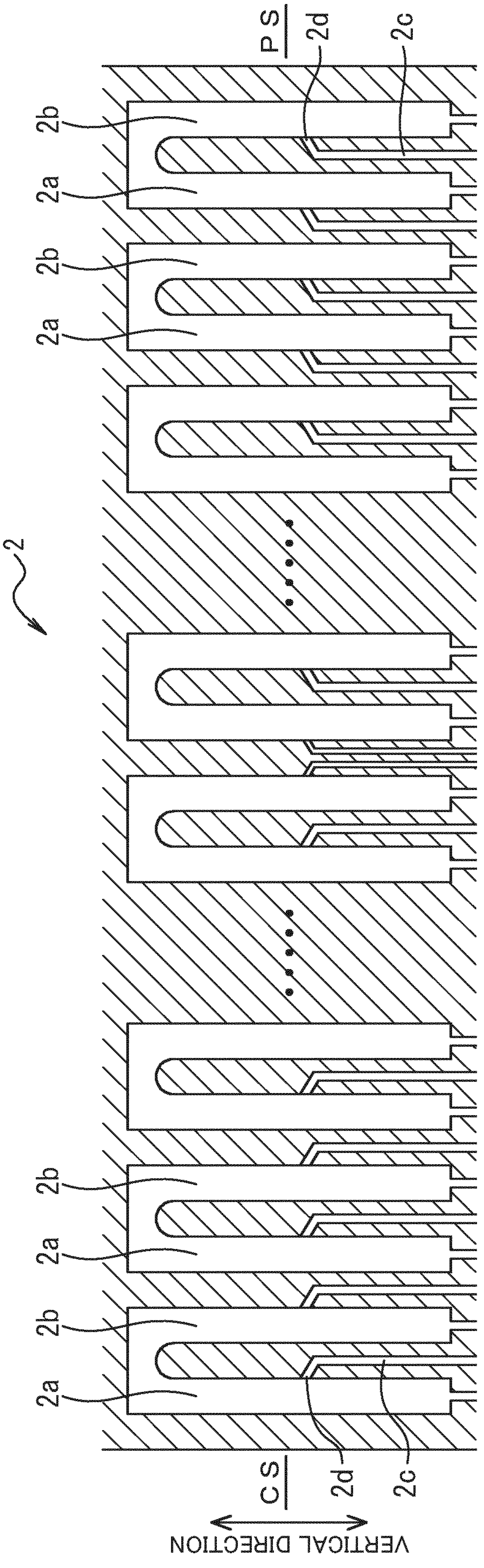

2
PS
CS
2a
2b
2c
2d
VERTICAL DIRECTION

FIG. 3B

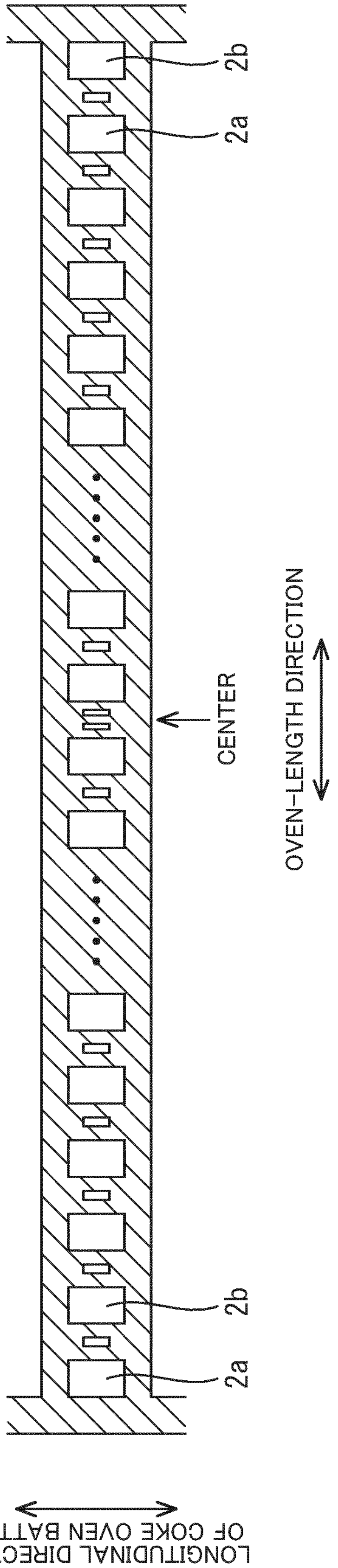

2a
2b
CENTER
OVEN-LENGTH DIRECTION
LONGITUDINAL DIRECTION OF COKE OVEN BATTERY

FIG. 4

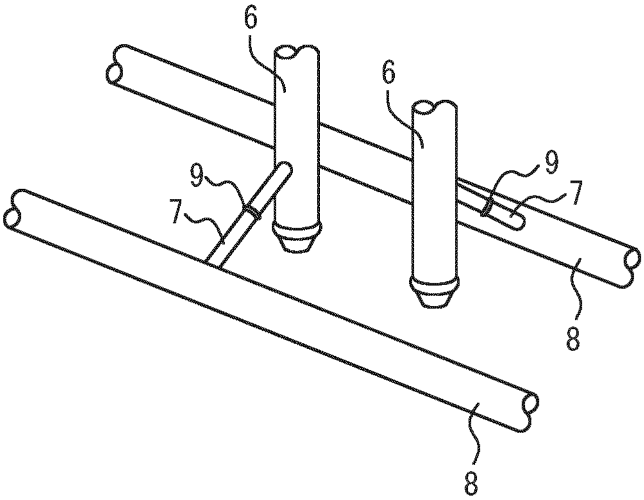


FIG. 5

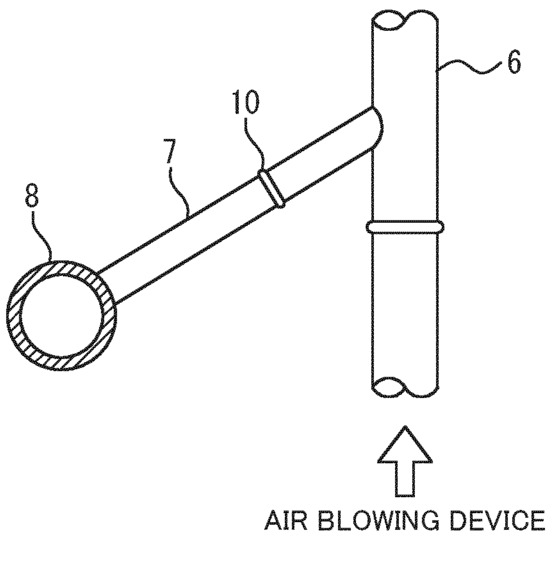


FIG. 6

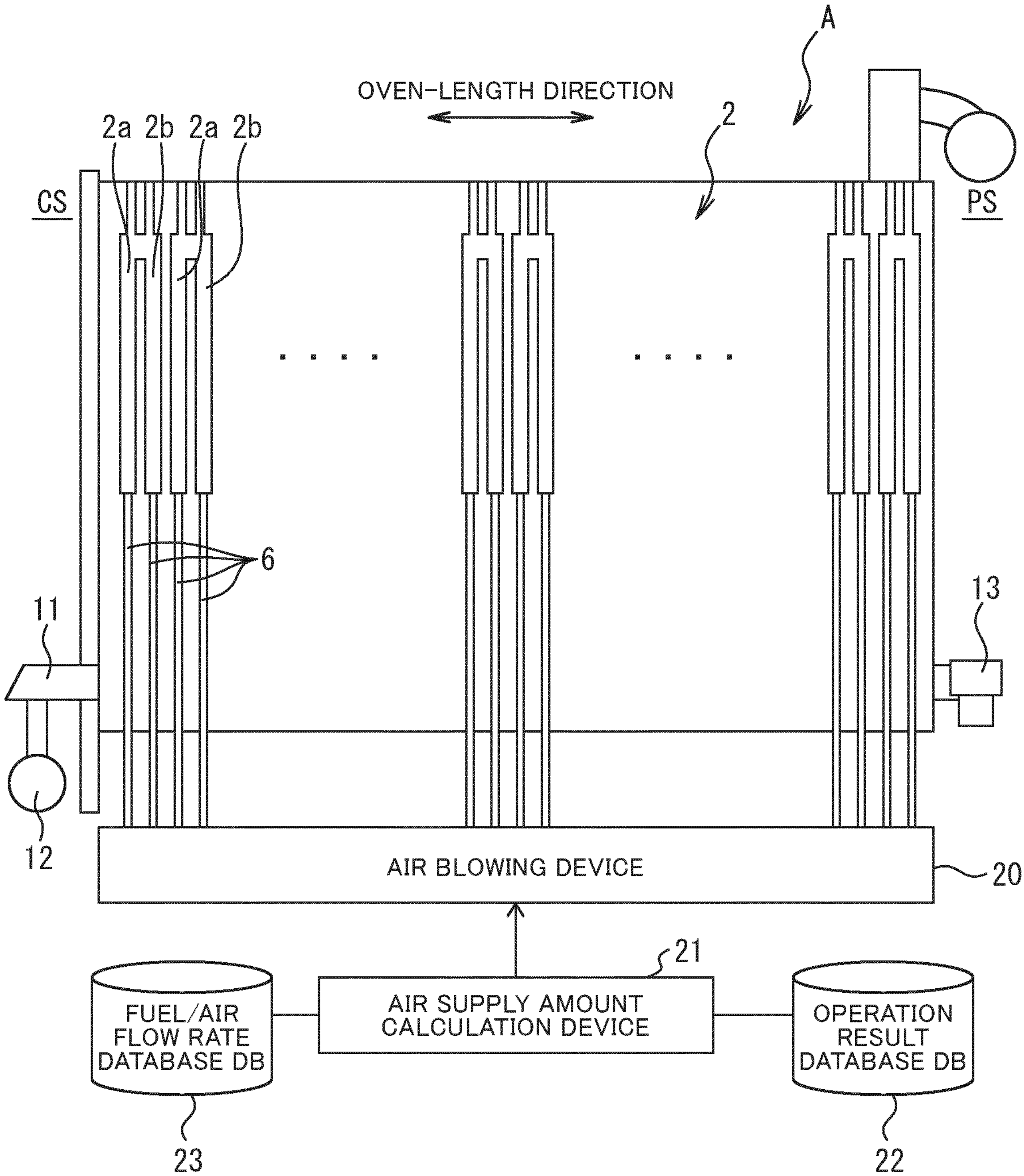

A
OVEN-LENGTH DIRECTION
2
2a 2b 2a 2b
CS
PS
6
11
13
12
AIR BLOWING DEVICE
20
21
AIR SUPPLY AMOUNT CALCULATION DEVICE
FUEL/AIR FLOW RATE DATABASE DB
OPERATION RESULT DATABASE DB
23
22

FIG. 7

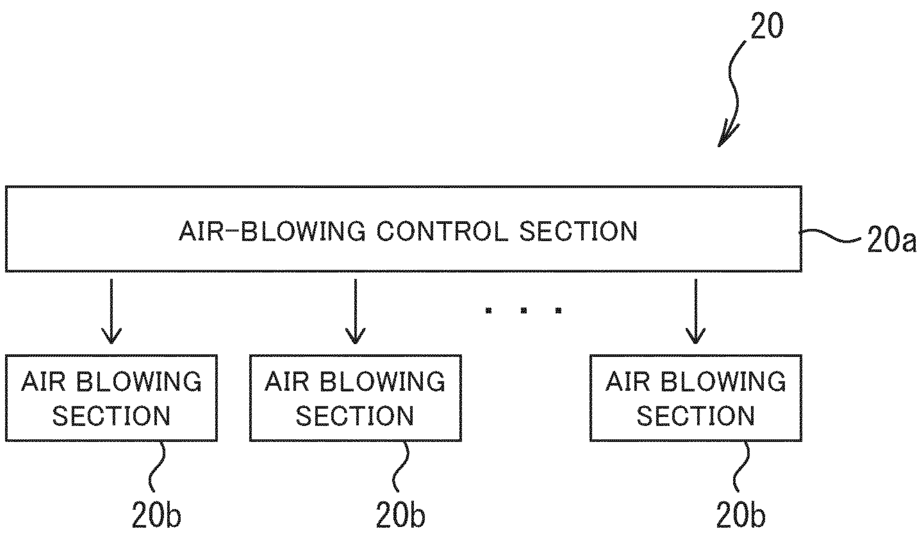

20
AIR-BLOWING CONTROL SECTION
20a
AIR BLOWING SECTION
AIR BLOWING SECTION
AIR BLOWING SECTION
20b
20b
20b

FIG. 8

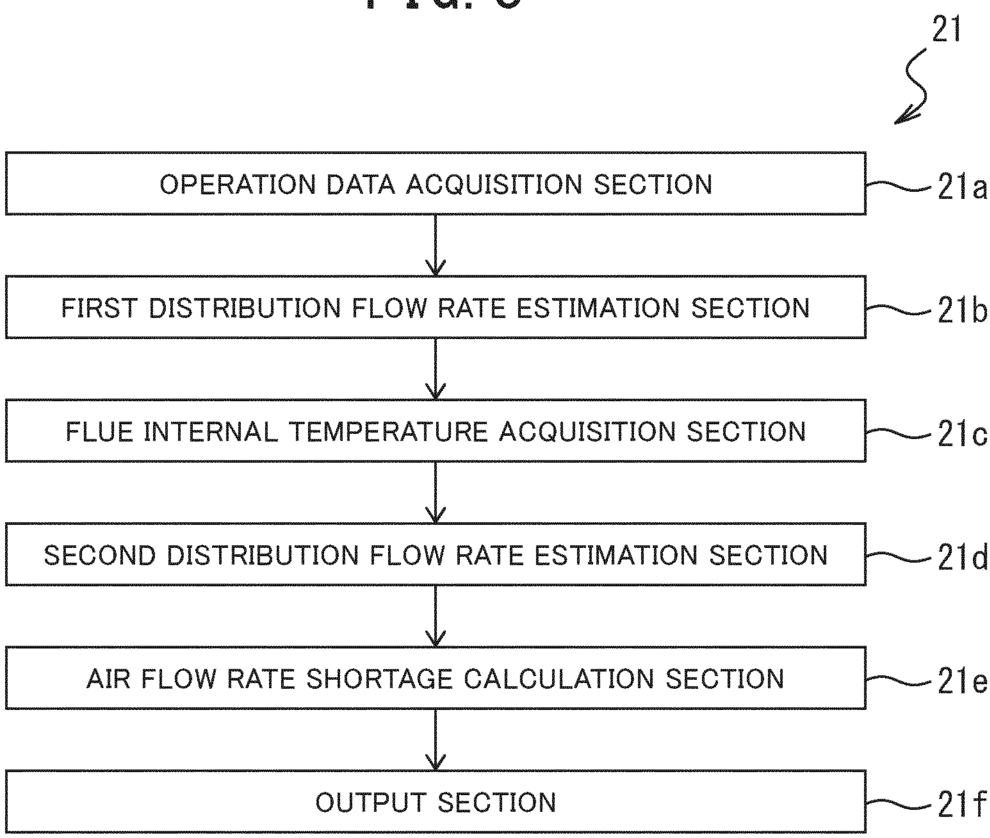

21
OPERATION DATA ACQUISITION SECTION
21a
FIRST DISTRIBUTION FLOW RATE ESTIMATION SECTION
21b
FLUE INTERNAL TEMPERATURE ACQUISITION SECTION
21c
SECOND DISTRIBUTION FLOW RATE ESTIMATION SECTION
21d
AIR FLOW RATE SHORTAGE CALCULATION SECTION
21e
OUTPUT SECTION
21f

FIG. 9

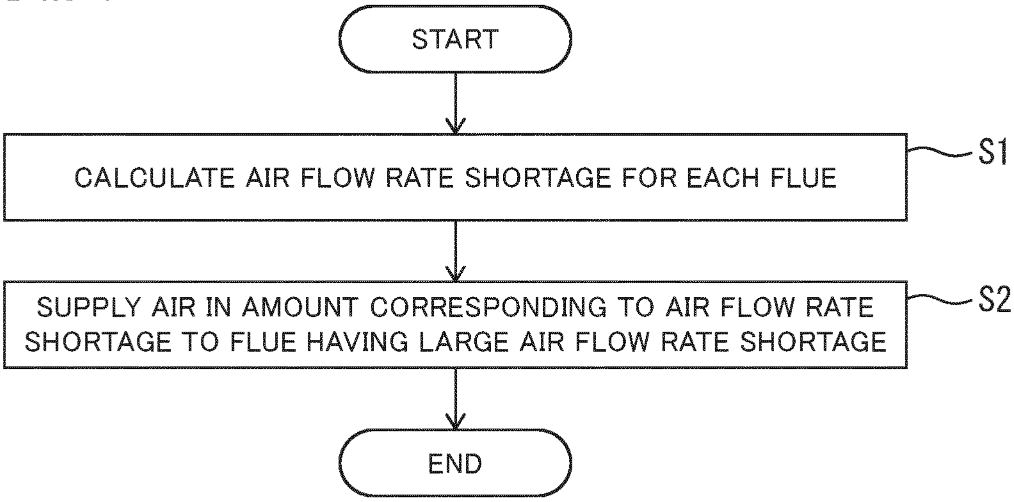

START
CALCULATE AIR FLOW RATE SHORTAGE FOR EACH FLUE
S1
SUPPLY AIR IN AMOUNT CORRESPONDING TO AIR FLOW RATE SHORTAGE TO FLUE HAVING LARGE AIR FLOW RATE SHORTAGE
S2
END

FIG. 10

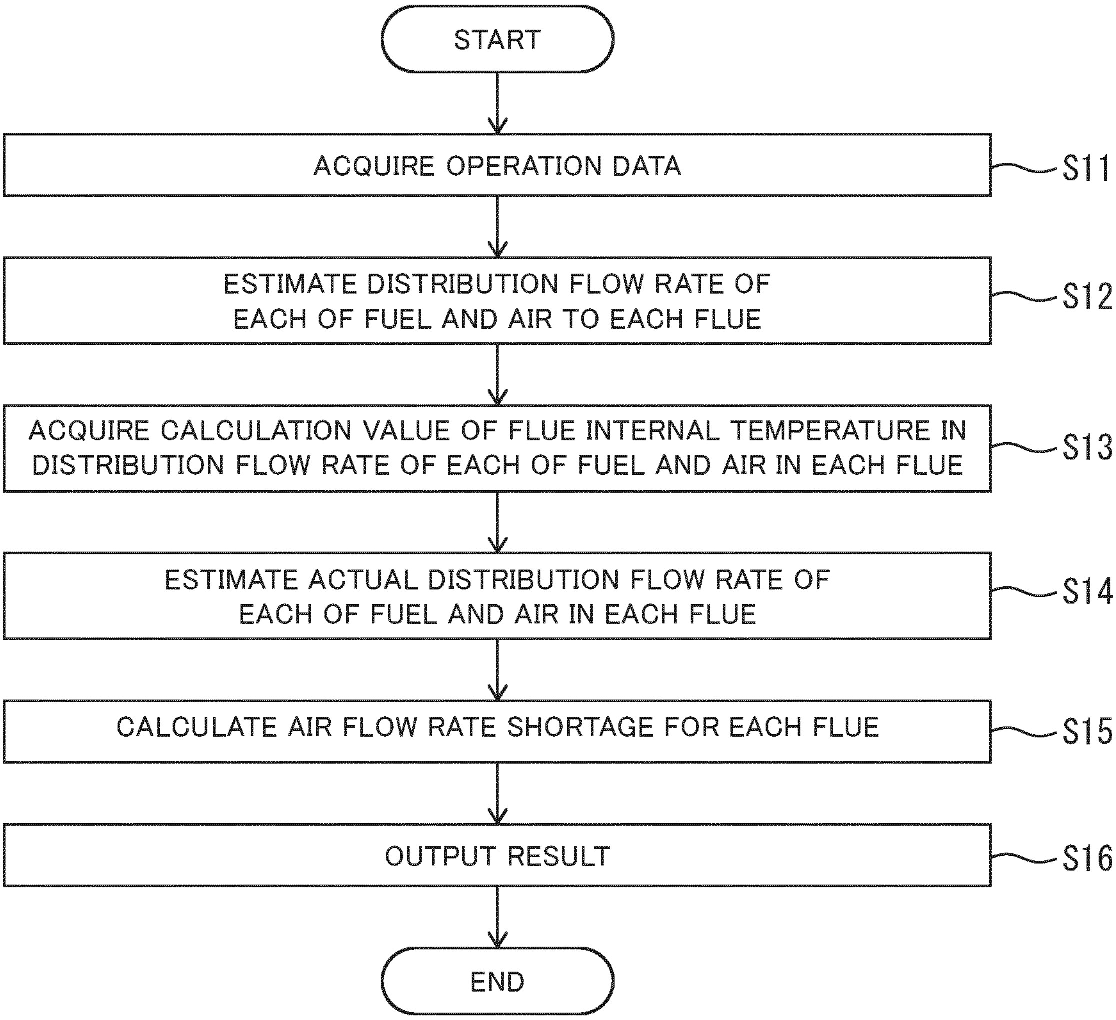

START
ACQUIRE OPERATION DATA
S11
ESTIMATE DISTRIBUTION FLOW RATE OF EACH OF FUEL AND AIR TO EACH FLUE
S12
ACQUIRE CALCULATION VALUE OF FLUE INTERNAL TEMPERATURE IN DISTRIBUTION FLOW RATE OF EACH OF FUEL AND AIR IN EACH FLUE
S13
ESTIMATE ACTUAL DISTRIBUTION FLOW RATE OF EACH OF FUEL AND AIR IN EACH FLUE
S14
CALCULATE AIR FLOW RATE SHORTAGE FOR EACH FLUE
S15
OUTPUT RESULT
S16
END

FIG. 11

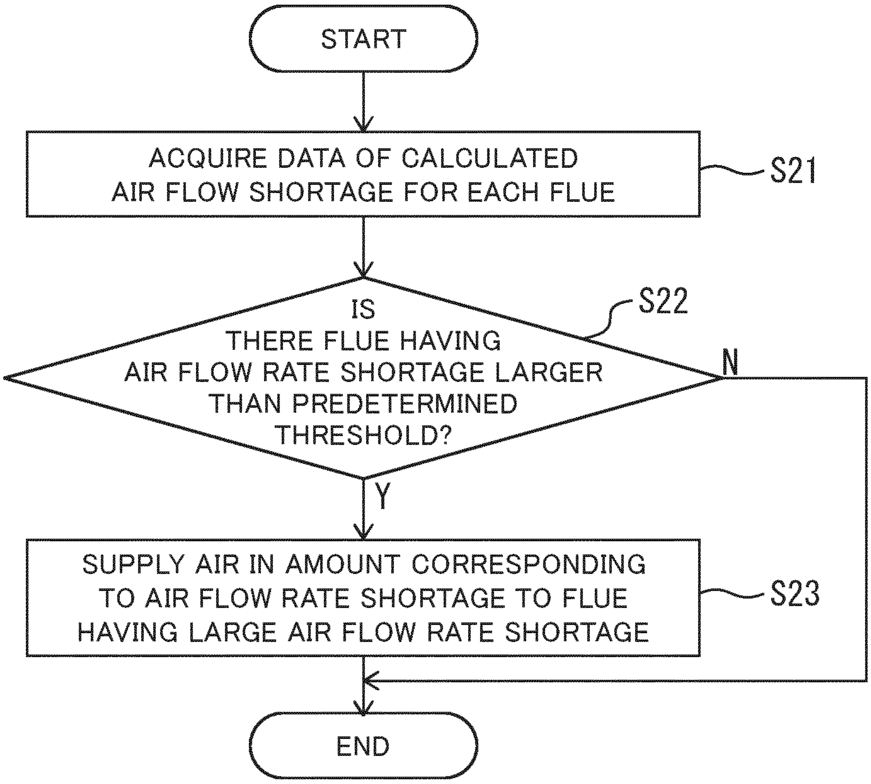

START
ACQUIRE DATA OF CALCULATED AIR FLOW SHORTAGE FOR EACH FLUE
S21
IS THERE FLUE HAVING AIR FLOW RATE SHORTAGE LARGER THAN PREDETERMINED THRESHOLD?
S22
N
Y
SUPPLY AIR IN AMOUNT CORRESPONDING TO AIR FLOW RATE SHORTAGE TO FLUE HAVING LARGE AIR FLOW RATE SHORTAGE
S23
END

FIG. 12

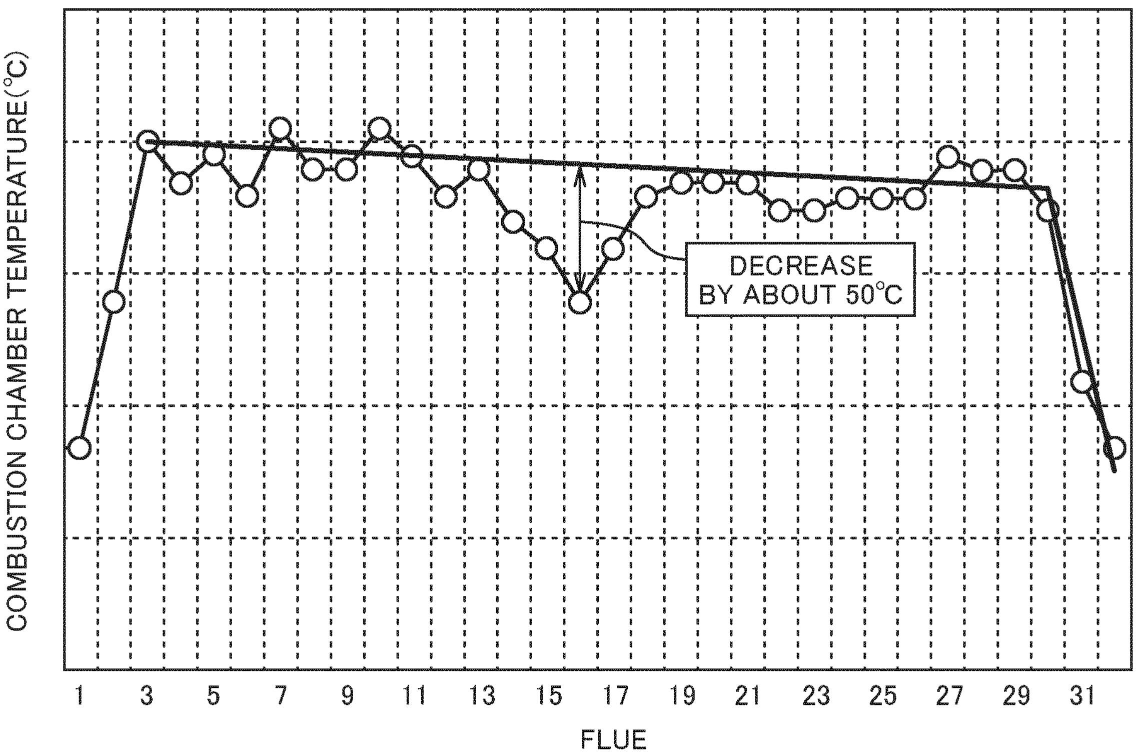

COMBUSTION CHAMBER TEMPERATURE(°C)
DECREASE BY ABOUT 50°C
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
FLUE

FIG. 13

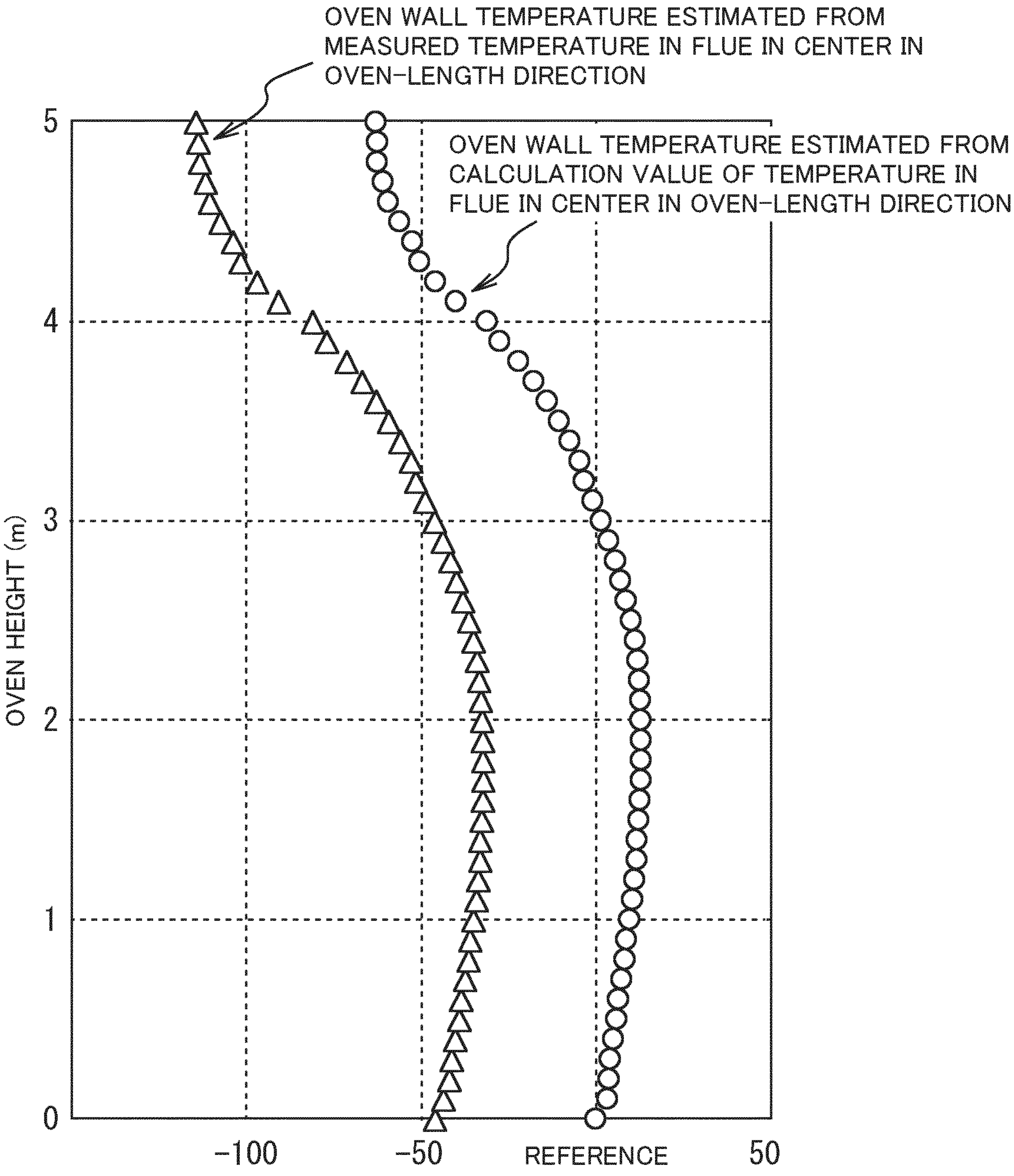

OVEN WALL TEMPERATURE ESTIMATED FROM MEASURED TEMPERATURE IN FLUE IN CENTER IN OVEN-LENGTH DIRECTION
OVEN WALL TEMPERATURE ESTIMATED FROM CALCULATION VALUE OF TEMPERATURE IN FLUE IN CENTER IN OVEN-LENGTH DIRECTION
OVEN HEIGHT (m)
0
1
2
3
4
5
-100
-50
REFERENCE
50
TEMPERATURE (°C)

FIG. 14

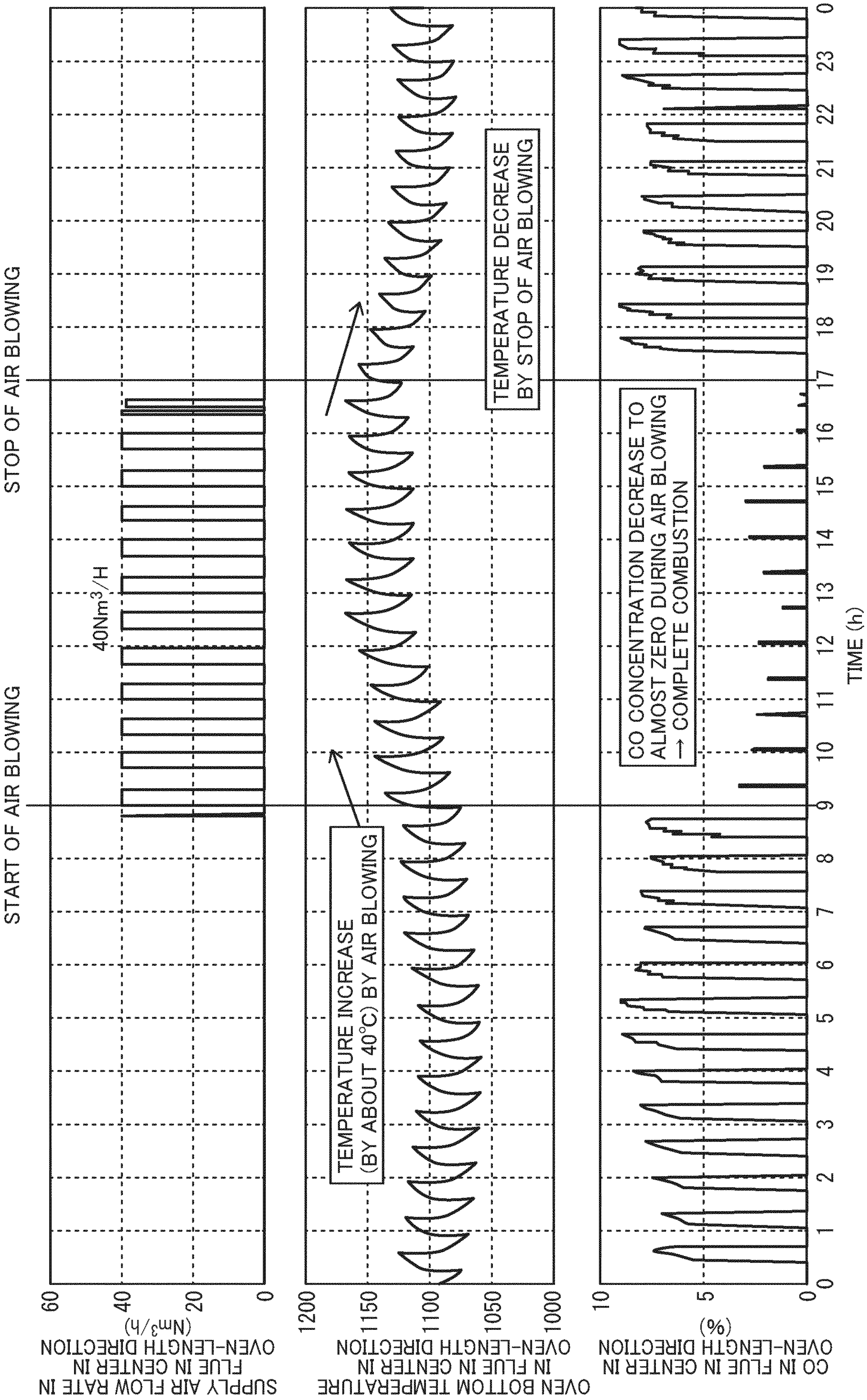
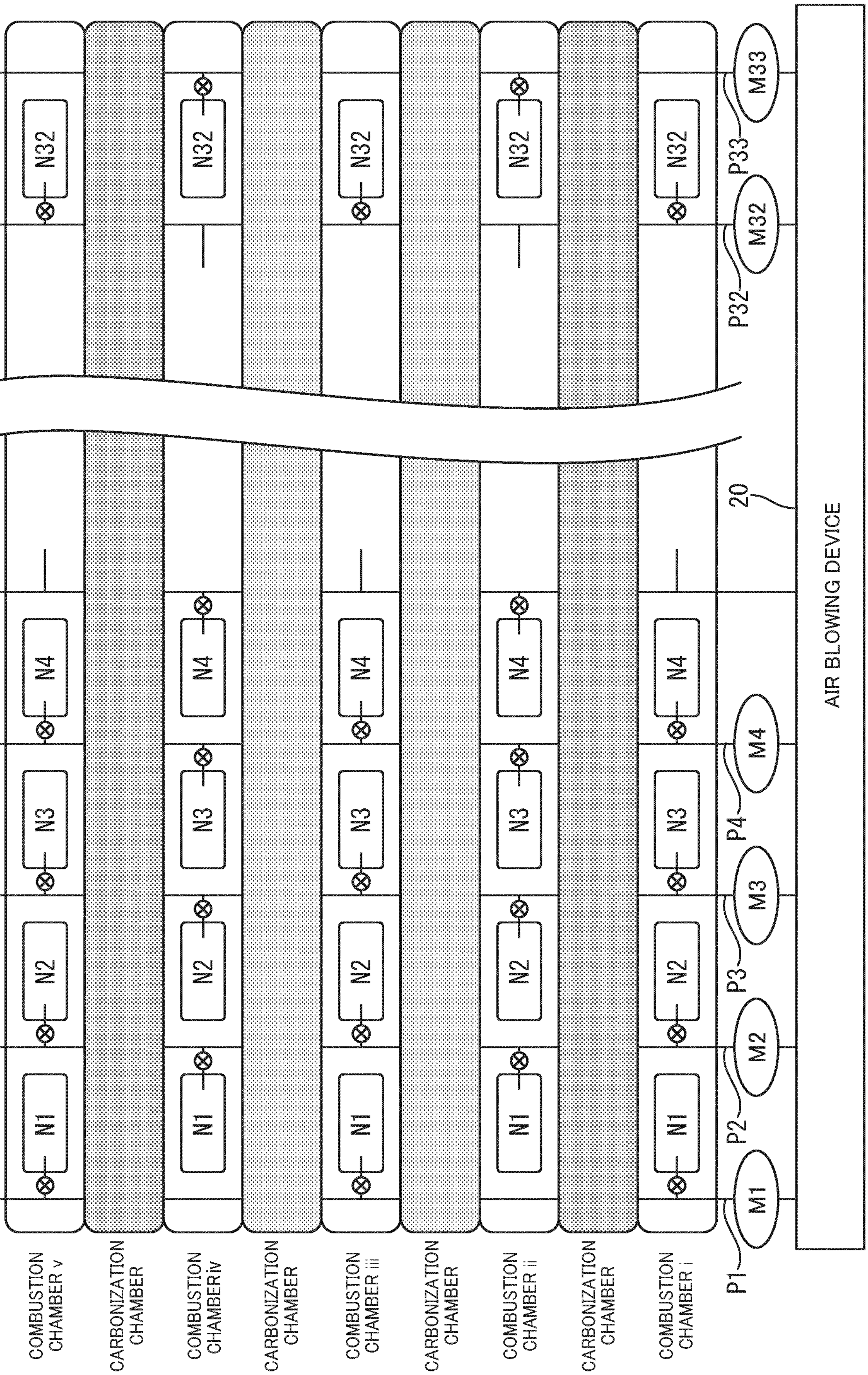

START OF AIR BLOWING
STOP OF AIR BLOWING
40Nm3/H
SUPPLY AIR FLOW RATE IN FLUE IN CENTER IN OVEN-LENGTH DIRECTION (Nm3/h)
60
40
20
0
OVEN BOTTOM TEMPERATURE IN FLUE IN CENTER IN OVEN-LENGTH DIRECTION
1200
1150
1100
1050
1000
TEMPERATURE INCREASE (BY ABOUT 40°C) BY AIR BLOWING
TEMPERATURE DECREASE BY STOP OF AIR BLOWING
CO IN FLUE IN CENTER IN OVEN-LENGTH DIRECTION (%)
10
5
0
CO CONCENTRATION DECREASE TO ALMOST ZERO DURING AIR BLOWING → COMPLETE COMBUSTION
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0
TIME (h)

FIG. 15


COMBUSTION CHAMBER v
CARBONIZATION CHAMBER
COMBUSTION CHAMBERiv
CARBONIZATION CHAMBER
COMBUSTION CHAMBER iii
CARBONIZATION CHAMBER
COMBUSTION CHAMBER ii
CARBONIZATION CHAMBER
COMBUSTION CHAMBER i
N1
N2
N3
N4
N32
M1
M2
M3
M4
M32
M33
P1
P2
P3
P4
P32
P33
20
AIR BLOWING DEVICE

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/021143

A. CLASSIFICATION OF SUBJECT MATTER

C10B 21/10(2006.01)i
FI: C10B21/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C10B21/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2009-46536 A (JFE STEEL KK) 05 March 2009 (2009-03-05)	1-8
A	JP 2007-45871 A (JFE STEEL KK) 22 February 2007 (2007-02-22)	1-8
A	JP 2003-342582 A (JFE STEEL KK) 03 December 2003 (2003-12-03)	1-8
A	JP 2003-206486 A (JFE STEEL KK) 22 July 2003 (2003-07-22)	1-8

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02 June 2022	**14 June 2022**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/021143

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2009-46536 A	05 March 2009	(Family: none)	
JP 2007-45871 A	22 February 2007	(Family: none)	
JP 2003-342582 A	03 December 2003	(Family: none)	
JP 2003-206486 A	22 July 2003	(Family: none)	

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Patent documents cited in the description

- JP 2001081470 A **[0006]**
- JP 2009046536 A **[0006]**