(19) Europäisches Patentamt / European Patent Office / Office européen des brevets

(11) EP 2 258 810 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
**08.12.2010 Bulletin 2010/49**

(21) Application number: **09718422.0**

(22) Date of filing: **05.03.2009**

(51) Int Cl.:
***C10B 39/02*** *(2006.01)*

(86) International application number:
**PCT/JP2009/054133**

(87) International publication number:
**WO 2009/110535 (11.09.2009 Gazette 2009/37)**

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK TR**
Designated Extension States:
**AL BA RS**

(30) Priority: **07.03.2008 JP 2008058217**

(71) Applicants:
- **Nippon Steel Engineering Co., Ltd**
  **Tokyo 100-8071 (JP)**
- **Nittetsu Plant Designing Co., Ltd.**
  **Fukuoka 804-0002 (JP)**

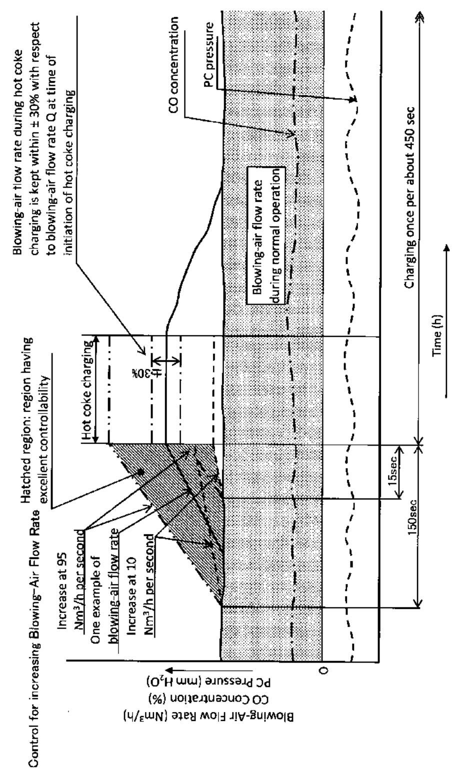
(72) Inventors:
- **SASAHARA, Takashi**
  **Kitakyushu-shi**
  **Fukuoka 804-8505 (JP)**
- **OTANI, Hiroshi**
  **Kitakyushu-shi**
  **Fukuoka 804-0002 (JP)**
- **MAEDA, Kazuaki**
  **Kitakyushu-shi**
  **Fukuoka 804-0002 (JP)**

(74) Representative: **Vossius & Partner**
**Siebertstrasse 4**
**81675 München (DE)**

# (54) METHOD AND DEVICE FOR CONTROLLING CO CONCENTRATION IN COKE DRY-QUENCHING EQUIPMENT

(57) It is intended to provide a CO concentration control method and apparatus for a coke dry quenching facility, which is capable of suppressing a rapid increase in CO concentration during hot coke charging into the coke dry quenching facility. In a coke dry quenching facility designed to subject hot coke to heat exchange with a cooling gas consisting of an inert gas, in a quenching tower of the coke dry quenching facility, and blow CO-burning air into the cooling gas heated to a high temperature and discharged from the quenching tower, whereafter the cooling gas with the air is introduced to a boiler to recover heat therefrom, and the cooling gas cooled by and discharged from the boiler is circulated to the quenching tower, the air is blown at a flow rate which is increased at a rate of 10 to 95 Nm$^3$/h per second with respect to an air flow rate to be blown during a normal operation of the coke dry quenching facility, from 150 to 15 seconds before initiation of hot coke charging into the quenching tower, and subsequently blown at a flow rate ranging from 0.7 × Q to 1.3 × Q, during a period between the initiation and completion of the hot coke charging, wherein Q is an air flow rate to be blown at an initiation timing of the hot coke charging.

**Fig. 2**




EP 2 258 810 A1

## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to a coke dry quenching facility for cooling hot coke taken out of a coke oven, by an inert circulation gas, and more specifically to a technique of adjusting an air-blowing amount during hot coke charging in such a manner that the air-blowing amount is adjusted during a period before the hot coke charging through until completion of the charging to control a CO concentration of the circulation gas during the hot coke charging to a predetermined value or less so as to suppress a rapid increase in the CO concentration.

### BACKGROUND ART

**[0002]** A coke dry quenching facility is used for cooling of hot coke taken out of a coke oven. The hot coke is charged into a prechamber from a top of a quenching tower of the coke dry quenching facility, and the charged coke is cooled while falling through a cooling chamber, by contact with an inert circulation gas blown from a lower side of the cooling chamber.

**[0003]** The coke dry quenching facility is widely known, wherein the quenching tower comprises a prechamber, a cooling chamber, and a sloping flue between the prechamber and the cooling chamber.

**[0004]** The cooling chamber has a lower portion provided with a cooling gas-blowing device for blowing a cooling gas consisting of an inert gas such as nitrogen, and a coke discharge port. The hot coke conveyed from a coke oven is charged from a charging device into the prechamber, and the charged coke is cooled while falling through the cooling chamber, by contact with the cooling gas blown from the cooling gas-blowing device, and then discharged from the coke discharge port.

The cooling gas heated to a high temperature and discharged from the quenching tower is introduced to a boiler to undergo heat exchange therein. The cooling gas discharged from the boiler is introduced to a heat exchanger and sent to the cooling gas-blowing device, by a circulation fan, so that it is blown into the cooling chamber in a circulating manner.

**[0005]** In an operation of the coke dry quenching facility, hot coke is charged from above the prechamber (several times per hour). Due to the hot coke charging, a CO concentration of the circulation gas (cooling gas), i.e., an internal atmosphere of the prechamber, is rapidly increased by a burnable gas (CO) generated during the hot coke charging and CO derived from the charged coke. If the operation is continued under the increased CO concentration, a specific heat of the circulation gas is lowered to cause a reduction in sensible heat recovery amount in the boiler in a subsequent stage. Thus, it is important to reduce the CO concentration. Therefore, there has been employed a technique of blowing air into the circulation gas at a position upstream of the boiler to bum CO to reduce the CO concentration.

**[0006]** As a gas-concentration control method, the following Patent Document 1 discloses a technique of performing: a feedback control based on a PID (Proportional-Integral-Derivative algorithm) control process designed to compensate for a difference between preset and actual values of blowing-air flow rate, using a device for adjusting an amount of fresh air and bypass air to be blown from an air-blowing port provided between a sloping flue and a boiler; and a feedforward control based on a coke discharge amount and an actual gas concentration, in order to constantly maintain a burnable gas (CO) and an oxygen component in a circulation gas at a minimum level to maximize a sensible heat recovery amount.

Patent Document 1: JP 2006-183058A

### DISCLOSURE OF THE INVENTION

### [PROBLEM TO BE SOLVED BY THE INVENTION]

**[0007]** However, the technique disclosed in the Patent Document 1 does not particularly consider the phenomenon that a CO concentration is rapidly increased after hot coke charging, and thereby it is still the case that an operator manually adjusts the CO concentration when it is rapidly increased after the coke charging, so as to reduce the CO concentration. Details thereof will be described with reference to FIG. 7.

**[0008]** FIG. 7 is a graph showing an influence of air blowing during the hot coke charging, on a CO concentration and a prechamber pressure, in the conventional technique. In FIG. 7, the CO concentration is a value measured at an outlet side of a heat exchanger.

**[0009]** As shown in FIG. 7, the CO concentration is increased after a short time from the coke charging. Thus, the amount of air to be blown from the air-blowing port provided between the sloping flue and the boiler is increased by a manual operation of an operator. However, the control is liable to lag behind an increase in the CO concentration caused by CO derived from hot coke and air entering from a charging port, just after the hot coke charging, resulting in failing to suppress an increase in the CO concentration.

**[0010]** As above, it is extremely difficult for an operator to adjust the CO concentration to a stable and low value by adjusting a flow rate of air to be brown from the air-blowing port. Consequently, after the coke charging, a specific heat of the circulation gas is lowered due to the occurrence of an increase in the CO concentration of the circulation gas, which causes a problem a reduction in sensible heat (steam) recovery amount in the boiler provided in a subsequent stage.

**[0011]** It is therefore an object of the present invention to provide a CO concentration control method and apparatus for a coke dry quenching facility, which is capable of suppressing a rapid increase in CO concentration during hot coke charging into the coke dry quenching facility.

[MEANS FOR SOLVING THE PROBLEM]

**[0012]** As set forth in the appended claim 1, the present invention provides a CO concentration control method for a coke dry quenching facility designed to subject hot coke to heat exchange with a cooling gas consisting of an inert gas, in a quenching tower of the coke dry quenching facility, and blow CO-burning air into the cooling gas heated to a high temperature and discharged from the quenching tower, whereafter the cooling gas with the air is introduced to a boiler to recover heat therefrom, and the cooling gas cooled by and discharged from the boiler is circulated to the quenching tower. The method is **characterized in that** it comprises: in advance of hot coke charging into the quenching tower, blowing the air at a flow rate which is increased by an air amount required for burning of CO to be increased after the coke charging, with respect to an air flow rate to be blown during a normal operation of the coke dry quenching facility; and during a subsequent period from initiation of the charging through until completion of the charging, blowing the air in the increased flow rate at an initiation timing of the charging.

**[0013]** As set forth in claim 2, the method set forth in claim 1 is **characterized in that** it comprises, from 150 to 15 seconds before the initiation of the hot coke charging into the quenching tower, blowing the air at a flow rate which is increased at a rate of 10 to 95 $Nm^3/h$ per second with respect to the air flow rate to be blown during the normal operation.

**[0014]** As set forth in the appended claim 3, the present invention also provides a CO concentration control method for a coke dry quenching facility designed to subject hot coke to heat exchange with a cooling gas consisting of an inert gas, in a quenching tower of the coke dry quenching facility, and blow CO-burning air into the cooling gas heated to a high temperature and discharged from the quenching tower, whereafter the cooling gas with the air is introduced to a boiler to recover heat therefrom, and the cooling gas cooled by and discharged from the boiler is recirculated to the quenching tower. The method is **characterized in that** it comprises: from 150 to 15 seconds before initiation of hot coke charging into the quenching tower, blowing the air at a flow rate which is increased at a rate of 10 to 95 $Nm^3/h$ per second with respect to an air flow rate to be blown during a normal operation of the coke dry quenching facility; and, during a subsequent period between the initiation and completion of the hot coke charging, blowing the air at a flow rate ranging from $0.7 \times Q$ to $1.3 \times Q$, wherein Q is an air flow rate to be blown at an initiation timing of the hot coke charging.

**[0015]** As set forth in the appended claim 4, the present invention further provides a CO concentration control apparatus for a coke dry quenching facility designed to subject hot coke to heat exchange with a cooling gas consisting of an inert gas, in a quenching tower comprising a prechamber and a cooling chamber located beneath the prechamber, and blow CO-burning air into the cooling gas heated to a high temperature and discharged from the quenching tower to a gas duct, whereafter the cooling gas with the air is introduced to a boiler to recover heat therefrom, and the cooling gas cooled by and discharged from the boiler is circulated to the quenching tower. The apparatus is **characterized in that** it comprises flow rate adjusting means operable, from 150 to 15 seconds before initiation of hot coke charging into the quenching tower, to blow the air at a flow rate which is increased at a rate of 10 to 95 $Nm^3/h$ per second with respect to an air flow rate to be blown during a normal operation of the coke dry quenching facility, and, during a subsequent period between the initiation and completion of the hot coke charging, to blow the air at a flow rate ranging from $0.7 \times Q$ to $1.3 \times Q$, wherein Q is an air flow rate to be blown at an initiation timing of the hot coke charging.

[EFFECT OF THE INVENTION]

**[0016]** In the present invention, in advance of the hot coke charging into the quenching tower, the CO-burning air is blown into the high-temperature cooling gas discharged from the quenching tower, at a flow rate which is increased by a given amount. Further, during the subsequent period from the initiation of the charging through until the completion of the charging, the air is blown at the flow rate at an initiation timing of the charging. This makes it possible to suppress an increase in CO concentration during the hot coke charging.

BEST MODE FOR CARRYING OUT THE INVENTION

**[0017]** A CO concentration control method and apparatus for a coke dry quenching facility of the present invention will be described based on an embodiment thereof.

[FIRST EMBODIMENT]

**[0018]** FIG. 1 is a schematic diagram showing one example of a coke dry quenching facility using the present invention.

**[0019]** In FIG. 1, the coke dry quenching facility comprises a quenching tower 1 which has a prechamber 3 adapted to receive therein hot coke charged from a charging device 2 on a top of the quenching tower 1, and a cooling chamber 4 disposed beneath the prechamber 3 to cool the hot coke which is falling therethrough. An annular-shaped sloping flue 5 is provided between the prechamber 3 and the cooling chamber 4 to extract an after-mentioned cooling gas after being heated to a high temperature through heat exchange. The sloping flue 5 is connected to a gas duct 6.

**[0020]** The cooling chamber 4 has a reverse conical-shaped lower portion provided with a cooling gas-blowing device 7 adapted to blow therefrom a cooling gas consisting of an inert gas such as nitrogen, and a coke discharge device 8. The cooling gas is supplied from a heat exchanger 9 to the cooling gas-blowing device 7.

**[0021]** Hot coke conveyed from a coke oven is charged from the charging device 2 into the prechamber 3, and the charged coke is cooled while falling through the cooling chamber 4, by contact with the cooling gas blown from the cooling gas-blowing device 7, and then discharged from the coke discharge device 8.

Meanwhile, the cooling gas heated to a high temperature by contact and heat exchange with the hot coke is subjected to dust removal through the gas duct 6, and then introduced into a boiler 10. In the boiler 10, the cooling gas is cooled through heat exchange. The cooling gas discharged from the boiler 10 is subjected to dust removal through a dust catcher 11 coupled to a gas outlet of the boiler 10. Then, the cooling gas is introduced to the heat exchanger 9 and sent to the cooling gas-blowing device 7, by a circulation fan 12, so that it is blown into the cooling chamber 4 in a circulating manner.

**[0022]** In an operation of the coke dry quenching facility, if the operation is performed under a condition that a CO concentration of the circulation gas (cooling gas) is excessively increased, a specific heat of the circulation gas will be lowered to cause a reduction in sensible heat recovery amount in the boiler in a subsequent stage. Thus, in order to reduce the CO concentration, air is blown from an air-blowing port 13 into the cooling gas heated to a high temperature through the heat exchange and discharged from the quenching tower 1, on an upstream side of the boiler 10, to bum CO so as to reduce the CO concentration. A blowing-air flow rate is adjusted by a flow rate-adjusting valve serving as flow rate adjusting means 14. In place of the flow rate-adjusting value serving as the flow rate adjusting means 14, a rotation speed of a blower may be controllably adjusted, as shown in FIG. 6.

**[0023]** In the present invention, in order to suppress the rapid increase in CO concentration during the hot coke charging, a blowing-air flow rate is adjusted before the hot coke charging into the quenching tower and during a subsequent period between initiation and completion of the hot coke charging, as described later. Then, after the completion of the charging, the blowing-air flow rate is adjusted by a feedback control based on a CO concentration,.

**[0024]** FIG. 2 is a graph showing an influence of a rate of increase per second in a blowing-air flow rate, on a CO concentration and a prechamber pressure.

**[0025]** In FIG. 2, from 150 to 15 seconds before initiation of the hot coke charging into the quenching tower, air is blown at a flow rate which is increased at a rate ranging from 10 $Nm^3/h$ per second (broken line) to 95 $Nm^3/h$ per second (two-dot chain line) with respect to an air flow rate to be blown during a normal cooling operation (about 7000 to 10000 $Nm^3/h$).

**[0026]** Then, when the hot coke charging is initiated after opening a cover of the prechamber, the air is blown at a flow rate of $\pm$ 30% with respect to an air flow rate Q to be blown at an initiation timing of the hot coke charging, i.e., at a flow rate ranging from $0.7 \times Q$ to $1.3 \times Q$. This makes it possible to suppress an increase of CO concentration due to the increase in CO concentration during the hot coke charging.

**[0027]** An initiation timing of the air blowing was analyzed by a test performed on condition that it is variously changed with respect to the initiation timing of the hot coke charging, while setting the rate of increase in the blowing-air flow rate, to a constant value (range of 10 to 95 $Nm^3/h$ per second). As a result, the following knowledge was obtained.

**[0028]** If a time period of the increased blowing-air flow rate is set to an excessively large value (i.e., an initiation timing of increasing the blowing-air flow rate is set to be greater than 150 seconds before the initiation of the charging), a total blowing-air flow rate becomes excessively large, and $O_2$ in the blowing air causes burning of the coke in the prechamber to produce CO through a reduction reaction, so that the CO concentration cannot be controlled at a low level. It was also proven that, if the time period of the increased blowing-air flow rate is set to an excessively small value (i.e., the initiation timing of increasing the blowing-air flow rate is set to be less than 15 seconds before the initiation of the charging), an amount of $O_2$ required for burning of CO becomes deficient to preclude a possibility to control the CO concentration.

**[0029]** From the above results, it has become clear that it is adequate to initiate increasing the blowing-air flow rate, from 150 to 15 seconds before the initiation of the hot coke charging.

**[0030]** Further, a test was performed on condition that the rate of increase per second in the blowing-air flow rate is variously changed while increasing the blowing-air flow rate from the adequate timing (150 to 15 seconds) before the initiation of the hot coke charging.

**[0031]** FIGS. 3 to 5 illustrates an influence of the rate of increase per second in the blowing-air flow rate, on the CO concentration and the prechamber pressure, wherein FIG. 3, FIG. 4 and FIG. 5 are a graph in case of setting the rate of increase per second in the blowing-air flow rate to 100 $Nm^3/h$, a graph in case of setting the rate of increase per second in the blowing-air flow rate to 7 $Nm^3/h$, and a graph in case of setting the rate of increase per second in the blowing-air flow rate to 10 to 95 $Nm^3/h$, respectively.

**[0032]** As shown in FIG. 3, if the blowing-air flow rate is sharply increased at a rate of 100 $Nm^3/h$ per second, a pressure fluctuation occurs in the prechamber to cause a change in pressure balancing of the entire CDQ (coke dry quenching) facility, which leads to fluctuation in amount of the circulation gas and in steam recovery amount in the boiler provided in the subsequent stage.

**[0033]** As shown in FIG. 4, conversely, if the blowing-air flow rate is gently increased at a rate of 7 $Nm^3/h$ per second, air becomes deficient with respect to CO derived from charged coke and air entering from a charging port during hot coke charging in the next cycle, which precludes a possibility to reduce the CO concentration.

**[0034]** A test was further performed on condition that the rate of increase per second in the blowing-air flow rate is variously changed in the range between the rates in FIGS. 3 and 4. As a result, a stable CO concentration and a stable prechamber pressure were obtained at a rate of 10 to 95 $Nm^3/h$ per second, as shown in FIG. 5.

**[0035]** During a period between initiation and completion of the hot coke charging, the air is blown at a flow rate ranging from $0.7 \times Q$ to $1.3 \times Q$, wherein Q is an air flow rate of 10 to 95 $Nm^3/h$ per second to be blown before a timing of the initiation of the hot coke charging. If the blowing-air flow rate is greater than $1.3 \times Q$, hot gas will be blown out to an outside of the facility. This undesirably contaminates the environment and causes safety hazards. If the blowing-air flow rate is less than $0.7 \times Q$, an internal pressure of the prechamber will be lowered, and thereby an outside air (ambient air) will enter from outside the facility. Consequently, the entered air causes burning of coke inside the facility to produce CO through a reduction reaction, which precludes a possibility to reduce the CO concentration of the circulation gas. Therefore, it has become clear that an adequate blowing-air flow rate is in the range of $0.7 \times Q$ to $1.3 \times Q$.

BRIEF DESCRIPTION OF THE DRAWINGS

**[0036]**

FIG. 1 is a schematic diagram showing one example of a coke dry quenching facility using the present invention.

FIG. 2 is a graph showing an influence of a rate of increase per second in a blowing-air flow rate, on a CO concentration and a prechamber pressure, in the present invention.

FIG. 3 is a graph showing an influence of the rate of increase per second in the blowing-air flow rate, on the CO concentration and the prechamber pressure, in case of setting the rate to 100 $Nm^3/h$.

FIG. 4 is a graph showing an influence of the rate of increase per second in the blowing-air flow rate, on the CO concentration and the prechamber pressure, in case of setting the rate to 7 $Nm^3/h$.

FIG. 5 is a graph showing an influence of the rate of increase per second in the blowing-air flow rate, on the CO concentration and the prechamber pressure, in case of setting the rate to 10 to 95 $Nm^3/h$.

FIG. 6 is a schematic diagram showing another example of the coke dry quenching facility using the present invention.

FIG. 7 is a graph showing an influence of air blowing during the hot coke charging, on a CO concentration and a prechamber pressure, in a conventional technique.

EXPLANATION OF CODES

**[0037]**

1: quenching tower
2: charging device
3: prechamber (PC)
4: cooling chamber
5: sloping flue
6: gas duct
7: cooling gas-blowing device
8: coke discharge device
9: heat exchanger
10: boiler
11: dust catcher
12: circulation fan
13: air-blowing port
14: flow rate adjusting means (flow rate-adjusting valve, blower)

**Claims**

**1.** A CO concentration control method for a coke dry quenching facility designed to subject hot coke to heat exchange with a cooling gas consisting of an inert gas, in a quenching tower of the coke dry quenching facility, and blow CO-burning air into the cooling gas heated to a high temperature and discharged from the quenching tower, whereafter the cooling gas with the air is introduced to a boiler to recover heat therefrom, and the cooling gas cooled by and discharged from the boiler is recirculated to the quenching tower, the CO concentration control method being **characterized in that** it comprises: in advance of hot coke charging into the quenching tower, blowing the air at a flow rate which is increased by an air amount required for burning of CO to be increased after the coke charging, with respect to an air flow rate to be blown during a normal operation of the coke dry quenching facility; and, during a subsequent period from initiation of the charging through until completion of the charging, blowing the air in the increased flow rate at an initiation timing of the charging.

**2.** The CO concentration control method as defined in claim 1, **characterized in that** it comprises, from 150 to 15 seconds before the initiation of the hot coke charging into the quenching tower, blowing the air at a flow rate which is increased at a rate of 10 to 95 $Nm^3/h$ per second with respect to the air flow rate to be blown during the normal operation.

**3.** A CO concentration control method for a coke dry quenching facility designed to subject hot coke to heat exchange with a cooling gas consisting of an inert gas, in a quenching tower of the coke dry quenching facility, and blow CO-burning air into the cooling gas heated to a high temperature and discharged from the quenching tower, whereafter the cooling gas with the air is introduced to a boiler to recover heat therefrom, and the cooling gas cooled by and discharged from the boiler is recirculated to the quenching tower, the CO concentration control method being **characterized in that** it comprises: from 150 to 15 seconds before initiation of hot coke charging into the quenching tower, blowing the air at a flow rate which is increased at a rate of 10 to 95 $Nm^3/h$ per second with respect to an air flow rate to be blown during a normal operation of the coke dry quenching facility; and, during a subsequent period between the initiation and completion of the hot coke charging, blowing the air at a flow rate ranging from $0.7 \times Q$ to $1.3 \times Q$, wherein Q is an air flow rate to be blown at an initiation timing of the hot coke charging.

**4.** A CO concentration control apparatus for a coke dry quenching facility designed to subject hot coke to heat exchange with a cooling gas consisting of an inert gas, in a quenching tower comprising a prechamber and a cooling chamber located beneath the prechamber, and blow CO-burning air into the cooling gas heated to a high temperature and discharged from the quenching tower to a gas duct, whereafter the cooling gas with the air is introduced to a boiler to recover heat therefrom, and the cooling gas cooled by and discharged from the boiler is circulated to the quenching tower, the CO concentration control apparatus being **characterized in that** it comprises flow rate adjusting means operable, from 150 to 15 seconds before initiation of hot coke charging into the quenching tower, to blow the air at a flow rate which is increased at a rate of 10 to 95 $Nm^3/h$ per second with respect to an air flow rate to be blown during a normal operation of the coke dry quenching facility, and, during a subsequent period between the initiation and completion of the hot coke charging, to blow the air at a flow rate ranging from $0.7 \times Q$ to $1.3 \times Q$, wherein Q is an air flow rate to be blown at an initiation timing of the hot coke charging.

**Fig. 1**

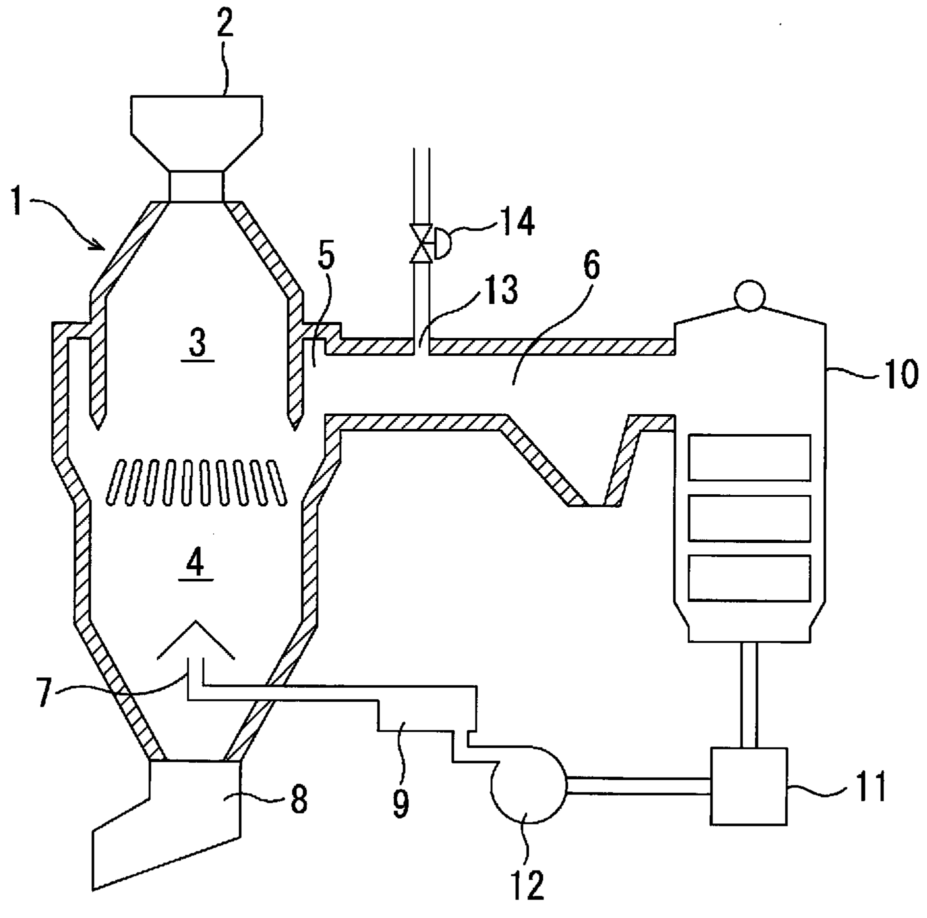
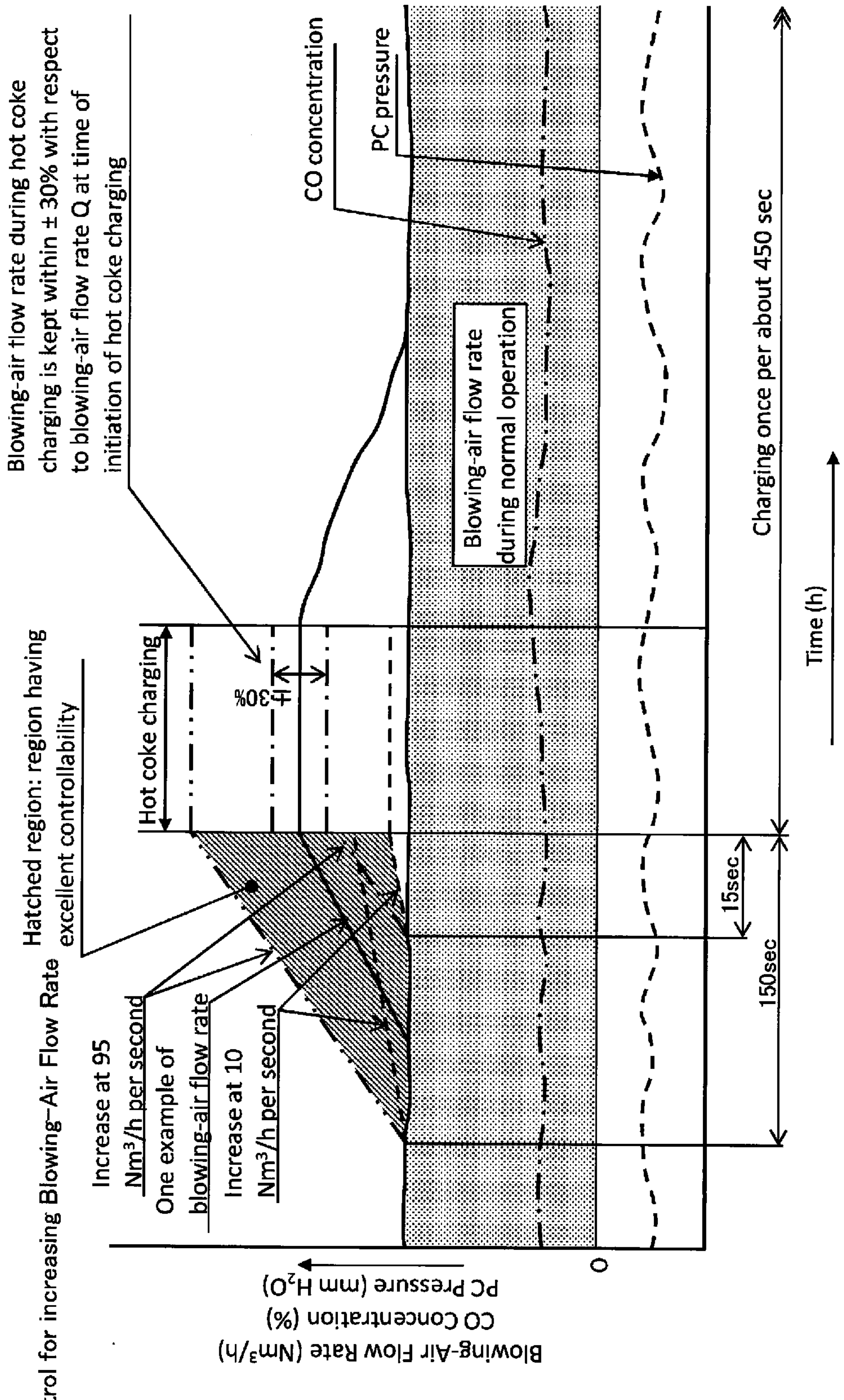
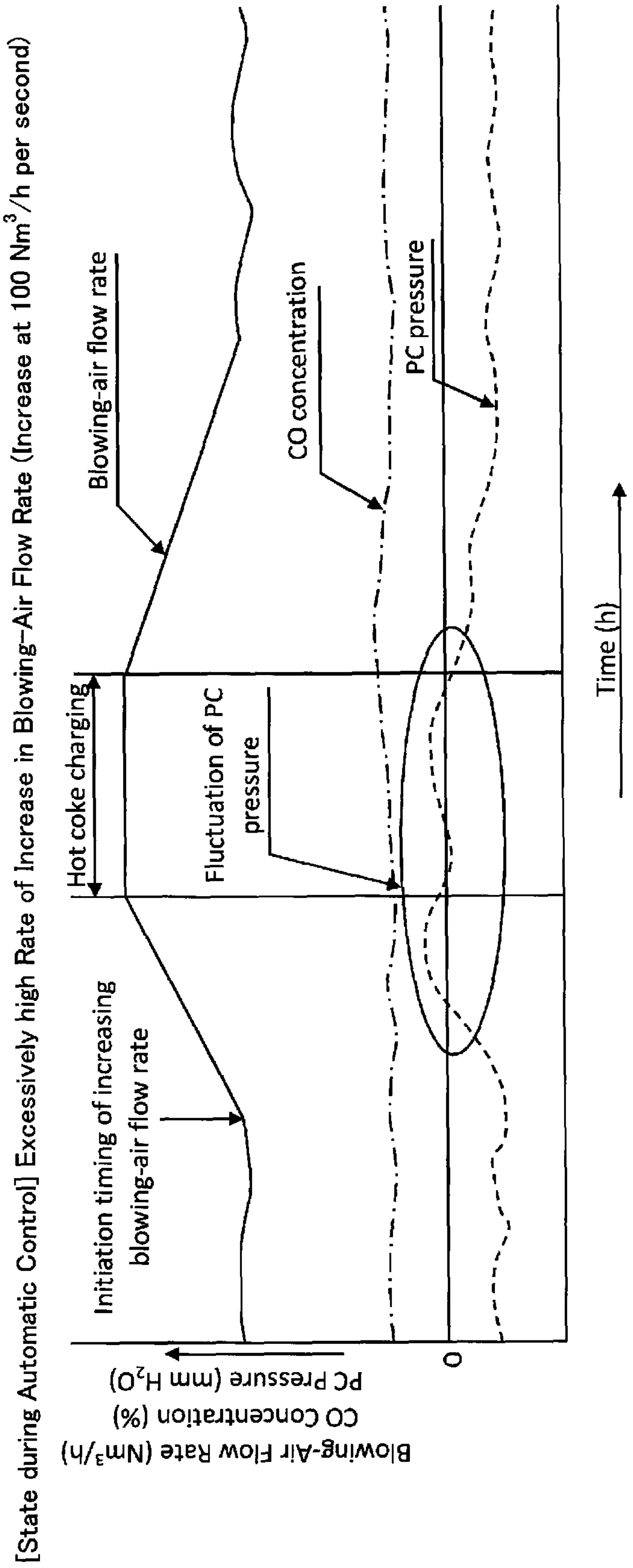


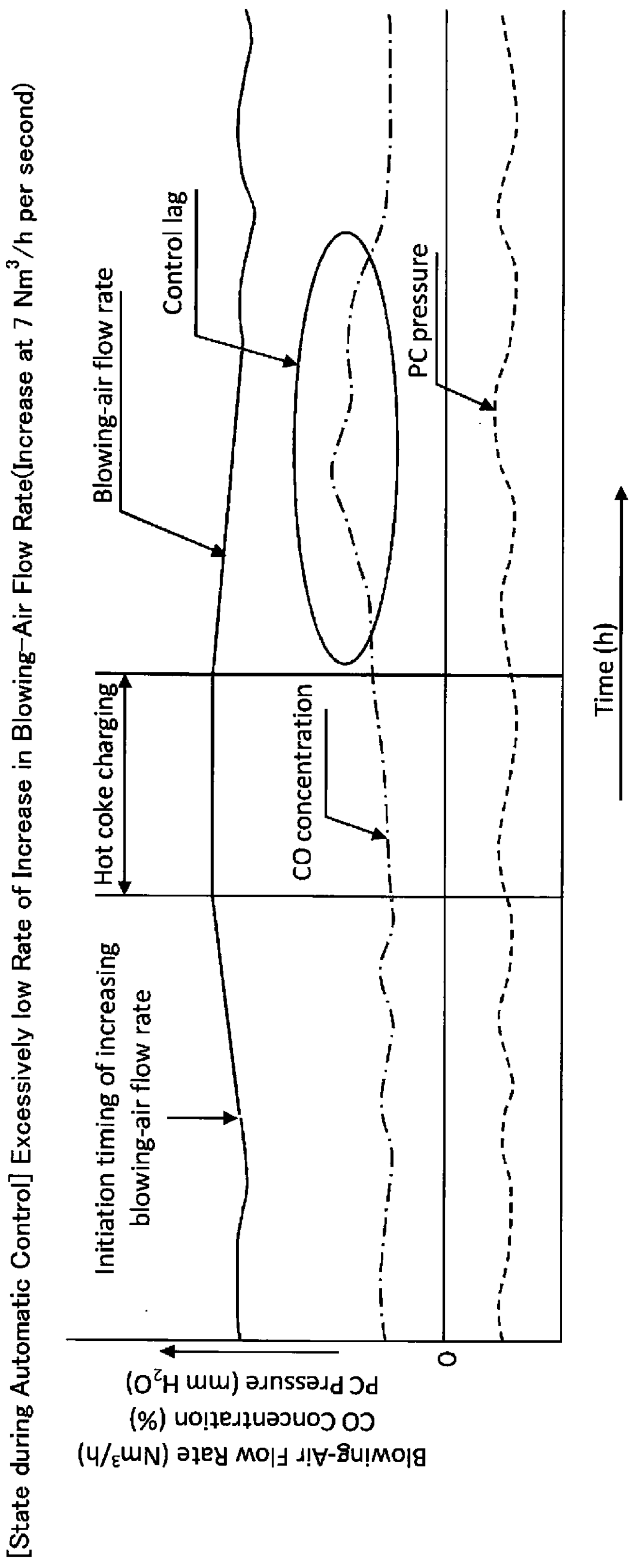
**Fig. 2**


Control for increasing Blowing-Air Flow Rate
Hatched region: region having excellent controllability
Increase at 95 Nm³/h per second
One example of blowing-air flow rate
Increase at 10 Nm³/h per second
Hot coke charging
±30%
Blowing-air flow rate during hot coke charging is kept within ± 30% with respect to blowing-air flow rate Q at time of initiation of hot coke charging
CO concentration
PC pressure
Blowing-air flow rate during normal operation
Charging once per about 450 sec
15sec
150sec
Time (h)
0
Blowing-Air Flow Rate (Nm³/h)
CO Concentration (%)
PC Pressure (mm H₂O)

# Fig. 3


[State during Automatic Control] Excessively high Rate of Increase in Blowing-Air Flow Rate (Increase at 100 Nm$^3$/h per second)
Blowing-air flow rate
CO concentration
PC pressure
Hot coke charging
Fluctuation of PC pressure
Initiation timing of increasing blowing-air flow rate
Time (h)
0
Blowing-Air Flow Rate (Nm$^3$/h)
CO Concentration (%)
PC Pressure (mm $H_2O$)

# Fig. 4


[State during Automatic Control] Excessively low Rate of Increase in Blowing-Air Flow Rate(Increase at 7 Nm3/h per second)
Blowing-air flow rate
Control lag
PC pressure
Hot coke charging
CO concentration
Initiation timing of increasing blowing-air flow rate
Time (h)
0
Blowing-Air Flow Rate (Nm3/h)
CO Concentration (%)
PC Pressure (mm H2O)

# Fig. 5

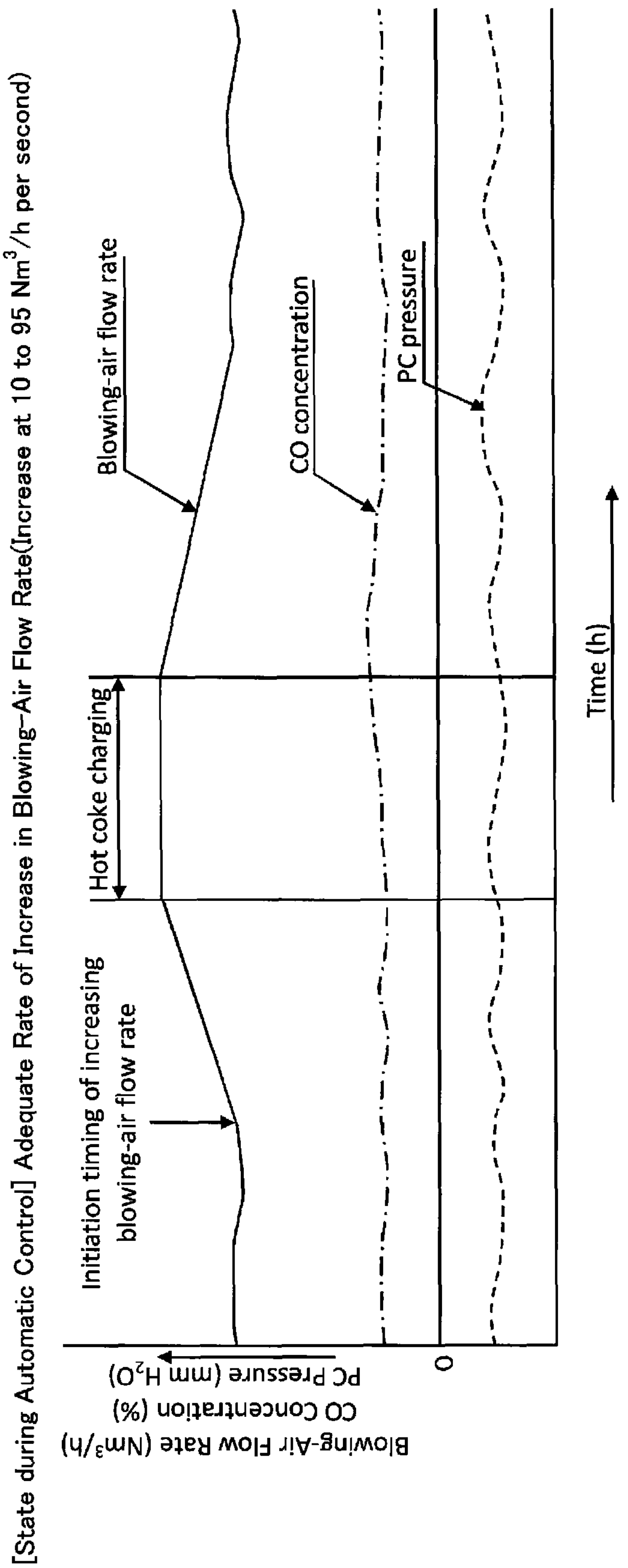
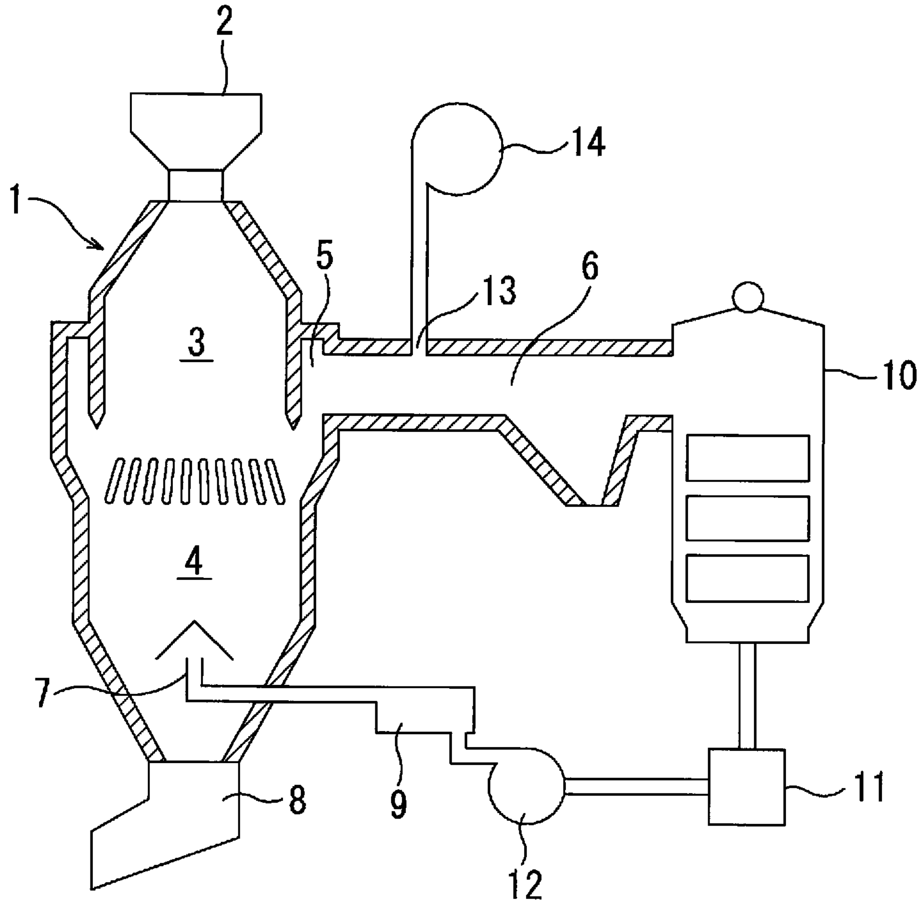
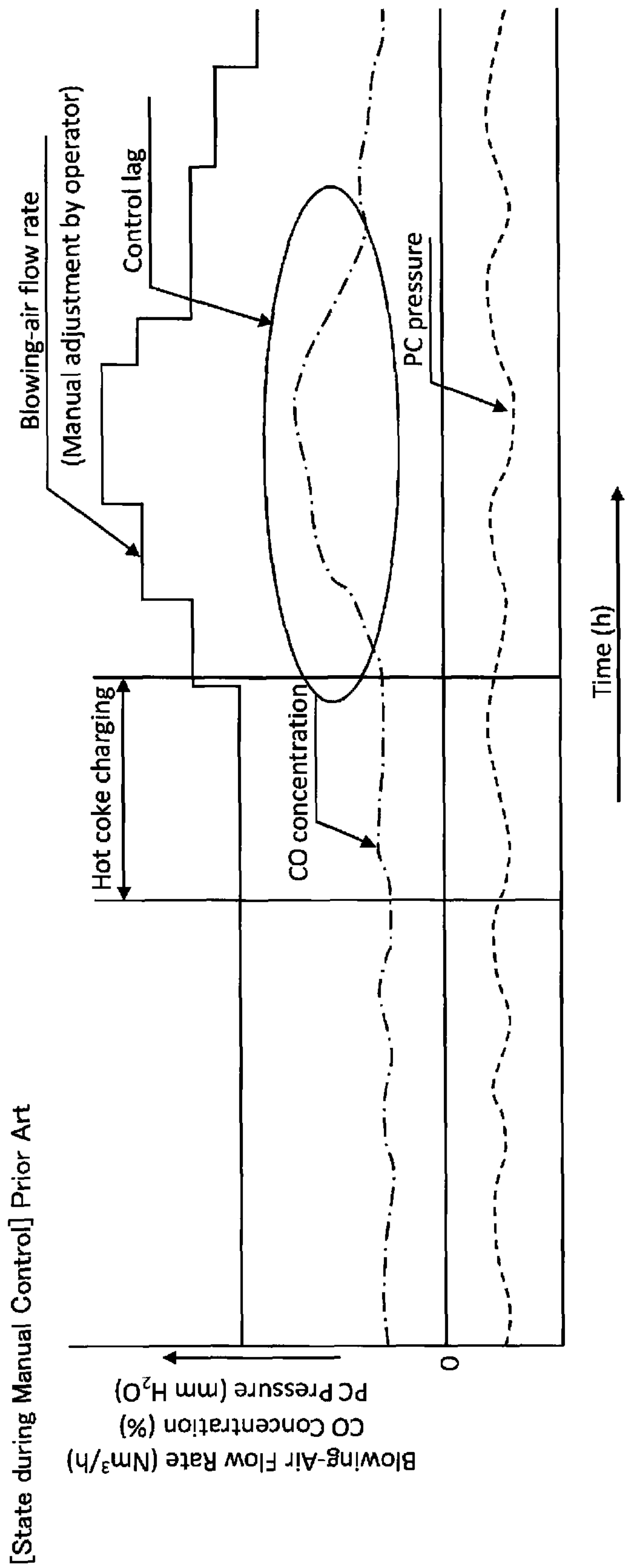

[State during Automatic Control] Adequate Rate of Increase in Blowing-Air Flow Rate(Increase at 10 to 95 Nm$^3$/h per second)
Blowing-air flow rate
CO concentration
PC pressure
Hot coke charging
Initiation timing of increasing blowing-air flow rate
Blowing-Air Flow Rate (Nm$^3$/h)
CO Concentration (%)
PC Pressure (mm $H_2O$)
0
Time (h)

**Fig. 6**



# Fig. 7


[State during Manual Control] Prior Art
Blowing-Air Flow Rate (Nm$^3$/h)
CO Concentration (%)
PC Pressure (mm $H_2O$)
0
Blowing-air flow rate
(Manual adjustment by operator)
Control lag
PC pressure
Hot coke charging
CO concentration
Time (h)

## INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/054133

A. CLASSIFICATION OF SUBJECT MATTER
*C10B39/02*(2006.01)i

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)
C10B39/02

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

| | | | |
|---|---|---|---|
| Jitsuyo Shinan Koho | 1922-1996 | Jitsuyo Shinan Toroku Koho | 1996-2009 |
| Kokai Jitsuyo Shinan Koho | 1971-2009 | Toroku Jitsuyo Shinan Koho | 1994-2009 |

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. |
|---|---|---|
| X | JP 3-9988 A (Nippon Steel Chemical Co., Ltd.), 17 January, 1991 (17.01.91), Full text (Family: none) | 1 |
| X | JP 2-120392 A (Kawasaki Steel Corp.), 08 May, 1990 (08.05.90), Full text (Family: none) | 1 |
| A | JP 3-157485 A (Sumitomo Metal Industries, Ltd.), 05 July, 1991 (05.07.91), Full text (Family: none) | 1-4 |

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 01 April, 2009 (01.04.09) | 14 April, 2009 (14.04.09) |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| Japanese Patent Office | |
| Facsimile No. | Telephone No. |

Form PCT/ISA/210 (second sheet) (April 2007)

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2009/054133

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | JP 7-268335 A (Sumitomo Metal Industries, Ltd.), 17 October, 1995 (17.10.95), Full text (Family: none) | 1-4 |

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

## REFERENCES CITED IN THE DESCRIPTION

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

### Patent documents cited in the description


- JP 2006183058 A **[0006]**