



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

(43) Date of publication:
13.05.2015 Bulletin 2015/20

(51) Int Cl.:
C21B 5/00 (2006.01) C21B 7/00 (2006.01)

(21) Application number: **13813190.9**

(86) International application number:
PCT/JP2013/067788

(22) Date of filing: **28.06.2013**

(87) International publication number:
WO 2014/007152 (09.01.2014 Gazette 2014/02)

(84) Designated Contracting States:
AL 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 RS SE SI SK SM TR
Designated Extension States:
BA ME

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(30) Priority: **03.07.2012 JP 2012149384**
03.04.2013 JP 2013077526

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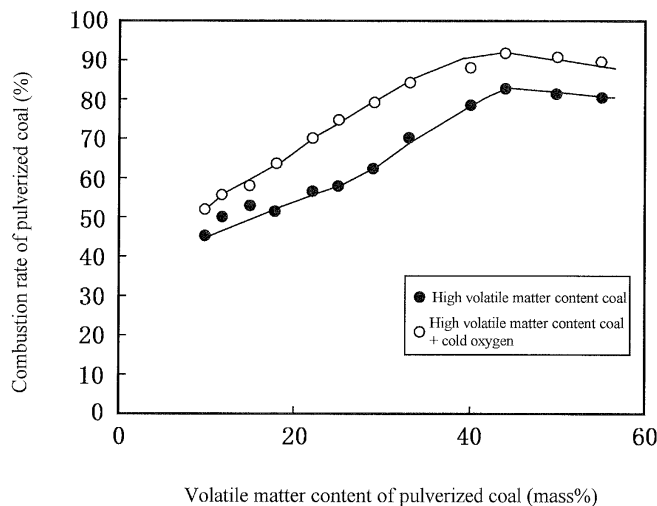
(54) **METHOD FOR OPERATING BLAST FURNACE**

(57) To provide a method for operating a blast furnace that allows an improvement in combustion rate of pulverized coal blown from a tuyere and a reduction in a reducing material basic unit.

A method for operating a blast furnace blown from a tuyere via a lance, in which, when a blowing amount of the solid reducing material blown from the tuyere is

not less than 150 kg/t per ton of pig iron, a double tube lance is used as the lance to blow the solid reducing material from an inner tube and blow oxygen of not higher than 100°C from between the inner tube and an outer tube, and pulverized coal having an average volatile matter content of more than 25 mass% and not more than 50 mass% is used as the blowing solid reducing material.

FIG. 7



Description

Patent Document 5: JP 8-260010 A

TECHNICAL FIELD**DISCLOSURE OF THE INVENTION**

[0001] This invention relates to a method for operating a blast furnace, and particularly to a method for operating a blast furnace that is effective in improving productivity and reducing a reducing material basic unit by blowing a solid reducing material such as pulverized coal from a tuyere of a blast furnace.

5 PROBLEM TO BE SOLVED BY THE INVENTION

[0005] However, in the method of using LNG as disclosed in Patent Document 1, there is a problem in that LNG is expensive and a large amount of LNG is necessary to improve the combustion rate of the pulverized coal. Furthermore, in the method disclosed in Patent Document 3, there is a need for modification of the tuyere, which leads to an increase in equipment cost.

BACKGROUND ART

[0002] In recent years, global warming due to an increase in carbon dioxide emission has become a problem, and this has also become an important issue in an iron manufacturing industry. In response to this problem, in the recent blast furnace, a low reduction agent ratio (low RAR: an abbreviation for Reduction Agent Ratio, a total amount of a reducing material blown from the tuyere and coke charged from a furnace top per ton production of pig iron) operation has been promoted. The blast furnace primarily uses coke and pulverized coal as the reducing material. Therefore, in order to achieve suppression of the above-described low reduction agent ratio and carbon dioxide emission, a method for improving the combustion rate of the pulverized coal and improving air permeability of the furnace by reducing an amount of powder occurring in the furnace has been considered to be effective.

[0006] The method for operating a blast furnace disclosed in Patent Document 2 is effective in reducing the reducing material basic unit by an improvement in combustion rate of pulverized coal, as compared to the method for blowing the pulverized coal having a low volatile matter content from the tuyere. However, in this method, the combustion rate is improved, but since a combustion point moves to a furnace wall side by an increase in the combustion rate, heat removal from the furnace wall increases, and the thermal efficiency of the blast furnace decreases. Moreover, in this method, pressure loss of the tuyere due to rapid expansion of gas increases, the blast pressure increases, and the running cost increases.

[0007] An object of this invention is to provide a method for operating a blast furnace capable of improving a combustion rate of the solid reducing material without causing heat removal and pressure loss.

[0003] In this respect, Patent Document 1 suggests a method for improving the combustion rate of the pulverized coal by mixed-combustion of liquefied natural gas (LNG) and the pulverized coal. Further, Patent Document 2 suggests a method for promoting the combustion of the pulverized coal by the volatile matter content by using the pulverized coal having a high volatile matter content. Patent Document 3 suggests a method for coping by providing a reduced-diameter portion in the tuyere. Patent Document 4 suggests a method for improving combustibility of the pulverized coal by simultaneously blowing the solid reducing material and oxygen from the tuyere lance. Furthermore, Patent Document 5 suggests a method for improving the combustion efficiency of the pulverized coal by increasing the temperature of oxygen, when oxygen is used for the purpose of improving the combustion rate of the pulverized coal.

MEANS FOR SOLVING THE PROBLEM

[0008] As a method for achieving the above-described object, this invention provides a method for operating a blast furnace in which a solid reducing material is charged from a furnace top and also blown from a tuyere via a lance, in which, when a blowing amount of the solid reducing material blown from the tuyere is not less than 150 kg/t per ton of pig iron, a double tube lance is used as the lance to blow the solid reducing material from an inner tube and blow oxygen of not higher than 100°C from between the inner tube and an outer tube, and a material having an average volatile matter content of more than 25 mass% and not more than 50 mass% is used as the blowing solid reducing material.

[0009] Incidentally, as described above, Patent Document 4 suggests a method for simultaneously blowing the solid reducing material (pulverized coal) and oxygen into the blast furnace from the tuyere, thereby improving the combustibility of the pulverized coal. However, in this method, the pulverized coal having a low volatile matter content is used. The reason is that since the pulverized coal having a low volatile matter content has high amount of heat, when using such a low volatile matter content coal, it is possible to improve the combustibility in the furnace bottom, and additionally, it is possible to reduce the coke used for temperature maintenance of the fur-

PRIOR ART DOCUMENTS**PATENT DOCUMENT****[0004]**

Patent Document 1: JP 2006-233332 A
 Patent Document 2: JP 2002-241815 A
 Patent Document 3: JP 3644856 B1
 Patent Document 4: JP 4074467 B1

nace bottom.

[0010] However, when the blowing amount (hereinafter, referred to as a "pulverized coal ratio") of the pulverized coal from the tuyere per ton of pig iron is not less than 150 kg/t, or when a coke strength $[DI^{150}_{15}]$ is not more than 85%, since an increase in the furnace powder greatly contributes to the reduction agent ratio compared to the heat generation using the blown pulverized coal, it is advantageous to use the pulverized coal of a high volatile matter content.

[0011] Furthermore, the inventors have obtained the following knowledge in regard to the strength of the coke charged into the blast furnace from the blast furnace top. In the blast furnace operation, as the coke strength is low, it is easy to generate the coke powder of not more than 15 mm under the influence of load and friction in the furnace. When the amount of the coke powder becomes greater than an amount consumed by a solution loss reaction (reaction in which solid carbon reacts with carbon dioxide to produce carbon monoxide), a part of the coke powder is deposited on a central region (hereinafter, referred to as a "furnace core") of the furnace bottom. If the amount of deposition of the coke powder increases, hot air blown from the tuyere passes through a furnace wall side, without passing through the furnace core part (hereinafter, this phenomenon is referred to as "drift"). When the flow of hot air is drifted to the furnace wall side in this way, an amount of heat removal from the furnace wall increases or the reaction efficiency between the reducing gas and ore decreases, which leads to an increase in the reduction agent ratio.

[0012] At this time, when the blown pulverized coal ratio from the tuyere increases, unburned char flowing into the furnace also increases. If the unburned char is predominantly consumed in the solution loss reaction, the amount of the coke powder deposited on the furnace core without being consumed in the solution loss increases. Thus, if the strength $[DI^{150}_{15} \text{ [\%]}]$ of coke charged from the blast furnace top is not more than 85, and the blowing amount of pulverized coal from the tuyere is not less than 150 kg/t (pig iron), it becomes possible to reduce an amount of inflow of unburned char into the furnace by improving the combustion rate of the pulverized coal, which is advantageous to reduce the reduction agent ratio.

[0013] In addition, Patent Document 5 discloses that raising the oxygen temperature is desirable for the combustion of pulverized coal. However, in the case of considering the durability of the lance, when raising the temperature of oxygen, as described below, the surface temperature of the lance also increases, and deformation or erosion of the lance occurs, which may cause trouble such as blowing failure of the pulverized coal or the tuyere wear. For that reason, it is desirable that the temperature of the oxygen blown from the lance is adjusted to a temperature below the temperature at which the deformation of the lance occurs.

[0014] From the above, it is preferred that the method

for operating the blast furnace according to this invention is configured as follows:

- (1) The solid reducing material charged from the furnace top is coke having strength: $[DI^{150}_{15} \text{ [\%]}]$ of not more than 85 measured by a test method described in JIS K2151;
- (2) As the blowing solid reducing material, a material, in which the solid reducing material having a volatile matter content of 30 mass% to 60 mass% is contained in amount of not less than 10 mass%, is used; and
- (3) The blowing solid reducing material is pulverized coal.

EFFECTS OF THE INVENTION

[0015] According to the method for operating a blast furnace of this invention, when the pulverized coal ratio is not less than 150 kg/t (pig iron: this will not be described below), and the strength $[DI^{150}_{15} \text{ [\%]}]$ of the coke charged from the furnace top of the blast furnace is not more than 85, the double tube lance is used to blow the solid reducing material from the inner tube thereof and blow oxygen of not higher than 100°C from between the inner tube and the outer tube, and as the solid reducing material at this time, a material having an average volatile matter content of more than 25 mass% and not more than 50 mass% is used. Accordingly, it is possible to improve a combustion rate of the solid reducing material, without causing heat removal from the furnace wall or pressure loss of the furnace bottom. As a result, when adopting the method of this invention, it is possible to achieve a reduction in the operating cost of the blast furnace, and a reduction in equipment cost.

BRIEF DESCRIPTION OF DRAWINGS

[0016]

[Fig. 1] is a longitudinal cross-sectional view illustrating an embodiment of a blast furnace to which a method for operating the blast furnace of this invention is applied.

[FIG. 2] is an explanatory view of each combustion state when only the pulverized coal is blown from a lance.

[FIG. 3] is an explanatory view of a combustion mechanism at the time of blowing the pulverized coal.

[FIG. 4] is an explanatory view of a combustion mechanism at the time of blowing the pulverized coal having a high volatile matter content.

[FIG. 5] is an explanatory view of a combustion mechanism when the pulverized coal having a high volatile matter content and cold oxygen are simultaneously blown.

[FIG. 6] is an explanatory view of a combustion test

device.

[FIG. 7] is a graph illustrating a relation between a volatile matter content of the pulverized coal and a combustion rate in a combustion test result.

[FIG. 8] is a graph illustrating a relation between a volatile matter content of the pulverized coal and an amount of heat removal from the furnace wall in a combustion test result.

[FIG. 9] is a graph illustrating a relation between a volatile matter content of the pulverized coal and a pressure loss of the furnace bottom in a combustion test result.

[FIG. 10] is a graph illustrating a relation between a pulverized coal ratio and a coke replacement rate.

[FIG. 11] is a graph illustrating a relation between a pulverized coal ratio and a coke replacement rate.

[FIG. 12] is a graph illustrating a relation between an oxygen temperature and a lance surface temperature.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0017] Hereinafter, an embodiment of a method for operating a blast furnace according to this invention will be described with reference to the accompanying drawings. FIG. 1 is an overall view of a blast furnace 1 to which the method for operating the blast furnace of this embodiment is applied. A tuyere 3 is disposed in a bosh part of the blast furnace 1, and a blast tube 2 for blowing hot air is connected to the tuyere 3. As illustrated in FIG. 2, a lance 4 for blowing the solid fuel or the like is attached to the blast tube 2. In a coke deposition layer portion of the furnace in front of a hot-air blowing direction from the tuyere 3, a combustion space called a raceway 5 is formed. Molten iron is primarily generated in the combustion space.

[0018] FIG. 2 is a diagram schematically illustrating a combustion state when only pulverized coal 6 as a solid reducing material is blown into the furnace from the lance 4 through the tuyere 3. As illustrated in this figure, the volatile matter content and the fixed carbon of the pulverized coal 6 blown into the raceway 5 from the lance 4 through the tuyere 3 are combusted with a furnace deposition coke 7, and aggregation of carbon and ash that remains without being completely combusted, that is, char is discharged as unburned char 8 from the raceways 5. In addition, the velocity of the hot wind in front of the hot-air blowing direction of the tuyere 3 is about 200 m/sec. Meanwhile, a distance reaching the raceway 5 from the front end portion of the lance 4, that is, a region where O_2 is present is about 0.3 to 0.5 m. Thus, there is a need to cause the temperature rise of the blown pulverized coal particles, and the contact (dispersibility) between the pulverized coal and O_2 to react substantially in a short period of 1/1000 seconds.

[0019] FIG. 3 illustrates a combustion mechanism in a case where only the pulverized coal (PC (Pulverized

Coal) in the figure) 6 is blown into the blast tube 2 via the lance 4. Particles of the pulverized coal 6 blown into the raceway 5 from the tuyere 3 are heated by radiation heat transfer from the flame of the raceway 5, the temperature of the particle sharply rises by the radiation heat transfer and the conduction heat transfer, thermal decomposition starts from a point of time at which the temperature rises to not lower than 300°C, and the volatile matter content is ignited and combusted (flame is formed) and a temperature of 1400 to 1700°C is achieved. The pulverized coal from which the volatile matter content is released becomes the char 8. Since the char 8 mainly consists of fixed carbon, carbon dissolution reaction also occurs together with the combustion reaction.

[0020] FIG. 4 illustrates a combustion mechanism in a case where the pulverized coal 6 having a high volatile matter content is blown into the blast tube 2 via the lance 4. In a case where the pulverized coal 6 having a high volatile matter content is blown in this way, ignition of the pulverized coal 6 is promoted by an increase in the volatile matter content, and an increase in the amount of combustion due to the volatile matter content occurs. As a result, the temperature rising rate and the maximum temperature of the pulverized coal increase, dispersibility of the pulverized coal increases, and the reaction velocity of the char is enhanced by the elevation of temperature. At this time, the pulverized coal 6 is dispersed by vaporization expansion of volatile matter content and causes the combustion of volatile matter content, and the pulverized coal itself is rapidly heated and the temperature rises by the combustion heat. Moreover, since the combustion of the pulverized coal in this case occurs at a position close to the furnace wall, the heat removal from the tuyere 3 and the pressure loss in the furnace increase.

[0021] FIG. 5 illustrates a combustion mechanism in a case where the pulverized coal 6 having a high volatile matter content and low-temperature oxygen (hereinafter, referred to as "cold oxygen") of not higher than 100°C are simultaneously blown into the blast tube 2 from the lance 4. When the pulverized coal 6 having a high volatile matter content and the cold oxygen are simultaneously blown in this way, the temperature rising rate of the pulverized coal drops by the effect of the cold oxygen, and the ignition is delayed. However, thereafter, the combustion velocity of the volatile matter content increases by the high oxygen concentration in the vicinity of the pulverized coal, at the same time, the temperature rise of the pulverized coal is also promoted, the temperature of pulverized coal rises, and thus, the reaction velocity of the char increases. Thus, when blowing the cold oxygen, the temperature rising rate of the pulverized coal initially drops and the combustion is delayed, but since the oxygen concentration in the vicinity of the pulverized coal is high as described above, when the temperature of the pulverized coal becomes a certain level or higher, the pulverized coal is rapidly combusted soon, and finally, the combustion rate of the pulverized coal rather improves. The improvement in the combustion rate, and

the prevention of increases in the heat removal from the furnace wall and the furnace pressure loss caused by the combustion delay are achieved by such a mechanism. That is, by setting the temperature of oxygen blown from the lance 4 to not higher than 100°C, it is possible to prevent the deformation or the erosion of the lance in the case of supplying high-temperature oxygen, and an increase in pressure loss of the blast tube 2 due to a rapid combustion, and it is possible to achieve both the effect of improving the combustion rate and the effect of preventing the heat removal from the furnace wall.

[0022] The inventors have performed a combustion test using a combustion test device simulating a blast furnace illustrated in FIG. 6, based on this knowledge. A test furnace 11 used in the test device is such that coke is filled inside and a viewing window is provided to be able to observe the interior of the raceway 15. Moreover, a blast tube 12 is also attached to the test furnace 11, hot air generated in a combustion burner 13 externally installed can be blown into the test furnace 11 via the blast tube 12, and it is possible to adjust the amount of oxygen enrichment during the blast. In addition, the lance 14 is inserted into the blast tube 12. The lance 14 is used to blow one or both of the pulverized coal and oxygen into the blast tube 12. Exhaust gas occurring within the test furnace 11 is separated into exhaust gas and dust via a separation device 16 called a cyclone, the exhaust gas is sent to an exhaust gas treatment apparatus such as a combustion-assisting furnace, and the dust is collected to a collection box 17.

[0023] Upon combustion test using the above-described device, a single tube lance and a double tube lance were used as the lance 14. In the test, the combustion rate, the tuyere heat removal, the furnace pressure loss and the like were measured, for each of a case where only the pulverized coal is blown using the single tube lance and a case where the pulverized coal and oxygen are simultaneously blown using the double tube lance. The combustion rate was determined from a weight change by recovering the unburned char by a probe from the rear of the raceway 15. The used pulverized coal was fixed carbon (FC: Fixed Carbon) of 40 to 80 mass%, volatile matter content (VM: Volatile Matter) of 10 to 50 vol.%, and an ash content (Ash) of 7 to 12 mass%, and blowing conditions were 50 kg/h (corresponding to 158 kg/t in the molten iron basic unit). In addition, blowing conditions of oxygen from the lance 14 were 12 Nm³/h (corresponding to 3% oxygen enrichment). Coke of [D1¹⁵⁰₁₅ [%]] 83 in the test method described in JIS K2151 was used. Conditions of the blast were the blast temperature: 1200°C, the flow rate: 350 Nm³/h, and the flow velocity: 80 m/s, and O₂ enrichment was +3.7 (oxygen concentration 24.7%, enrichment of 3.7% with respect to oxygen concentration 21 % in the air).

[0024] As evaluation of the test results, by variously changing the volatile matter content of the pulverized coal, the combustion rate, the heat removal from the

tuyere, and the furnace pressure loss when blowing only the pulverized coal from the single tube lance (using N₂ as a medium), and the combustion rate, the heat removal from the tuyere, and the furnace pressure loss when simultaneously blowing the pulverized coal and oxygen using the double tube lance were evaluated.

[0025] FIG. 7 is a graph illustrating a relation between the volatile matter content of the blown pulverized coal and the combustion rate. As illustrated in this figure, when blowing only the pulverized coal (high volatile matter content coal) from the single tube lance, the combustion rate began to significantly rise from 25 mass% of the volatile matter content of the pulverized coal, it became maximum at 45 mass%, and an effect of combustion rate improvement was saturated at not less than 45 mass%. It is thought that this is because the heat generated by the combustion of the volatile matter content escapes to the air blast in the range of the volatile matter content of not less than 45 mass%, heat used for raising the temperature of the pulverized coal reaches a peak, and the combustion velocity does not increase above the level.

[0026] In contrast, in the relation between the pulverized coal and the combustion rate, in the case of simultaneously blowing the pulverized coal (high volatility dispersion) and cold oxygen using the double tube lance, the combustion rate is generally improved, compared to the case of blowing only the pulverized coal from the single tube lance. The reason is that the combustion velocity of the pulverized coal increases by an increase in the oxygen concentration in the vicinity of the pulverized coal.

[0027] FIG. 8 is a diagram illustrating a relation between the volatile matter content of the pulverized coal and the tuyere heat removal. As illustrated in FIG. 8, when blowing only the pulverized coal from the single tube lance, heat removal from the furnace wall increases with an increase in volatile matter content. It is thought that this is because the combustion velocity of the pulverized coal increases by an increase in volatile matter content, and combustion point is shifted to the furnace wall side.

[0028] In contrast, in the relation between the volatile matter content of the pulverized coal and the tuyere heat removal, in the case of simultaneously blowing the pulverized coal (high volatility dispersion) of a high volatile matter content and cold oxygen using the double tube lance, the heat removal from the furnace wall generally decreases, as compared to the case of blowing only the pulverized coal from the single tube lance. The reason is that the temperature rising rate of the pulverized coal decreases by cold oxygen, and the combustion point is shifted to the furnace interior side.

[0029] In addition, cold oxygen (oxygen of not higher than 100°C to be blown from the lance) used in the above-described test was prepared as follows. That is, the cold oxygen blown from the lance was used such that the cold oxygen obtained by a cryogenic separation process becomes not higher than 20°C in the lance portion. In addition, since the front end portion of the lance is inserted

into the high-temperature blast tube 2, the front end portion is affected by the hot air in the blast tube 2 and heat from the wall surface of the blast tube 2. Therefore, the temperature of oxygen blown from the lance inevitably rises, but since oxygen obtained by the cryogenic separation is supplied to the lance while remaining in a low temperature, after all, the temperature of oxygen blown from the lance can be set to not higher than 100°C. Also, by adjusting the insertion depth of the lance into the blast tube 2, it is also possible to adjust the temperature of oxygen supplied from the lance. When the temperature of oxygen blown from the lance can be adjusted to not higher than 100°C by adjustment of the insertion depth of the lance, there is no need to set the supply oxygen temperature to the lance to not higher than 20°C.

[0030] FIG. 9 is a diagram illustrating a relation between the volatile matter content of the blown pulverized coal and the furnace pressure loss. As illustrated in FIG. 9, in the case of blowing only the pulverized coal from the single tube lance, a pressure loss of the furnace bottom decreases with an increase in volatile matter content up to the volatile matter content of 29 mass%, and increases with an increase in the volatile matter content in the range of not less than 29 mass%. This is because the air permeability of the furnace improves by a decrease in unburned content up to the volatile matter content of 29 mass%, whereas the combustion gas flows to be inclined to the furnace wall in the volatile matter content of not less than 29 mass%.

[0031] In contrast, in the relation between the volatile matter content of the pulverized coal and the furnace pressure, in the case of simultaneously blowing the pulverized coal having a high volatile matter content and cold oxygen using the double tube lance, as compared to the case of blowing only the pulverized coal using the single tube lance, the pressure loss of the furnace bottom is generally lowered, thereby maintaining a low pressure loss, particularly when blowing the pulverized coal having the volatile matter content of not less than 30 mass%. This is because the temperature rising rate of the pulverized coal is lowered by cold oxygen, and the drift of the gas is suppressed by transition of the combustion point to the furnace interior side. From this fact, in the solid reducing material (pulverized coal) having an average volatile matter content of 25 to 50 mass, by mixing the solid reducing material (pulverized coal) having the volatile matter content of 30 to 60 mass% in amount of not less than 10% in terms of weight percentage, the pressure loss reduction effect can be reliably obtained.

[0032] FIGs. 10 and 11 are graphs illustrating a relation between the pulverized coal ratio and the coke replacement rate. Here, the coke replacement rate is a coke ratio (kg/t) capable of being reduced in a case where the pulverized coal ratio increases by 1 kg/t in the blast furnace operation. The coke replacement rate decreases by an increase in the pulverized coal ratio, but this is because the amount of coke powder deposited on the furnace core increases by an increase in unburned content of the

pulverized coal in the furnace, the furnace gas flows to be inclined to the furnace wall side, and thus the reaction and the heat exchange efficiency of the furnace decrease.

[0033] As illustrated in FIG. 10, in a case where the strength $[DI^{150}_{15} \text{ [\%]}]$ of the coke charged into the blast furnace is not more than 85, when the pulverized coal ratio blown from the tuyere is not more than 150 kg/t, the coke replacement rate due to the pulverized coal is maintained at a high level, but when the pulverized coal ratio exceeds 150 kg/t, the replacement rate of coke due to the pulverized coal is lowered. That is, if the pulverized coal ratio exceeds 150 kg/t, when using the pulverized coal (solid reducing material) having an average volatile matter content exceeding 25 mass% referred to in this invention, a high coke replacement rate can be maintained. This means that, under the condition that the pulverized coal ratio is small, that is, the furnace gas does not drift, combustion of the pulverized coal on the furnace wall side, that is, in the vicinity of the tuyere is not promoted, the amount of heat in the vicinity of the tuyere is small even if the volatile matter content of the pulverized coal increases, and thus, the coke replacement rate is small.

[0034] In contrast, the reason is that, under the condition that the pulverized coal ratio is large, that is, the furnace gas drifts, since the combustion of the pulverized coal on the furnace wall side, that is, in the vicinity of the tuyere is promoted, the higher the volatile matter content of the pulverized coal is, the higher the combustion rate is, and thus, the pulverized coal reduces to consequentially suppress the drift of the furnace gas, and the reduction in coke replacement rate is shifted to a high pulverized coal ratio side.

[0035] Meanwhile, as illustrated in FIG. 11, in a case where the coke strength $[DI^{150}_{15} \text{ [\%]}]$ is not less than 85, a case where the average volatile matter content of the pulverized coal exceeds 25 mass% always has a high coke replacement rate, compared to a case where the average volatile matter content is not more than 25 mass%. This is because the larger the coke strength $[DI^{150}_{15} \text{ [\%]}]$ is, the smaller the proportion of coke powder in the furnace is, the drift in the furnace gas is suppressed, and thus, the effect of combustion rate improvement is lowered. In addition, FIGs. 10 and 11 illustrate a relation between the pulverized coal ratio and the coke replacement rate when using cold oxygen in this invention.

[0036] FIG. 12 is a graph illustrating a relation between the temperature of oxygen blown from the lance and the lance surface temperature. As can be seen from FIG. 12, the lance surface temperature also increases with an increase in temperature of oxygen. In this case, when using the double tube lance, if the surface temperature of the double tube lance exceeds 880°C, creep deformation occurs and the tube is bent, or corrosion of the lance also occurs. In addition, when the supply temperature of oxygen blown from the lance exceeds 100°C, since the surface temperature of the lance exceeds 880°C, there is a

risk of deformation or corrosion of the lance. For this reason, it is required to set the temperature of oxygen blown from the lance to not higher than 100°C.

[0037] As described above, in the method for operating the blast furnace according to this invention, when blowing the pulverized coal (solid reducing material) from the tuyere, the lance is used as a double tube to blow the pulverized coal (solid reducing material) from the inner tube, and blow oxygen of not higher than 100°C from between the inner tube and the outer tube, and the pulverized coal (solid reducing material) having an average volatile matter content of more than 25 mass% and not more than 50 mass% blown through the lance is used. Thus, it is possible to improve the combustion rate of the pulverized coal (solid reducing material) without increasing the heat removal and the pressure loss, and thus, it is possible to improve the coke replacement rate.

DESCRIPTION OF REFERENCE SYMBOLS

[0038]

- | | | |
|----|---|----|
| 1: | blast furnace | |
| 2: | blast tube | |
| 3: | tuyere | 25 |
| 4: | lance | |
| 5: | raceway | |
| 6: | pulverized coal (solid reducing material) | |
| 7: | coke | |
| 8: | char | 30 |

Claims

1. A method for operating a blast furnace in which a solid reducing material is charged from a furnace top and is also blown from a tuyere via a lance, wherein, when a blowing amount of the solid reducing material blown from the tuyere is not less than 150 kg/t per ton of pig iron, a double tube lance is used as the lance to blow the solid reducing material from an inner tube, and blow oxygen of not higher than 100°C from between the inner tube and an outer tube, and a material having an average volatile matter content of more than 25 mass% and not more than 50 mass% is used as the blowing solid reducing material.
2. The method for operating the blast furnace according to claim 1, wherein the solid reducing material charged from the furnace top is coke having strength: $[DI^{150}_{15} \text{ [\%]}]$ of not more than 85 measured by a test method described in JIS K2151.
3. The method for operating the blast furnace according to claim 2, wherein, as the blowing solid reducing material, a material, in which the solid reducing material having a volatile matter content of 30 mass% to 60 mass% is contained in amount of not less than

10 mass%, is used.

4. The method for operating the blast furnace according to claim 3, wherein the blowing solid reducing material is pulverized coal.

FIG. 1

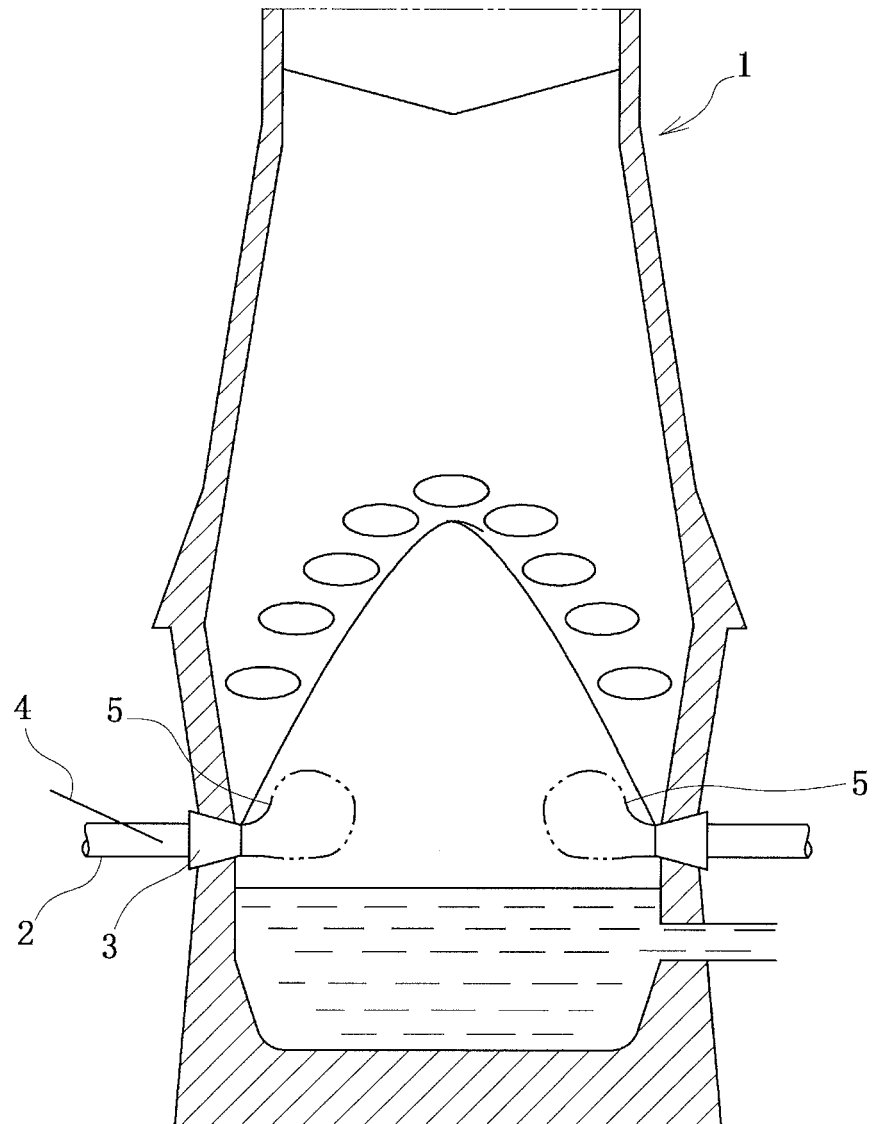


FIG. 2

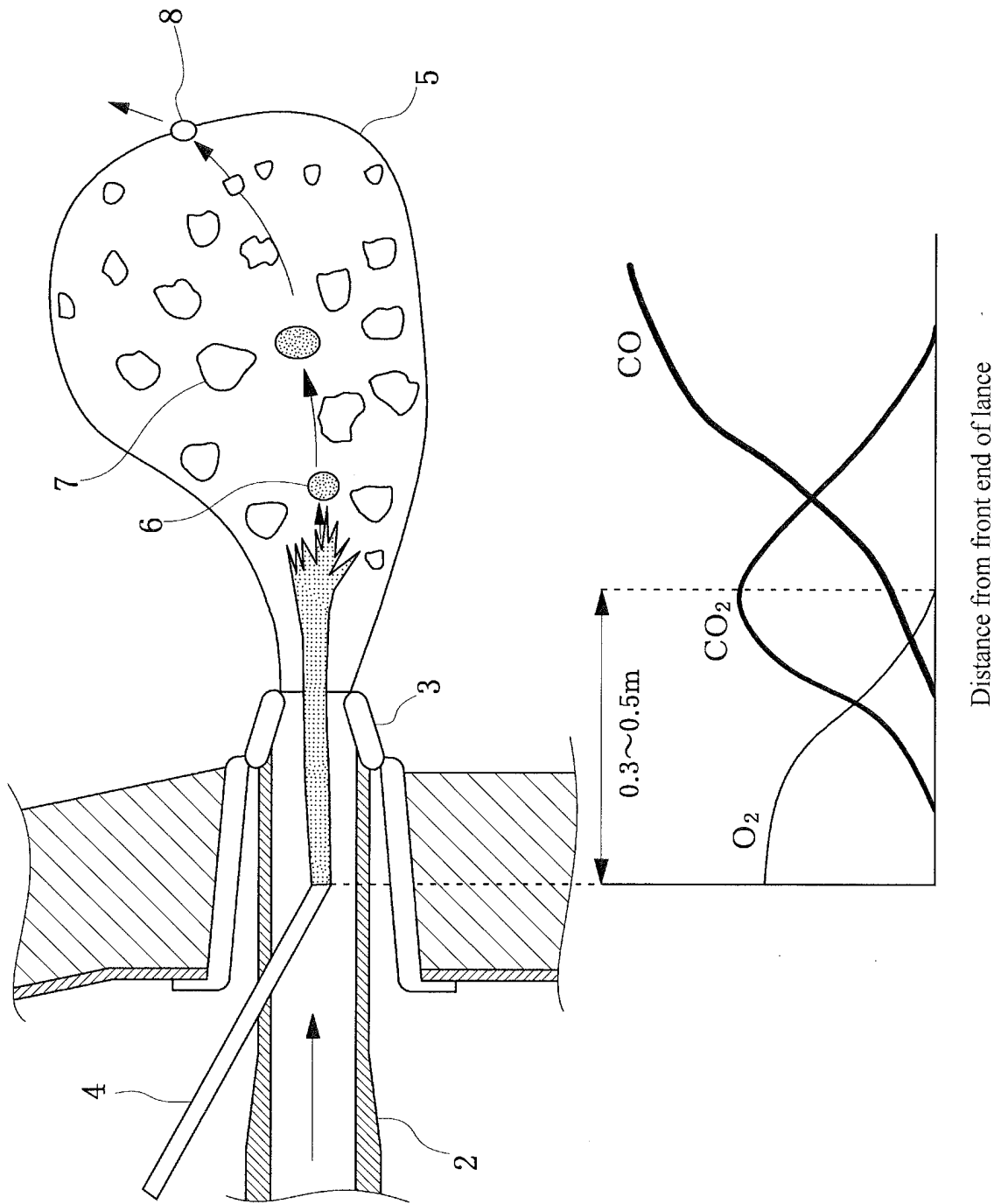


FIG. 3

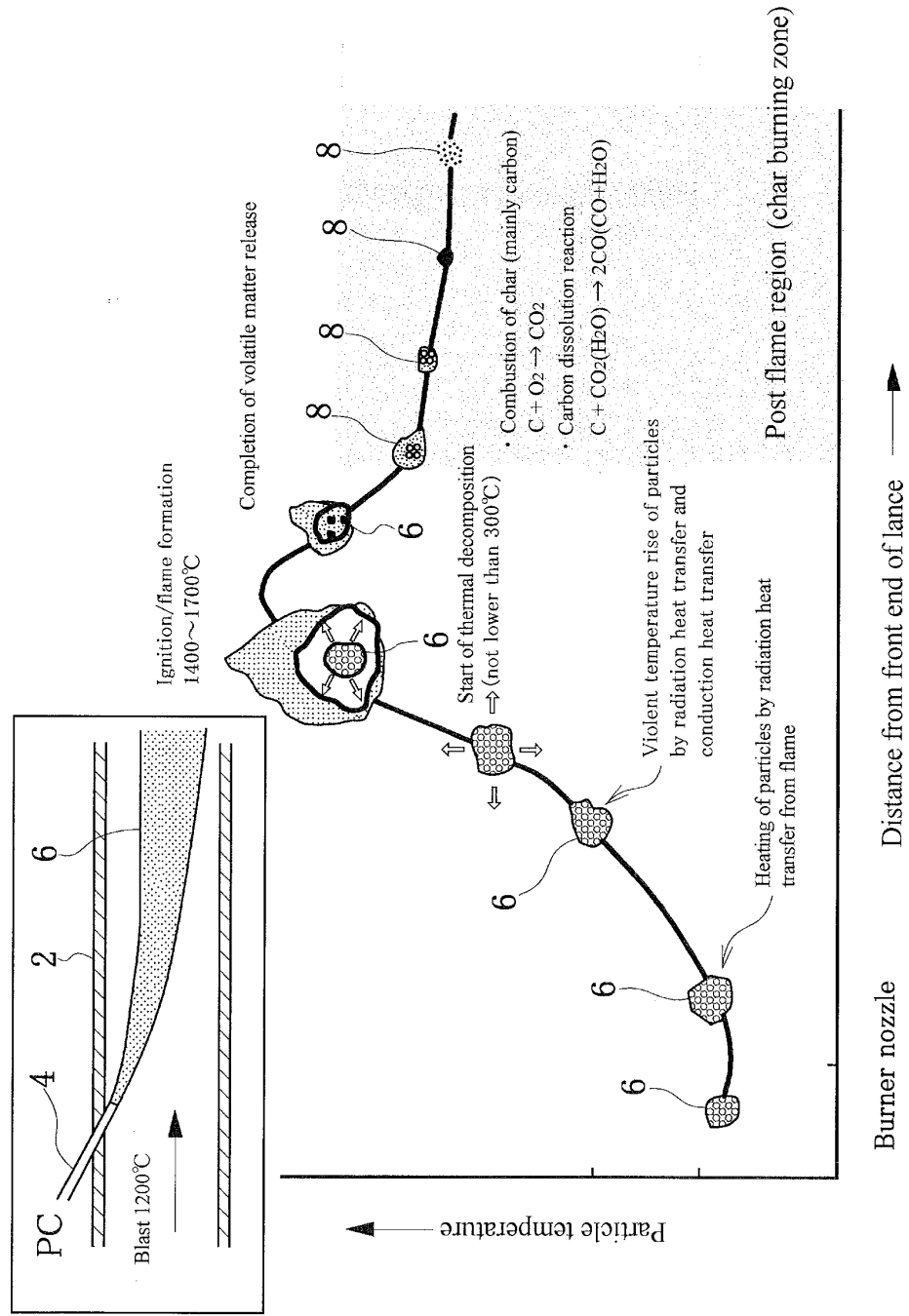


FIG. 4

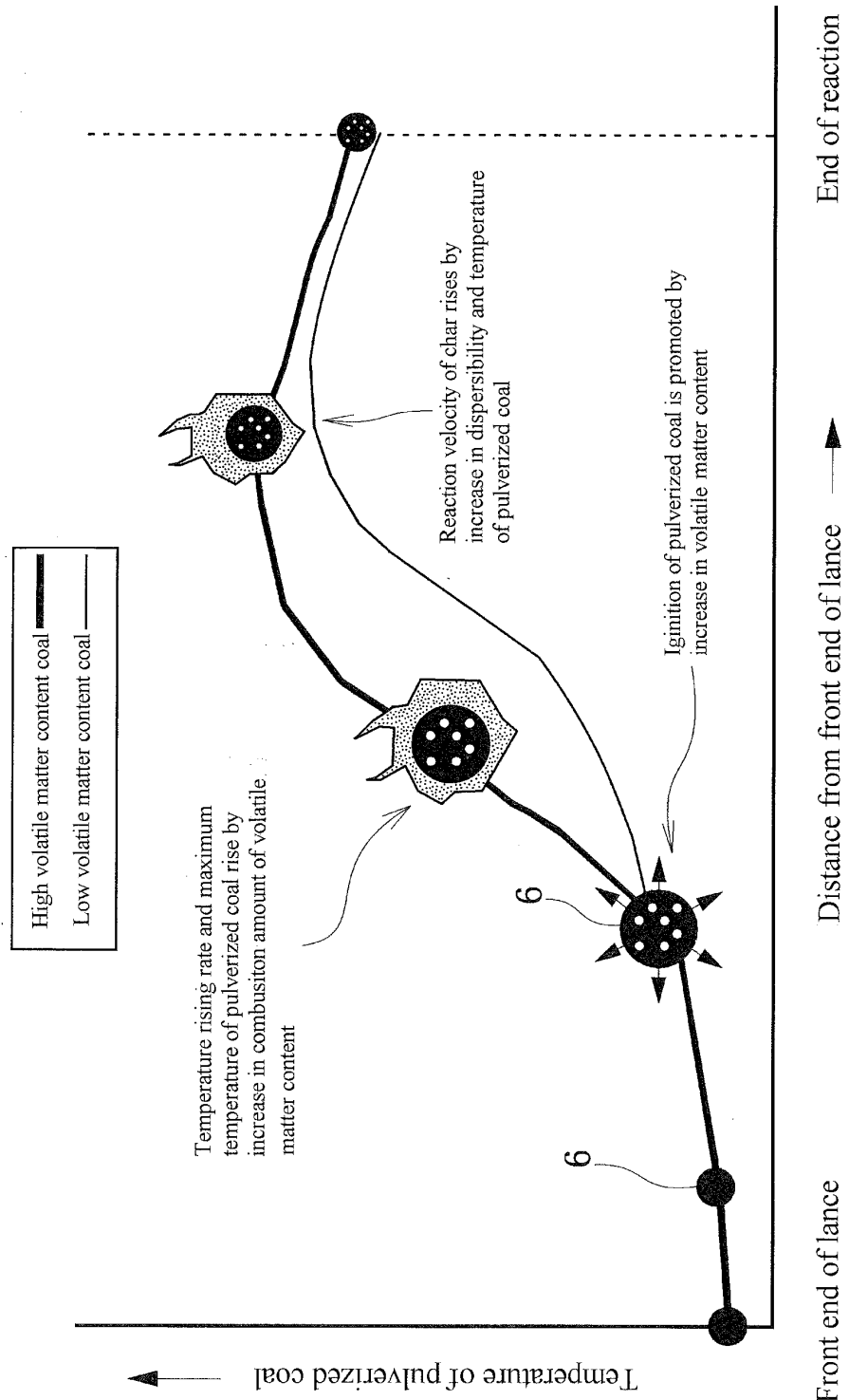


FIG. 5

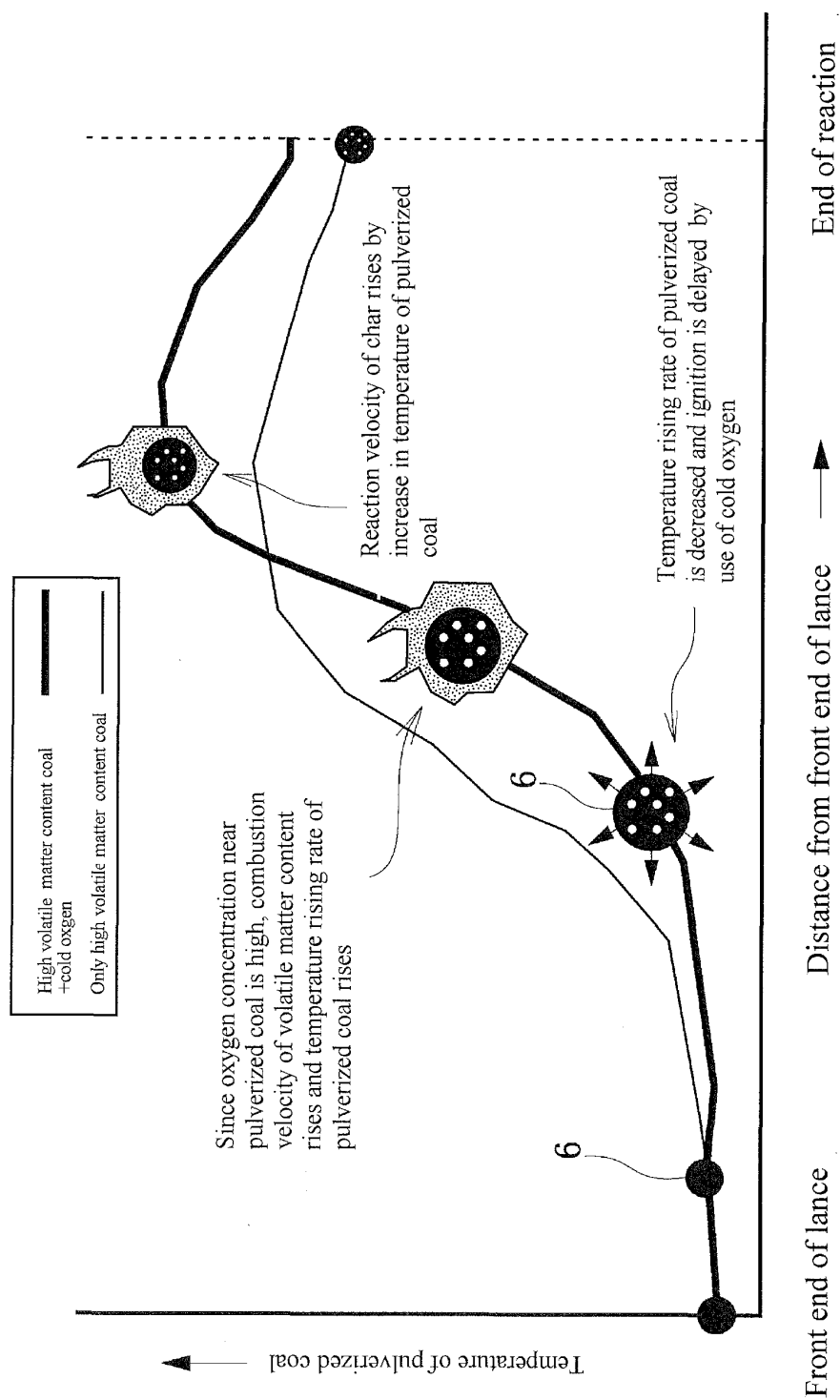


FIG. 6

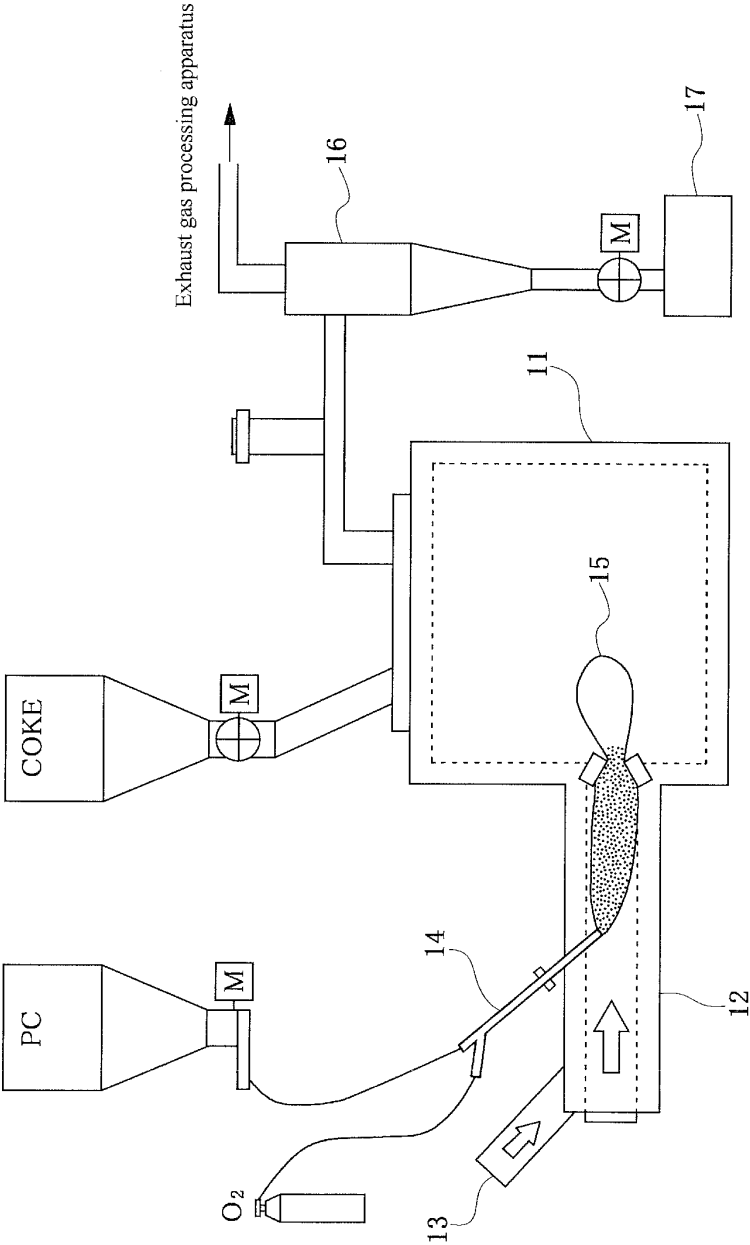


FIG. 7

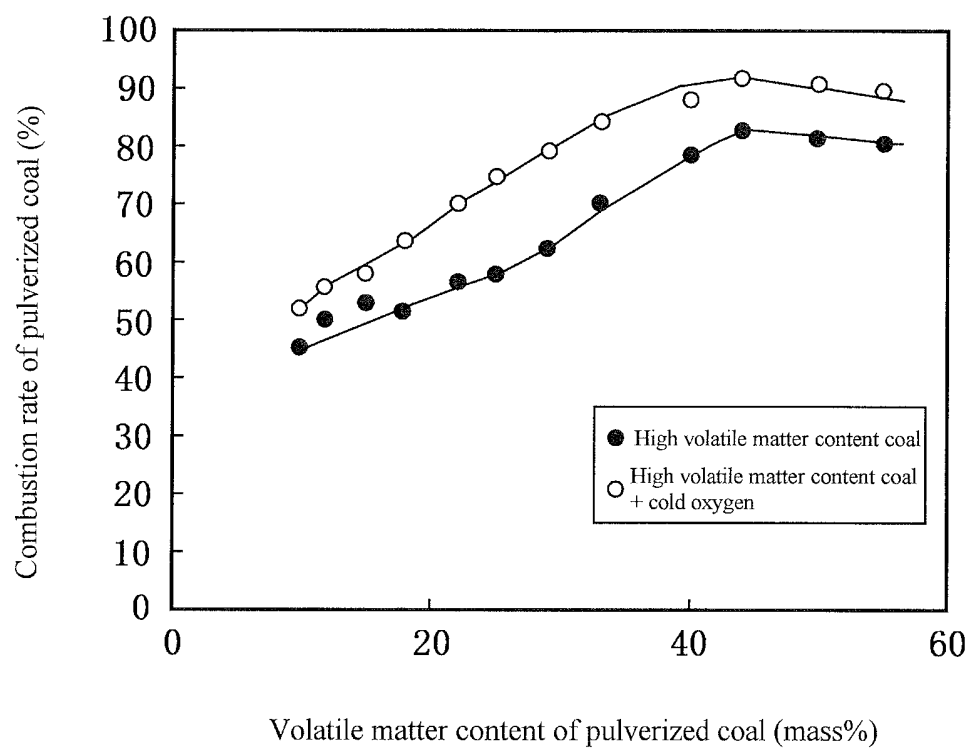


FIG. 8

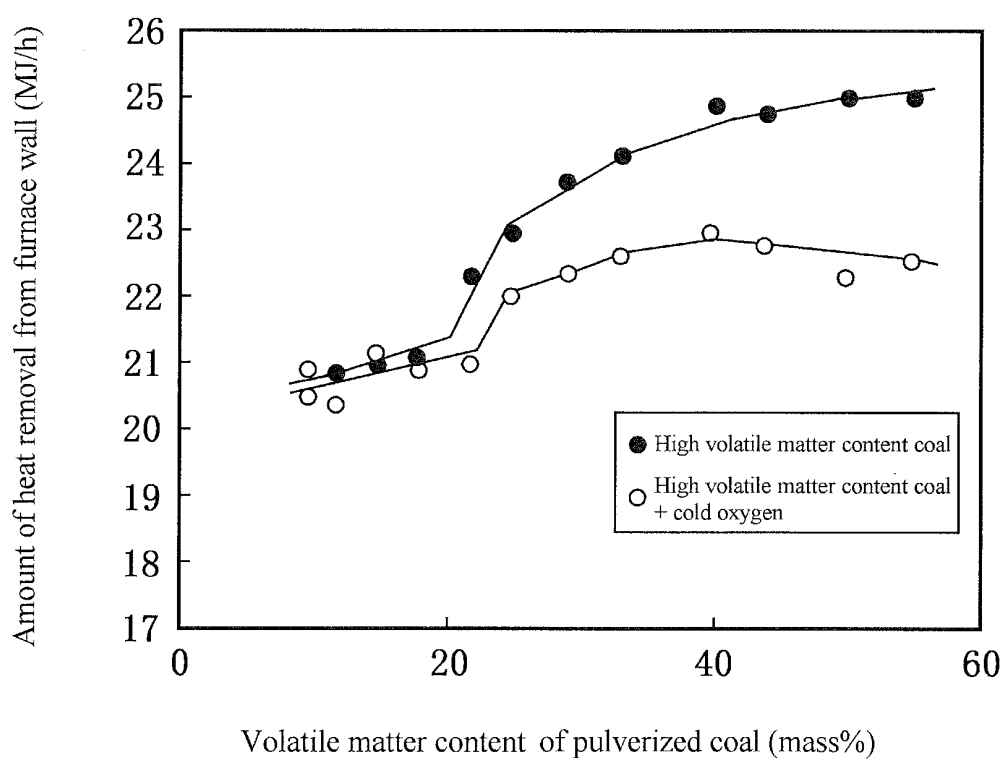


FIG. 9

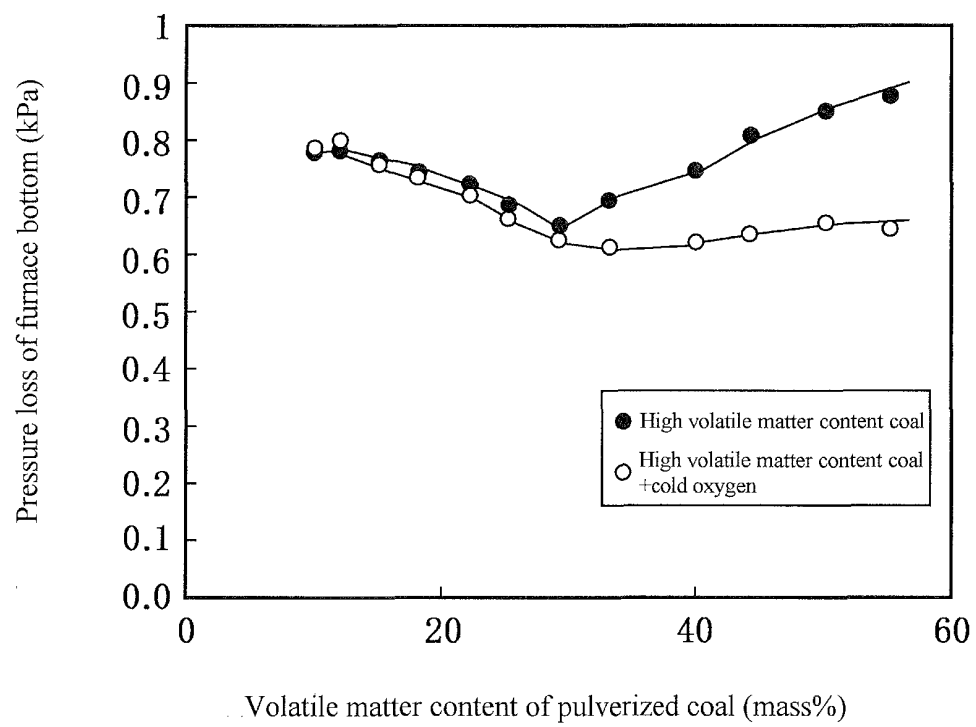


FIG. 10

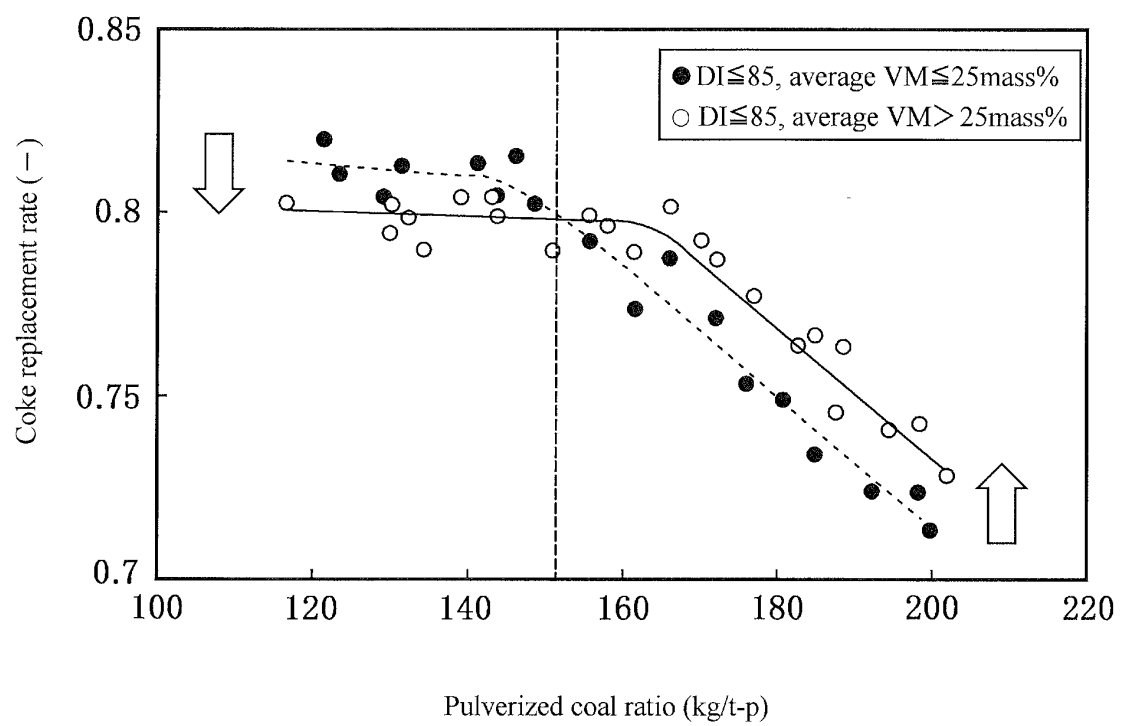


FIG. 11

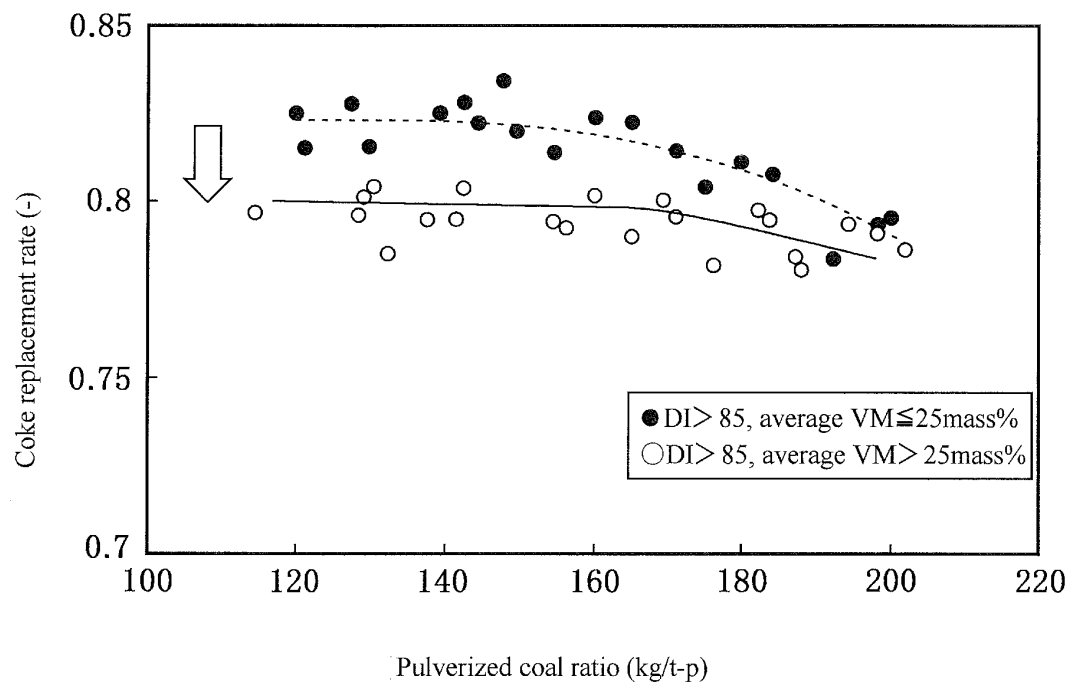
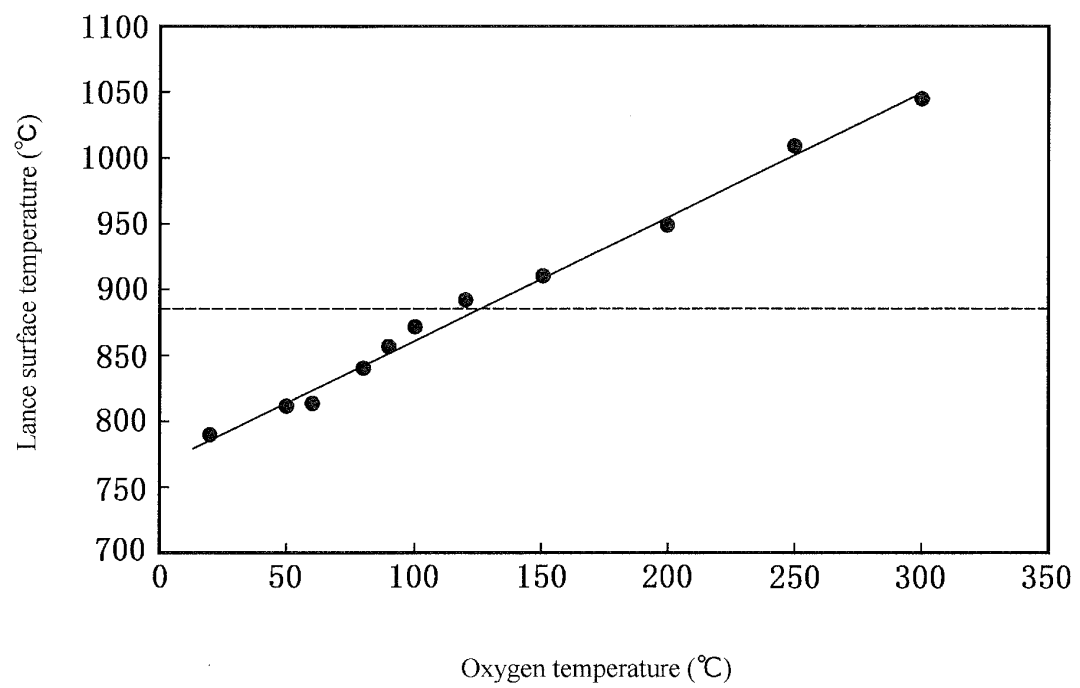


FIG. 12



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/067788

A. CLASSIFICATION OF SUBJECT MATTER

C21B5/00(2006.01) i, C21B7/00(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)

C21B5/00, C21B7/00

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	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

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 2011-127176 A (Kobe Steel, Ltd.), 30 June 2011 (30.06.2011), (Family: none)	1-4
A	JP 2006-241493 A (JFE Steel Corp.), 14 September 2006 (14.09.2006), (Family: none)	1-4
A	JP 2005-82852 A (Nippon Steel Corp.), 31 March 2005 (31.03.2005), (Family: none)	1-4
A	JP 10-310808 A (NKK Corp.), 24 November 1998 (24.11.1998), (Family: none)	1-4



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
11 July, 2013 (11.07.13)Date of mailing of the international search report
23 July, 2013 (23.07.13)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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