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

(11) **EP 2 840 152 A1**

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

(43) Date of publication:
25.02.2015 Bulletin 2015/09

(21) Application number: **12878418.8**

(22) Date of filing: **06.06.2012**

(51) Int Cl.:
C21B 5/00 *(2006.01)* ***C22B 1/245*** *(2006.01)*

(86) International application number:
PCT/JP2012/065056

(87) International publication number:
WO 2013/183170 (12.12.2013 Gazette 2013/50)

(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

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

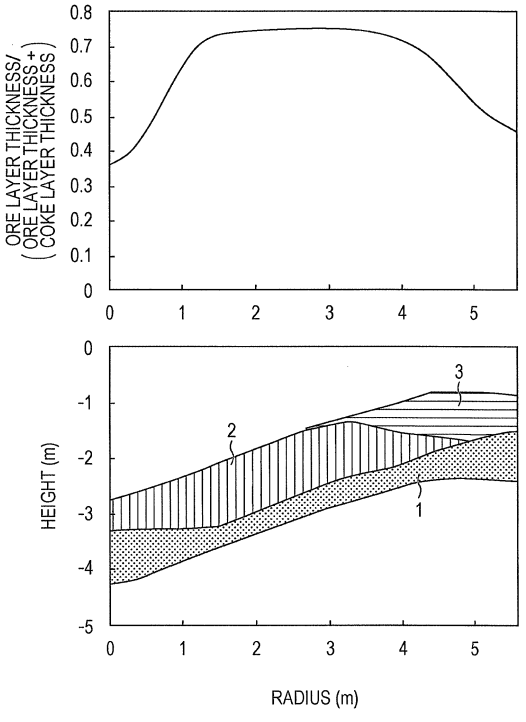
(72) Inventors:
- **SATO, Takeshi**
  Tokyo 100-0011 (JP)
- **SUMI, Hiroyuki**
  Tokyo 100-0011 (JP)
- **FUJIMOTO, Hidekazu**
  Tokyo 100-0011 (JP)
- **ANYASHIKI, Takashi**
  Tokyo 100-0011 (JP)
- **SATO, Hideaki**
  Tokyo 100-0011 (JP)

(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(54) BLAST FURNACE OPERATION METHOD USING FERROCOKE

(57) In a method for operating a blast furnace by forming a coke layer 1 and an ore layer in a blast furnace, an ore layer is formed as ore layer 2 and 3 of a plurality of batches including two or more batches, the carbon iron composite is mixed into the ore layer of at least one batch among the plurality of batches but not into at least another batch. In operation during which an ore layer thickness ratio, i.e., ore layer thickness/(ore layer thickness + coke layer thickness), is varied in a furnace radius direction, the furnace radius direction position preferably varies among ore layers of the plurality of batches and the carbon iron composite is preferably mixed into an ore layer 2 of a batch at a furnace radius direction position where the ore layer thickness ratio is relatively large.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a method for operating a blast furnace using carbon iron composite produced by briquetting a mixture of coal and iron ore and carbonizing the briquetted material.

Background Art

[0002] In order to decrease the reducing agent rate of a blast furnace, it is effective to use carbon iron composite as a blast furnace material and to utilize the effect of lowering the temperature of the thermal reserve zone in the blast furnace induced by the carbon iron composite (for example, see Patent Literature 1). Carbon iron composite produced by carbonizing a briquetted material prepared by briquetting a mixture of coal and iron ore has high reactivity, accelerates reduction of sintered ore, can decrease the thermal reserve zone temperature of the blast furnace since reduced iron ore is partly contained, and thus can decrease the reducing agent rate.

[0003] An example of a method for operating a blast furnace using carbon iron composite is disclosed in Patent Literature 1, in which ore and carbon iron composite are mixed and charged into a blast furnace.

[0004] Compared to conventional metallurgical coke produced by carbonizing coal in a coke oven or the like, carbon iron composite is characterized by its high reactivity with CO_2 gas shown in formula (a) below. Metallurgical coke is hereinafter referred to as "conventional coke" to distinguish from the carbon iron composite. The reaction of formula (a) is a reaction through which CO_2 generated by reduction of ore shown in formula (b) below is recycled into CO gas having a reducing ability.

$$CO_2 + C \rightarrow 2CO \qquad (a)$$

$$FeO + CO \rightarrow Fe + CO_2 \qquad (b)$$

Accordingly, when the reaction represented by formula (a) occurs rapidly in a region where the CO_2 gas concentration is increased through the reaction represented by formula (b), the CO_2 gas is recycled into CO gas having a reducing ability and the reduction of ore is accelerated.

[0005] The region with a high CO_2 gas concentration in the blast furnace is closely related to the gas distribution in the radius direction. Control of gas flow in a radius direction of a blast furnace is a critical operational item that affects permeability and reducing performance. Iron raw materials such as sintered ore, lump ore, and pellets have smaller grain size than the conventional coke produced in a chamber-type coke oven and become fused at high temperature; thus, permeation resistance is increased in a region where the amount of ore is large with respect to the amount of the conventional coke in the radius direction, namely, where the ore/coke amount ratio is high, thereby inhibiting gas flow. Accordingly, the gas flow in the radius direction is controlled by introducing a deviation in the ore/coke amount ratio in the radius direction. In the region where the ore/coke amount ratio is high, the ore/reducing gas amount ratio is increased. As a result, the proportion of CO gas in the furnace gas turning into CO_2 by the reaction represented by formula (b) is increased and the CO_2 gas concentration is increased. Iron raw materials such as sintered ore, lump ore, pellets, and the like are hereinafter referred to as "ore".

[0006] In the layer height direction within the ore layer formed each time the raw materials are charged, part of CO in the reducing gas ascending from below turns into CO_2 as a result of ore reduction; accordingly, the CO_2 concentration is higher in the upper layer if the radius position is the same (for example, refer to Non Patent Literature 1).

[0007] Selectively placing the carbon iron composite in the region with a high CO_2 concentration will accelerate gasification reaction of the carbon iron composite and improvements in reduction degree and a decrease in reducing agent rate can be expected as a result.

Citation List

Patent Literature

[0008] [PTL 1] Japanese Unexamined Patent Application Publication No. 2006-28594

Non Patent Literature

[0009] [NPL 1] Zairyo to Purosesu [Materials and Processes] 13, 2000, p. 893

Summary of Invention

Technical Problem

[0010] In order to yield the high reactivity of the carbon iron composite, that is, in order to rapidly convert CO_2 gas into CO gas, during operation of a blast furnace using the carbon iron composite, it is considered preferable to distribute the carbon iron composite so that the concentration of the carbon iron composite is high in the region with a high CO_2 concentration.

[0011] The gas distribution in the radius direction of the blast furnace is generally controlled by adjusting the ore/coke amount ratio in the radius direction. The region where the ore/coke amount ratio is high corresponds to the region with a high CO_2 concentration. In the case where carbon iron composite is used by being mixed into the ore layer and the carbon iron composite is uniformly mixed in all parts of the ore layer, it is difficult to increase the carbon iron composite ratio in the region where the ore/coke amount ratio is high.

[0012] In the layer height direction within the ore layer formed each time the raw materials are charged, part of CO in the reducing gas ascending from below turns into CO_2 as a result of ore reduction and thus the CO_2 concentration is increased in the upper layer. However, in the case where the carbon iron composite is uniformly mixed in the ore layer, the concentration of the carbon iron composite is not particularly high in the region with a high CO_2 concentration.

[0013] Accordingly, an object of the present invention is to address such issues of the related art and provide a method for operating a blast furnace using carbon iron composite, with which, when carbon iron composite is mixed with ore and used in a blast furnace, the carbon iron composite's function of recycling CO_2 generated by ore reduction into CO gas having a reducing property can be more effectively yielded.

Solution to Problem

[0014] The features of the present invention that address these issues are as follows:

(1) A method for operating a blast furnace using carbon iron composite by forming a coke layer and an ore layer in the blast furnace, the method including:

dividing ore into a plurarity of batches including two or more batches and charging the ore into a blast furnace to form an ore layer;
mixing the carbon iron composite into the ore layer of at least one batch in the ore layer formed by the plurality of batches; and
no carbon iron composite being mixed into the ore layer of at least another batch.

(2) The method for operating a blast furnace using the carbon iron composite according to (1), wherein
the ore is charged so that positions where the plurality of batches are charged vary in a furnace radius direction and an ore layer thickness ratio defined by ore layer thickness/(ore layer thickness + coke layer thickness) is varied in the furnace radius direction, and the carbon iron composite is mixed into an ore layer of a batch that has a relatively large ore layer thickness ratio.

(3) The method for operating a blast furnace using the carbon iron composite according to (1), wherein the ore is divided into two or more batches in a height direction of the ore layer and charged, and no carbon iron composite is mixed into at least an ore layer of a batch located at the bottom.

(4) The method for operating a blast furnace using the carbon iron composite according to (1), wherein the ore is divided into two batches in a height direction of the ore layer and charged so as to form an ore layer positioned in an upper portion and an ore layer positioned in a lower portion, and no carbon iron composite is mixed into the ore layer positioned in the lower portion.

(5) The method for operating a blast furnace using the carbon iron composite according to (1), wherein the ore is divided into three batches in a height direction of the ore layer and charged so as to form an ore layer positioned in an upper portion, an ore layer positioned in a middle portion, and an ore layer positioned in a lower portion, and no carbon iron composite is mixed into the ore layer positioned in the lower portion.

(6) The method for operating a blast furnace using the carbon iron composite according to any one of (1) to (3), wherein the carbon iron composite in the ore layer has a mixing ratio of 1% by mass or more relative to the ore.

(7) The method for operating a blast furnace using the carbon iron composite according to (6), wherein the mixing ratio is 1% by mass or more and 9% by mass or less.

(8) The method for operating a blast furnace using the carbon iron composite according to any one of (1) to (3), wherein an iron content of the carbon iron composite is 5% to 40% by mass.

(9) The method for operating a blast furnace using the carbon iron composite according to (8), wherein the iron

content of the carbon iron composite is 10% to 40% by mass. Advantageous Effects of Invention

[0015] According to the present invention, the concentration of the carbon iron composite can be increased in a blast furnace in a region where the CO_2 concentration is high, ore reduction can be accelerated through a gasification reaction of the carbon iron composite, and thus the reducing agent rate can be decreased.

Brief Description of Drawings

[0016]

[Fig. 1] Fig. 1A is a graph showing an ore layer thickness ratio in a radius direction in the case where the ore batch is divided into two in the radius direction and Fig. 1B is a schematic vertical sectional view of a blast furnace in which the ore layer thickness ratio is large in a middle portion.
[Fig. 2] Fig. 2A is a graph showing an ore layer thickness ratio in a radius direction in the case where the ore batch is divided into two in the radius direction and Fig. 2B is a schematic vertical sectional view of a blast furnace in which the ore layer thickness ratio is large in a peripheral portion.
[Fig. 3] Fig. 3A is a graph showing an ore layer thickness ratio in a radius direction in the case where the ore batch is divided into two in a layer height direction and Fig. 3B is a schematic vertical sectional view of a blast furnace.
[Fig. 4] Fig. 4 is a graph showing a relationship between the ratio of carbon iron composite used and the reduction degree of sintered ore.
[Fig. 5] Fig. 5 is a graph showing a relationship between the iron content in the carbon iron composite and the reaction start temperature.
[Fig. 6] Fig. 6A is a plan view and Fig. 6B is a front view schematically showing the shape of the carbon iron composite.

Description of Embodiments

[0017] In a typical blast furnace operation, conventional coke and ore are alternately charged from the furnace top so that coke layers and ore layers are alternately stacked inside the furnace. One known method for forming an ore layer by charging ore into the furnace is charging ore in several divided batches. This is necessary in some cases due to the limited capacity of the furnace top banker and, in other cases, employed as the means for controlling the grain size distribution in the radius direction achieved by introducing grain radius deviations among batches, for example. In the present invention, in forming an ore layer, the ore charge is divided into several batches and the amount of the carbon iron composite mixed is varied among batches so as to control the carbon iron composite mixing ratio in the radius direction and the layer height direction and increase the carbon iron composite ratio at a particular position. As a result, it becomes possible to increase the carbon iron composite ratio in the region where the CO_2 concentration is high. In other words, a blast furnace operation method that uses carbon iron composite includes forming a coke layer and an ore layer, in which the ore layer is formed as a plurality of batches ore layer divided into two or batches, carbon iron composite is mixed into at least one batch of an ore layer in the plurality of batches ore layer but not into at least one different batch of an ore layer.

[0018] The position where the carbon iron composite ratio is to be increased is preferably a position where the ore layer thickness ratio (= ore layer thickness/(ore layer thickness + coke layer thickness)) is large. When the carbon iron composite ratio at the position in the blast furnace radius direction where the ore layer thickness ratio is large is increased, the carbon iron composite ratio in the region where the CO_2 concentration is high can be increased and the effect of mixing the carbon iron composite can be further enhanced. Accordingly, in an operation in which the ore layer thickness ratio is varied in the furnace radius direction, ore is charged so that the furnace radius direction position varies among the batches of the ore layers and a carbon composite is mixed into a batch of an ore layer at a furnace radius direction position where the ore layer thickness ratio is relatively large. When the plurality of batches are two batches, the carbon iron composite is mixed into the batch having a larger ore layer thickness ratio. When the plurality of batches are three or more batches, the carbon iron composite is mixed into at least the batch having the highest ore layer thickness ratio and no carbon iron composite is mixed into the batch having the lowest ore layer thickness ratio.

[0019] The position where the carbon iron composite ratio is to be increased is preferably an upper portion of the ore layer. Increasing the carbon iron composite ratio in the upper portion of the ore layer can increase the carbon iron composite ratio in the region having a high CO_2 concentration and the effect of mixing the carbon iron composite can be further enhanced. In such a case, operation is conducted so that the ore layer is divided into two or more batches in the height direction of the ore layer and no carbon iron composite is mixed into at least the ore layer of the batch located at the bottom. The carbon iron composite is preferably mixed into at least the ore layer of the batch located at the top.

[0020] In the description below, the present invention is described using specific examples with reference to Figs. 1 to 3 each showing the ore layer thickness ratio (= ore layer thickness/(ore layer thickness + coke layer thickness)) and

layer structure in the radius direction.

[0021] Fig. 1 shows the case in which the ore layer thickness ratio in the middle portion is large. After forming a coke layer 1 in one batch, an ore layer 2 and an ore layer 3 divided into two batches are charged. Carbon iron composite is mixed into the batch of the ore layer 2 which is the first batch corresponding to a high-thickness-ratio portion so that the carbon iron composite can be selectively mixed into a portion in the radius direction where the ore layer thickness ratio is high.

[0022] Fig. 2 shows the case in which the ore layer thickness ratio in the peripheral portion is large. The carbon iron composite is mixed into the batch of an ore layer 5 which is the second batch corresponding to a high-thickness-ratio portion. As a result, the carbon iron composite can be selectively mixed into a portion in the radius direction where the ore layer thickness ratio is high.

[0023] In Fig. 3, the carbon iron composite is mixed into a batch of an ore layer 7 corresponding to the upper part of the entire ore layer and thus the carbon iron composite can be selectively mixed into the ore upper layer portion.

[0024] The above-described cases involve two-batch charging of the ore layer. Alternatively, the ore layer may be divided into three or more batches and the carbon iron composite may be mixed into only a particular batch or batches (one or more batches but the number of batches is at least 1 smaller than the total batch number) in order to selectively mix the carbon iron composite in a particular region.

[0025] The amount of the carbon iron composite to be mixed into the ore is discussed here. To 500 g of sintered ore serving as ore, conventional coke and carbon iron composite were mixed and the mixture was reacted in a $CO:N_2$ = 0.3:0.7 (volume ratio) atmosphere at 900°C for 3 hours. The results are shown in Fig. 4. The amount of the conventional coke mixed was 6% by mass. According to Fig. 4, when the amount of the carbon iron composite mixed with the ore is 1.0% by mass or more, the effect of increasing the sintered ore reduction degree is exhibited but the effect is saturated at about 9% by mass. Accordingly, the amount of the carbon iron composite mixed into the ore is preferably 1.0% by mass or more and 9% by mass or less.

[0026] Regarding the properties of the carbon iron composite, the reactivity with CO_2 gas is not high if the iron content in the carbon iron composite is small but the strength of the carbon iron composite is degraded if the iron content is excessively large, making the carbon iron composite unsuitable for the blast furnace charge. Fig. 5 shows the relationship between the iron content in the carbon iron composite and the start temperature of the reaction of the carbon iron composite with the CO_2-CO mixed gas. According to Fig. 5, along with the increase in the iron content in the carbon iron composite, the reactivity is improved and the reaction start temperature is decreased. A large effect is exhibited at the iron content of 5% by mass and onward and the effect is saturated at 40% by mass or higher. Accordingly, it can be deduced that the preferable iron content is 5% to 40% by mass and more. Thus, the iron content in the carbon iron composite is preferably 5% to 40% by mass and more preferably 10% to 40% by mass.

[EXAMPLES]

[0027] A blast furnace operation test was conducted by applying the method of the present invention. The carbon iron composite used was manufactured by briquetting a mixture of coal and iron ore with a briquetting machine, charging the briquettes into a vertical shaft furnace, and performing carbonizing. The shape of the carbon iron composite is illustrated in Fig. 6. The upper diagram of Fig. 6 is a plan view and the lower diagram of Fig. 6 is a front view. The dimensions shown in Fig. 6 are A = 30 mm, B = 25 mm, C = 18 mm. The iron content in the carbon iron composite was 30% by mass. Sintered ore was used as the ore.

[0028] Charging of raw materials into the blast furnace was conducted as follows: First, a coke layer constituted only by conventional coke was formed and then the ore was charged in two batches as illustrated in Fig. 1. The average carbon iron composite amount mixed was 100 kg/t. In conducting operation, the same percentage of the carbon iron composite was mixed into each of the two ore batches in one case and, in another case, the carbon iron composite was mixed into one (ore layer 2) of the two ore batches only. For the purposes of comparison, operation was also conducted without mixing the carbon iron composite.

[0029] The results are shown in Table 1.

[Table 1]

		Case a	Case b	Case c
Carbon iron composite rate (including Fe)	kg/t	0	100	100
Carbon iron composite rate (excluding Fe)	kg/t	0	70	70
Conventional coke rate	kg/t	352	249	246
Pulverized coal rate	kg/t	126	126	126

(continued)

		Case a	Case b	Case c
Reducing agent rate	kg/t	478	445	442
Gas utilization ratio	%	50.3	54.0	54.5
Reference		Comparative Example	Comparative Example	Example

[0030] Case a is a comparative example where the carbon iron composite was not mixed into any of the ore layers 2 and 3 in the distribution control shown in Fig. 1. Case b is also a comparative example where the carbon iron composite was mixed into both the ore layers 2 and 3 in the distribution control shown in Fig. 1. Case c is an example of the present invention where the carbon iron composite was mixed into the ore layer 2 only in the distribution control shown in Fig. 1. Compared to Case a, the reducing agent rate is low in Case b and Case c where the carbon iron composite was used. The gas utilization rate was higher and the reducing agent rate was lower in Case c where the carbon iron composite was mixed into the ore layer 2 only than in Case b. This is presumably because selectively mixing the carbon iron composite into a portion with a high ore layer thickness ratio promoted gasification of the carbon iron composite and allowed the reduction of the ore to progress.

[0031] Next, the ore was divided into two batches and charged as illustrated in Fig. 2. As described above, the average amount of the carbon iron composite mixed was 100 kg/t. In conducting operation, the same percentage of the carbon iron composite was mixed into each of the two ore batches in one case and, in another case, the carbon iron composite was mixed into one of the two ore batches only. Operation was also conducted without mixing the carbon iron composite.

[0032] The results are shown in Table 2.

[Table 2]

		Case d	Case e	Case f
Carbon iron composite rate (including Fe)	kg/t	0	100	100
Carbon iron composite rate (excluding Fe)	kg/t	0	70	70
Conventional coke rate	kg/t	354	251	248
Pulverized coal rate	kg/t	126	126	126
Reducing agent rate	kg/t	480	447	444
Gas utilization ratio	%	50.0	53.7	54.2
Reference		Comparative Example	Comparative Example	Example

[0033] Case d is a comparative example where the carbon iron composite was not mixed into any of the ore layers 4 and 5 in the distribution control shown in Fig. 2. Case e is also a comparative example where the carbon iron composite was mixed into both the ore layers 4 and 5 in the distribution control shown in Fig. 2. Case f is an example of the present invention where the carbon iron composite was mixed into the ore layer 5 only in the distribution control shown in Fig. 2. Compared to Case d, the reducing agent rate is low in Case e and Case f where the carbon iron composite was used. The gas utilization rate was higher and the reducing agent rate was lower in Case f where the carbon iron composite was mixed into the ore layer 5 only than in Case e. This is presumably because selectively mixing the carbon iron composite into a portion with a high ore layer thickness ratio promoted gasification of the carbon iron composite and allowed the reduction of the ore to progress.

[0034] Next, the ore was divided into two batches and charged as illustrated in Fig. 3. As in the case described above, the average amount of the carbon iron composite mixed was 100 kg/t. In conducting operation, the same percentage of the carbon iron composite was mixed into each of the two ore batches in one case and, in another case, the carbon iron composite was mixed into one of the two ore batches only. Operation was also conducted without mixing the carbon iron composite.

[0035] The results are shown in Table 3.

[Table 3]

		Case g	Case h	Case i
Carbon iron composite rate (including Fe)	kg/t	0	100	100

(continued)

		Case g	Case h	Case i
Carbon iron composite rate (excluding Fe)	kg/t	0	70	70
Conventional coke rate	kg/t	351	248	245
Pulverized coal rate	kg/t	126	126	126
Reducing agent rate Gas utilization ratio	kg/t	477	444	441
	%	50.4	54.1	54.6
Reference		Comparative Example	Comparative Example	Example

[0036] Case g is a comparative example where the carbon iron composite was not mixed into any of the ore layers 6 and 7 in the distribution control shown in Fig. 3. Case h is also a comparative example where the carbon iron composite was mixed into both the ore layers 6 and 7 in the distribution control shown in Fig. 3. Case i is an example of the present invention where the carbon iron composite is mixed into the ore layer 7 only in the distribution control shown in Fig. 3. Compared to Case g, the reducing agent rate is low in Case h and Case i where the carbon iron composite was used. The gas utilization rate was higher and the reducing agent rate was lower in Case i where the carbon iron composite was mixed into the ore layer 7 only than in Case h. This is presumably because selectively mixing the carbon iron composite into an upper layer of the ore layer promoted gasification of the carbon iron composite and allowed the reduction of the ore to progress.

Reference Signs List

[0037]

1 coke layer constituted by conventional coke
2 ore layer (first batch)
3 ore layer (second batch)
4 ore layer (first batch)
5 ore layer (second batch)
6 ore layer (first batch)
7 ore layer (second batch)

Claims

1. A method for operating a blast furnace using carbon iron composite by forming a coke layer and an ore layer in the blast furnace, the method comprising:

   dividing ore into a plurality of batches including two or more batches and charging the ore into a blast furnace to form an ore layer,
   mixing the carbon iron composite into the ore layer of at least one batch in the ore layer formed by the plurality of batches, and
   no carbon iron composite being mixed into the ore layer of at least another batch.

2. The method for operating a blast furnace using the carbon iron composite according to claim 1, wherein
   the ore is charged so that positions where the plurality of batches are charged vary in a furnace radius direction and an ore layer thickness ratio defined by ore layer thickness/(ore layer thickness + coke layer thickness) is varied in the furnace radius direction, and
   the carbon iron composite is mixed into an ore layer of a batch that has a relatively large ore layer thickness ratio.

3. The method for operating a blast furnace using the carbon iron composite according to claim 1, wherein
   the ore is divided into two or more batches in a height direction of the ore layer and charged, and
   no carbon iron composite is mixed into at least an ore layer of a batch located at the bottom.

4. The method for operating a blast furnace using the carbon iron composite according to claim 1, wherein

the ore is divided into two batches in a height direction of the ore layer and charged so as to form an ore layer positioned in an upper portion and an ore layer positioned in a lower portion, and
no carbon iron composite is mixed into the ore layer positioned in the lower portion.

5. The method for operating a blast furnace usingthe carbon iron composite according to claim 1, wherein
the ore is divided into three batches in a height direction of the ore layer and charged so as to form an ore layer positioned in an upper portion, an ore layer positioned in a middle portion, and an ore layer positioned in a lower portion, and
no carbon iron composite is mixed into the ore layer positioned in the lower portion.

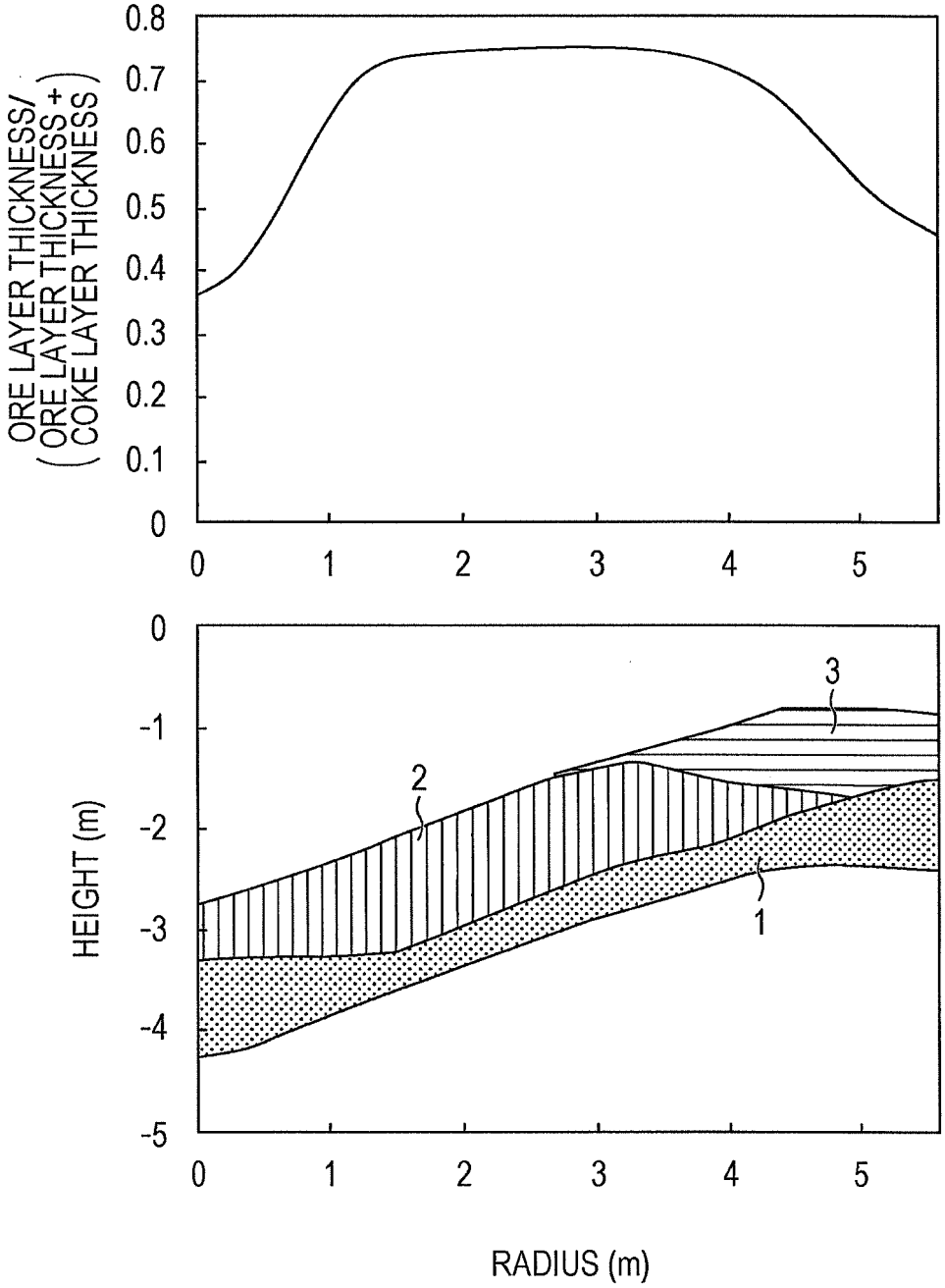
6. The method for operating a blast furnace using the carbon iron composite according to any one of claims 1 to 3, wherein the carbon iron composite in the ore layer has a mixing ratio of 1% by mass or more relative to the ore.

7. The method for operating a blast furnace using the carbon iron composite according to claim 6, wherein the mixing ratio is 1% by mass or more and 9% by mass or less.

8. The method for operating a blast furnace using the carbon iron composite according to any one of claims 1 to 3, wherein the iron contents of the carbon iron composite is 5% to 40% by mass.

9. The method for operating a blast furnace using the carbon iron composite according to claim 8, wherein the iron contents of the carbon iron composite is 10% to 40% by mass.

FIG. 1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(ORE LAYER THICKNESS + COKE LAYER THICKNESS)
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0.4
0.3
0.2
0.1
0
0
1
2
3
4
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-2
-3
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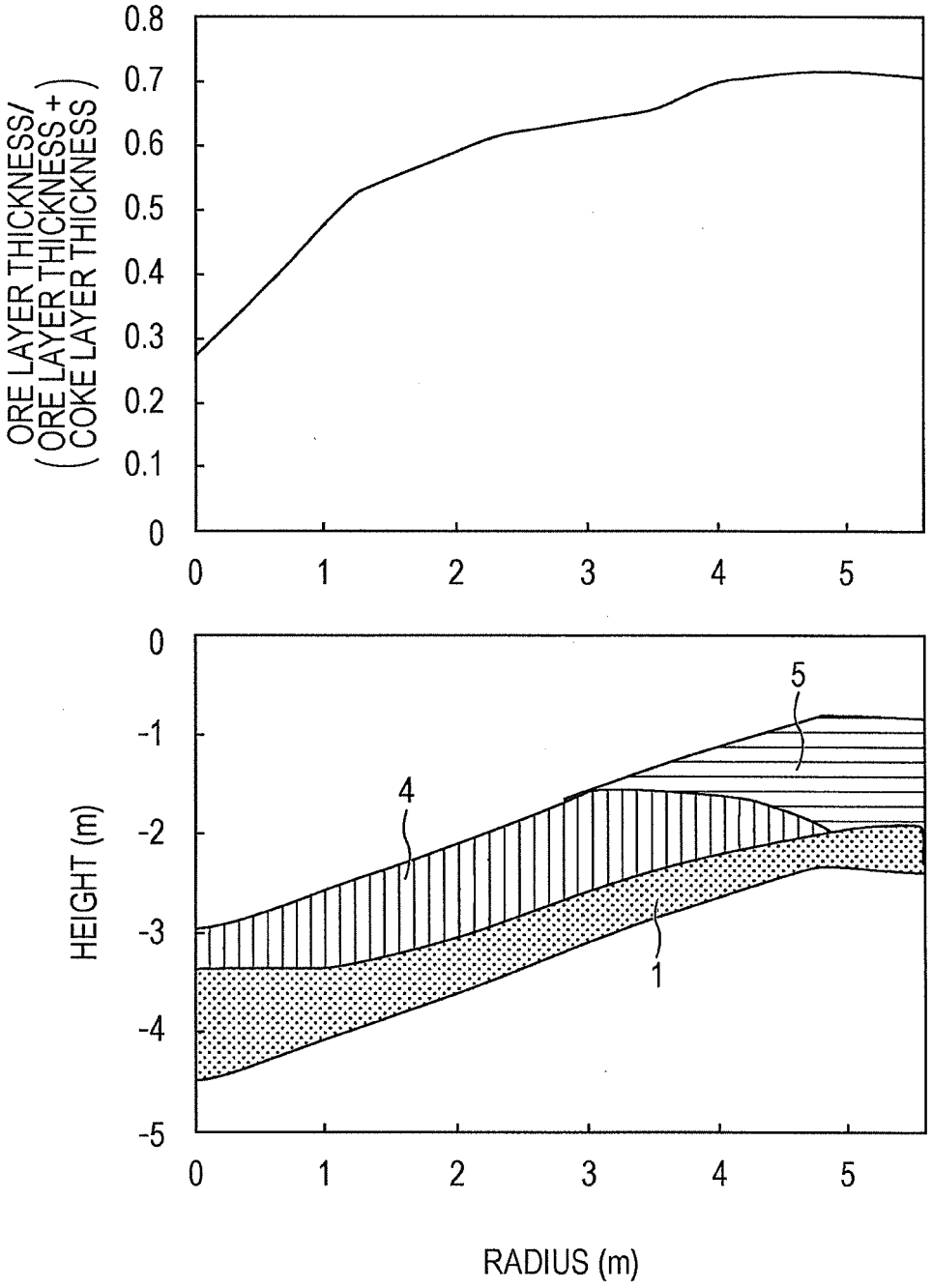
-5
1
2
3
RADIUS (m)

FIG. 2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(ORE LAYER THICKNESS + COKE LAYER THICKNESS)
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0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
HEIGHT (m)
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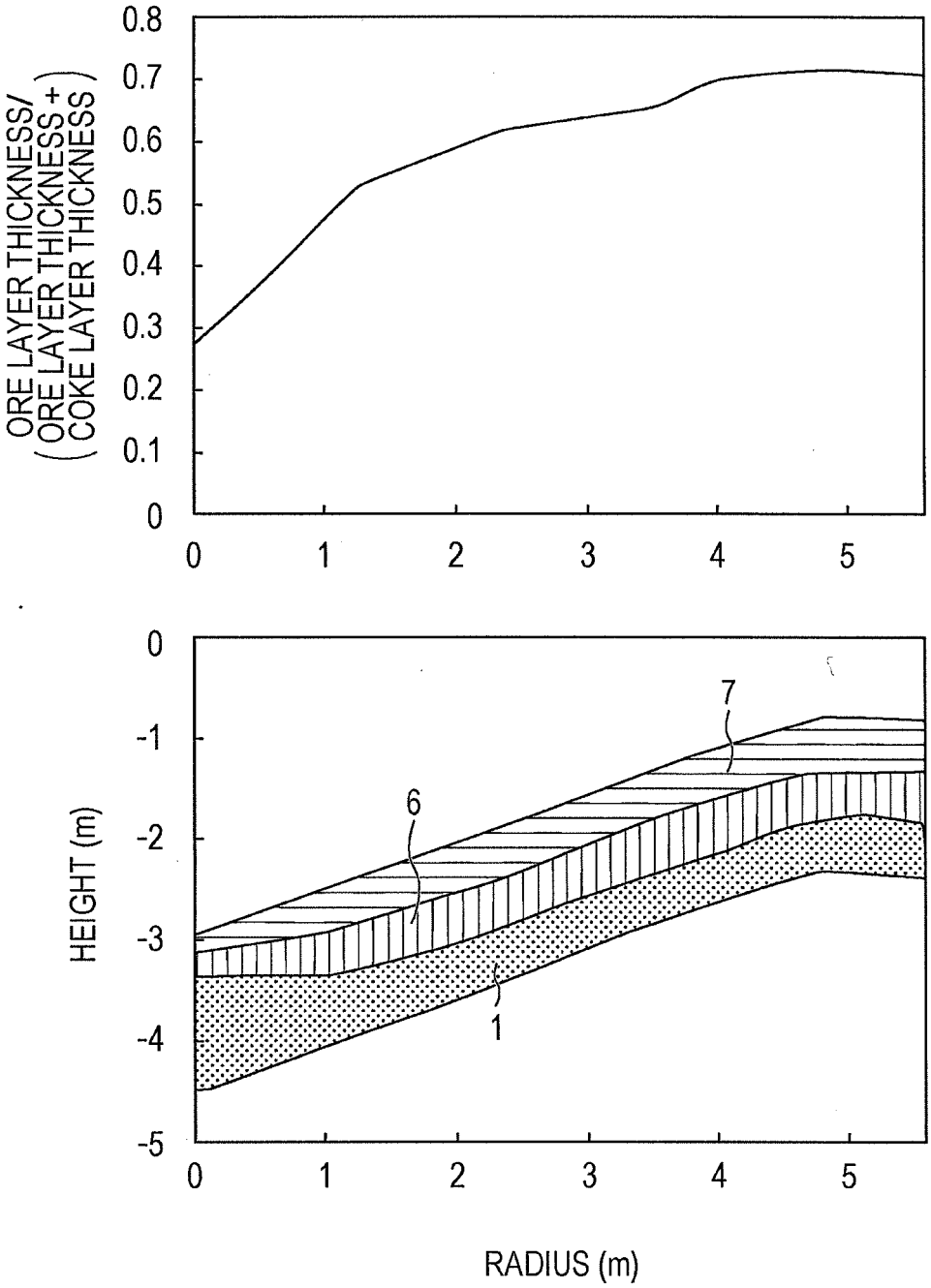
-2
-3
-4
-5
4
5
1
RADIUS (m)

FIG. 3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(ORE LAYER THICKNESS + COKE LAYER THICKNESS)
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0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
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-2
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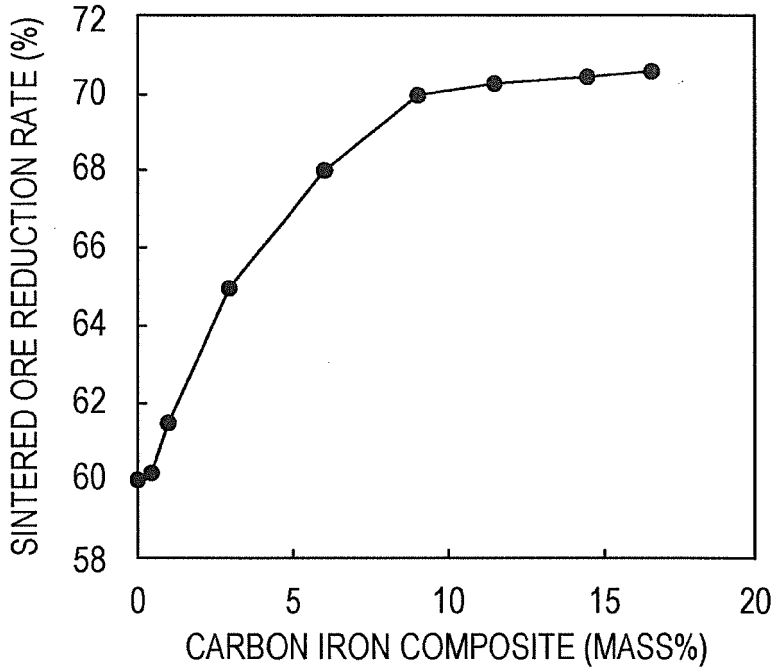
-4
-5
7
6
1
RADIUS (m)

FIG. 4


SINTERED ORE REDUCTION RATE (%)
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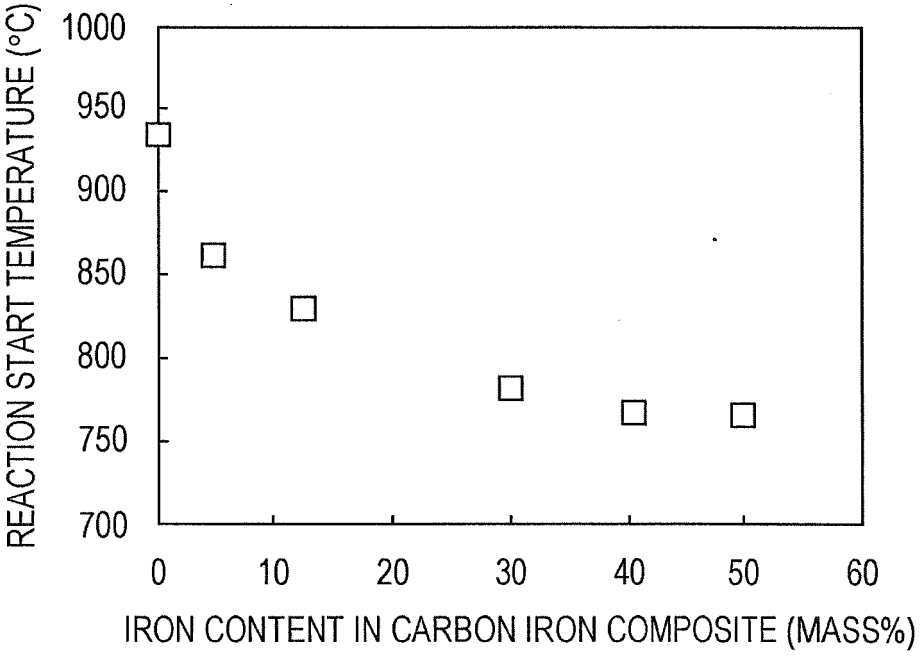
70
68
66
64
62
60
58
0
5
10
15
20
CARBON IRON COMPOSITE (MASS%)

FIG. 5


REACTION START TEMPERATURE (°C)
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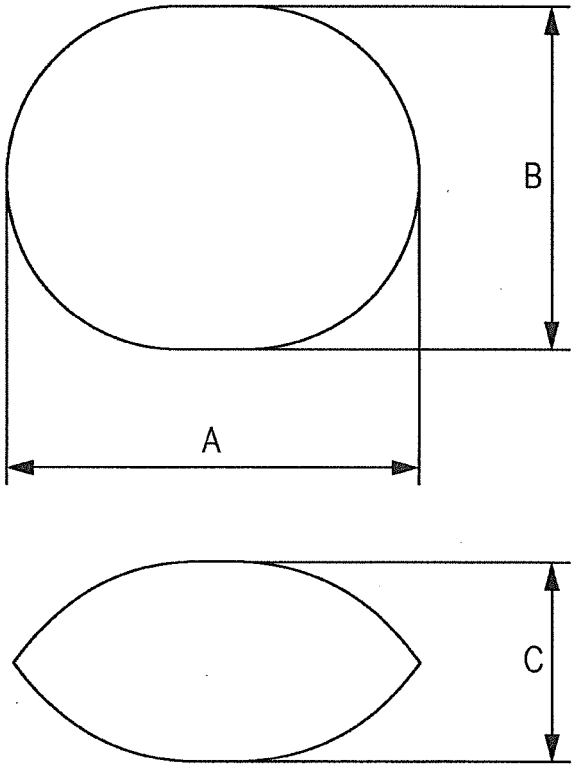
950
900
850
800
750
700
0
10
20
30
40
50
60
IRON CONTENT IN CARBON IRON COMPOSITE (MASS%)

FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/065056

A. CLASSIFICATION OF SUBJECT MATTER
C21B5/00(2006.01)i, *C22B1/245*(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, C22B1/245

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 1996-2012
Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012

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 Y A	JP 2008-56985 A (JFE Steel Corp.), 13 March 2008 (13.03.2008), paragraphs [0010], [0012], [0015]; table 1 (Family: none)	1 6-9 2-4
X Y A	JP 2008-111176 A (JFE Steel Corp.), 15 May 2008 (15.05.2008), paragraphs [0021] to [0024]; table 1; fig. 4 (Family: none)	1 6-9 2-4
X Y A	JP 2011-162845 A (JFE Steel Corp.), 25 August 2011 (25.08.2011), paragraphs [0016], [0021] to [0023]; fig. 3, 5, 7 (Family: none)	1,3-5 6-9 2

☒ 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
17 August, 2012 (17.08.12)	28 August, 2012 (28.08.12)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/065056

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 8-134517 A (Kawasaki Steel Corp.), 28 May 1996 (28.05.1996), paragraphs [0006] to [0010] (Family: none)	1-9
A	JP 2006-28593 A (JFE Steel Corp.), 02 February 2006 (02.02.2006), entire text (Family: none)	1-9
A	JP 63-210207 A (NKK Corp.), 31 August 1988 (31.08.1988), entire text (Family: none)	1-9

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2006028594 A **[0008]**

Non-patent literature cited in the description

- *Zairyo to Purosesu,* 2000, vol. 13, 893 **[0009]**