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

(11) EP 3 279 340 A1

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

(43) Date of publication:
07.02.2018 Bulletin 2018/06

(21) Application number: **16772595.1**

(22) Date of filing: **25.03.2016**

(51) Int Cl.:
C21C 5/35 *(2006.01)* ***C21C 5/46*** *(2006.01)*
C21C 5/48 *(2006.01)*

(86) International application number:
PCT/JP2016/059541

(87) International publication number:
WO 2016/158714 (06.10.2016 Gazette 2016/40)

(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
Designated Validation States:
MA MD

(30) Priority: **30.03.2015 JP 2015068542**

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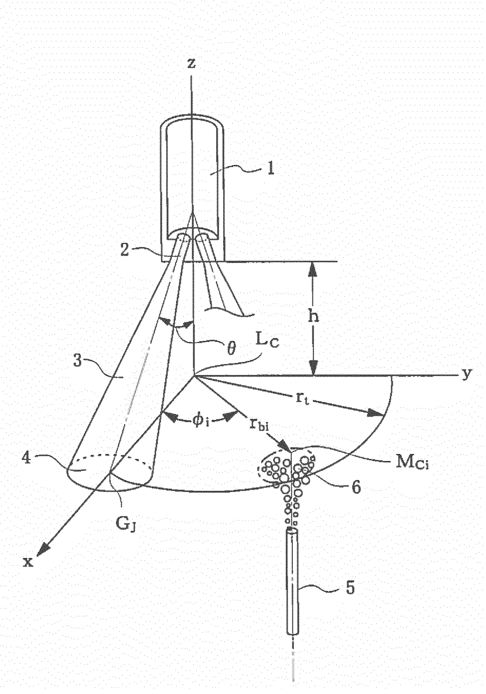
(54) METHOD FOR OPERATING TOP-BLOWN CONVERTER

(57) [Task] It is to provide a method of operating a top and bottom blowing converter which is capable of suppressing oscillation of a converter and generation of duct and also suppressing wear of furnace wall refractory in a decarburization refining with a top and bottom blowing converter.

[Solution] A method of operating a top and bottom blowing converter by using a top-blown multihole lance having a plurality of lance nozzles for jetting oxygen gas, jetting oxygen jets from the lance nozzles at a nozzle tilting angle inclined with respect to a center axis of the top-blown multihole lance, disposing n bottom-blown tuyeres in a bottom of the converter and blowing an agitating gas from the bottom-blown tuyeres, wherein an interference rate (IR) showing an involving degree between a hot spot formed by impinging the oxygen jet jetted from the top-blown multihole lance to a bath surface of molten iron and an agitating gas floating region formed on a bath surface of molten iron by blowing and floating the agitating gas from the bottom-blown tuyeres in molten iron is not more than 0.7.

FIG. 1



EP 3 279 340 A1

Description

TECHNICAL FIELD

[0001] This invention relates to a method of operating a top and bottom blowing converter effective for suppressing wear of furnace wall refractory and generation of dust.

RELATED ART

[0002] In the operation of a top and bottom blowing converter, especially in the decarburization refining thereof, an improvement of productivity is attained by increasing an amount of oxygen gas supplied per a unit time. In this regard, the increase in the supply amount of oxygen gas leads to an easy scattering of iron content as a dust, which is a phenomenon that the dust adheres to a surrounding equipment or a neighborhood of a furnace side wall and/or a furnace throat. The dust is roughly divided into one obtained by breaking away bubbles generated in the furnace from a bath surface of molten iron together with grained iron (so-called "bubble burst") and one generated by evaporating iron atom (so-called "fume"). It is known that a generation ratio between them is varied with a progress of the decarburization refining.

[0003] In the decarburization refining, hot metal is finally changed into molten steel because carbon in the hot metal is decreased gradually with the progress of the decarburization reaction. However, it is not possible to clearly distinguish a state of hot metal and a state of molten steel, so that the hot metal and molten steel are called generically as "molten iron" in the following description.

[0004] The scattered dust (iron content) is recovered and then recycled as an iron source even if it is generated by any of the above causes. In the recovery of iron content from the dust, however, there is such a problem that the operation cost is increased or the decrease of the operating rate is caused in the top and bottom blowing converter. Accordingly, it is examined to suppress the generation of the dust in the conventional operation of the top and bottom generation of the dust in the conventional operation of the top and bottom blowing converter during the decarburization refining.

[0005] For example, Patent Document 1 discloses a technique focused on a high-temperature reaction region exceeding 2000°C (so-called "hot spot") which is formed by impinging an oxygen jet jetted from respective lance nozzles of a top-blown lance onto the bath surface of molten iron. That is, when an overlapping state between adjacent hot spots with each other is defined by an index value as an overlap ratio, the above technique is a method of suppressing the generation of dust by adjusting a jet angle of the oxygen jet from the top-blown lance so as to set the index value to not more than 20%.

[0006] Moreover, Patent Document 2 discloses a technique of suppressing the dust with a top-blown multihole lance having seven holes inclusive of a center hole by adjusting the jet angle of the oxygen jet from the top-blown lance so that the overlap ratio is set to not more than 30% and a ratio of a total area of the hot spots occupied in an area surrounding outermost periphery of the hot spots is set to not more than 75%.

[0007] In these techniques, the generation of the dust due to the bubble burst is suppressed by controlling mutual interference of the oxygen jets jetted from the top-blown lance. However, they cannot be said to be effective for suppressing the dust due to the fume.

[0008] On the other hand, it is known in the decarburization refining that the molten iron accommodated in the top and bottom blowing converter is fluctuated by the oxygen jet jetted from the top-blown lance or an agitating gas supplied from a bottom-blown tuyere (such as inert gas, oxidizing gas or the like). The fluctuation of molten iron promotes scattering of the dust (especially dust due to the bubble burst). Accordingly, it is important to suppress the fluctuation of molten iron or an oscillation of a furnace body for suppressing the generation of the dust. Furthermore, the suppression of the oscillation of the furnace body has an effect for preventing equipment failures.

[0009] In Patent Document 3 is disclosed a technique of suppressing the oscillation of the furnace body by adjusting the jet angle of the oxygen jet to a range of 20-30° so as not to overlap the hot spot formed by the oxygen jet jetted from the top-blown lance with a region floating the agitating gas supplied from the bottom-blown tuyere. However, if the jet angle of the oxygen jet is increased excessively, a refractory in the top and bottom blowing converter is easily worn.

[0010] Moreover, the scattering of molten iron or molten slag (so-called slopping) must be prevented because the scattered material is adhered to a furnace wall or a neighborhood of a furnace throat like the dust due to bubble burst or fume and then deposited to bring about troubles in the operation of the top and bottom blowing converter.

[0011] In Patent Document 4 is disclosed a technique wherein bottom-blown tuyeres are arranged inside a circle formed by plural hot spots to suppress spitting. However, since the high-temperature hot spots are arranged near to the furnace wall, a refractory in the furnace wall of the top and bottom blowing converter is easily worn.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0012]

Patent Document 1: JP-A-S60-165313

Patent Document 2: JP-A-2002-285224

Patent Document 3: JP-A-S58-16013

Patent Document 4: JP-A-2013-142189

SUMMARY OF THE INVENTION

TASK TO BE SOLVED BY THE INVENTION

[0013] An object of the invention is to solve the above problems inherent to the conventional techniques and to provide a method of operating a top and bottom blowing converter capable of suppressing oscillation of furnace body and generation of dust as well as wearing of furnace wall refractory in the operation of the top and bottom blowing converter during decarburization refining.

SOLUTION FOR TASK

[0014] In order to further improve the techniques disclosed in Patent Documents 1-4, the inventors have focused attention on mutual interference between mutual oxygen jets from a top-blown lance having a plurality of lance nozzles (nozzles for jetting oxygen jet) (hereinafter referred to as "top-blown multihole lance) and mutual interference between a hot spot formed by oxygen jet from the top-blown multihole lance and a floating region of an agitating gas supplied from a bottom-blown tuyere, and studied thereto repeatedly. As a result, it has been found that the following cases (a) and (b) are effective to suppress wearing of a furnace wall refractory in the top and bottom blowing converter and generation of dust:

(a) the number of lance nozzles (for example, Laval nozzle, straight nozzle and so on) in the top-blown multihole lance especially jetting oxygen jets onto a surface of molten iron accommodated in the top and bottom blowing converter and jet angles thereof are adequately controlled, and
(b) a hot spot formed by the oxygen jet from the top-blown multihole lance and a floating region of an agitating gas supplied from a bottom-blown tuyere are desirable to be arranged so as not to mutually interfere to each other.

[0015] That is, the invention is a method of operating a top and bottom blowing converter by using a top-blown multihole lance having a plurality of lance nozzles for jetting oxygen gas to jet oxygen jets from the lance nozzles at a nozzle tilting angle θ (°) inclined with respect to a center axis of the top-blown multihole lance and arranging n bottom-blown tuyeres in a furnace bottom to blow an agitating gas from the bottom-blown tuyeres, characterized in that an interference rate (IR) indicated by the following equation (1) is not more than 0.7 with respect to a positional relation between a hot spot formed by impinging the top-blown oxygen jets jetted from the top-blown multihole lance onto a bath surface of molten iron and a floating region of an agitating gas blown from the bottom-blown tuyeres to molten iron and formed in a bath surface of molten iron when a point of intersecting a center axis of the top-blown multihole lance with a plane perpendicular to the center axis of the top-blown multihole lance at the bath surface of molten iron in the top and bottom blowing converter is a lance center point L_C and a point of intersecting a jetting direction of the oxygen jets jetted from the lance nozzle with the plane is a hot spot center point G_J and a point of intersecting a center axis of the bottom-blown tuyere with the plane is a tuyere center point M_C:

$$IR = \Sigma[(r_i / r_{bi}) \times (90 - \phi_i) / 90] / n \quad ..... (1)$$

, wherein

IR: interference rate;
n: an integer of 2 or more;
ϕ: an angle (°) between a line from the lance center point L_C to the hot spot center point G_J and a line from the lance center point L_C to the tuyere center point M_C;
r_t: a distance (m) between the lance center point L_C and the hot spot center point G_J;
r_b: a distance (m) between the tuyere center point M_C in each bottom blown tuyere and the lance center point Lc.

[0016] Moreover, Φ_i and r_{bi} are an angle (°) and a distance (m), respectively, determined for i-th (i: 1-n) bottom-blown tuyere.

[0017] In the operation method according to the invention, the followings are preferable embodiments:

(1) the interference rate (IR) satisfies (IR) $\leq$ 0.70 when the angel ϕ showing a positional relation between the lance nozzle and the bottom-blown tuyere is minimum;
(2) the interference rate (IR) is not more than 0.46;
(3) the lance nozzle is a Laval nozzle or a straight nozzle;
(4) the top-blown multihole lance has 2 to 5 lance nozzles; and
(5) the top and bottom blowing converter is operated by arranging a combination of the top-blown lance and the bottom-blown tuyere so as to satisfy the interference rate (IR).

EFFECT OF THE INVENTION

[0018] According to the invention, when decarburization refining is performed by using a top and bottom blowing converter, the improvement of iron yield can be attained by suppressing generation of dust and also the oscillation of the furnace body can be suppressed to effectively prevent wearing of a furnace wall refractory.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

FIG. 1 is a perspective view schematically showing a relation between a top-blown multihole lance and a bottom-blown tuyere applied by the invention.
FIG. 2 is a graph showing a relation between an interference rate and an average dust generation rate.
FIG. 3 is a graph showing a relation between an interference rate and a refractory wear index.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0020] FIG. 1 is a view schematically showing a relation between a top-blown multihole lance and a bottom-blown tuyere applied by the invention. A top-blown multihole lance 1 has a plurality of lance nozzles 2 for jetting oxygen gas in which an oxygen jet 3 can be jetted from each of the lance nozzles 2. In FIG. 1, the z-axis is a center axis of the top-blown multihole lance 1 and a bath surface of molten iron is orthogonal to this axis (z = 0). Therefore, a distance h between a lower end of the top-blown multihole lance 1 and the bath surface of molten iron is a lance height. A plane perpendicular to the center axis of the top-blown multihole lance 1 (hereinafter referred to as "x-y plane") is the bath surface of molten iron defined by the x-axis and y-axis. A point of intersecting the center axis of the top-blown multihole lance 1 with the x-y plane corresponds to an origin of coordinate axes, which is called as a lance center point L_C hereinafter.

[0021] In FIG. 1 is shown an example of arranging two lance nozzles 2, but the number of the lance nozzles 2 is not limited and is preferable to be set to about 2 to 5.

[0022] The oxygen jet 3 is jetted from the top-blown multihole lance 1 in a direction with an angle inclined to the center axis of the top-blown multihole lance 1 (hereinafter referred to as "nozzle tilting angle θ (°)"). A point of intersecting the oxygen jet 3 with the x-y plane corresponds to a center of a hot spot (that is, a high temperature reaction region exceeding 2000°C formed by impinging the oxygen jet to the bath surface of molten iron) 4. Hereinafter, this point is called as a hot spot center point G_J. All of the plural lance nozzles 2 disposed in the top-blown multihole lance 1 have the same nozzle tilting angle θ. Therefore, the top-blown oxygen jets 3 are also jetted at the same angle.

[0023] On the other hand, a plurality (that is, i = 1-n) of bottom-blown tuyeres 5 are disposed in the top and bottom blowing converter (not shown). In this regard, only one tuyere is illustrated in FIG. 1, which is described as i-th bottom-blown tuyere 5 hereinafter. Moreover, an agitating gas supplied from the bottom-blown tuyere 5 is floated in molten iron as bubbles to form an aggregated region 6 of the bubbles (hereinafter referred to as "agitating gas floating region").

[0024] For example, when a point of intersecting the center axis of the bottom-blown tuyere 5 with the x-y plane is a tuyere center point M_C, i-th tuyere center point M_C is indicated as M_{Ci} in FIG. 1.

[0025] When an angle between a line from the lance center point L_C to the hot spot center point G_J and a line from the lance center point L_C to the tuyere center point M_C is defined as ϕ (°), an angle of i-th bottom-blown tuyere 5 in FIG. 1 is defined as ϕ_i (°).

[0026] Further, a distance (m) between the lance center point L_C and the hot spot center point G_J is defined as r_t. As to the distance r_t, since the nozzle tilting angles θ of the plural lance nozzles 2 are all the same, a distance r_t defined for each lance nozzle 2 is the same.

[0027] On the other hand, a distance (m) between the lance center point L_C and the tuyere center point M_C is defined as r_b. In this regard, r_{bi} is represented in FIG. 1 for indicating a distance r_b of i-th bottom-blown tuyere 5.

[0028] An example of the method of operating a top and bottom blowing converter according to the invention will be described with reference to FIG. 1.

[0029] The inventors have conducted an experiment for decarburization refining of molten iron with an experimental top and bottom blowing converter (capacity: 5 tons) capable of jetting the oxygen jet 3 from the top-blown multihole lance 1 and supplying the agitating gas from the bottom-blown tuyere 5 simultaneously and then investigated an influence of an arrangement of the top-blown multihole lance 1 and the bottom-blown tuyere 5, especially an interference rate (IR) of them upon a dust generation amount and a refractory wearing amount.

[0030] As the top-blown multihole lance 1 is used a lance of water-cooled type having a triple tube structure. A plurality of lance nozzles 2 capable of jetting the oxygen jet 3 into a direction inclined by the nozzle tilting angle θ with respect to the center axis of the top-blown multihole lance 1 are disposed in a tip portion of the lance on the same circumference at equal intervals. Moreover, the shape and dimensions of the lance nozzle 2 are shown in Table 1. In this experiment, an oxygen gas (flow rate: m^3/minute (Normal)) is used as the oxygen jet 3 and argon gas is used as the agitating gas. Moreover, the lance height h is set to 400 mm, and the jet of the oxygen jet 3 starts when a carbon concentration in molten iron is 4.0 mass% and stops when it decreases to 0.05 mass%.

Table 1

Number of nozzles	Nozzle shape	Throat diameter of nozzle (mm)	Exit diameter of nozzle (mm)	Nozzle tilting angle (°)
4	Laval type	10.1	11.9	14
				23
5		9.0	10.7	14
				23
5		8.2	9.7	14
				23

[0031] In this experiment, combinations showing a relation between the top-blown multihole lance 1 and the bottom-blown tuyere 5 are as shown in Table 2, Table 3, Table 4 and Table 5. The interference rate (IR) shown in Table 2 and Table 3 is a value calculated by the following equation (1), which shows a positional relation between the hot spot 4 formed by impinging the top-blown oxygen jet 3 jetted from the top-blown multihole lance 1 onto the bath surface of molten iron and the agitating gas floating region 6 formed on the bath surface of molten iron by blowing and floating the agitating gas from the bottom-blown tuyere 5 in molten iron:

$$IR = \Sigma[(r_t / r_{bi}) \times (90 - \phi_i) / 90] / n \quad \cdots\cdots(1)$$

, wherein

IR: an interference rate;
n: an integer of 2 or more;
ϕ: an angle (°) between a line from the lance center point L_C to the hot spot center point G_J and a line from the lance center point L_C to the tuyere center point Mc;
r_t: a distance (m) between the lance center point L_C and the hot spot center point G_J;
r_b: a distance (m) between the tuyere center point M_C in each bottom blown tuyere and the lance center point L_C.

[0032] Moreover, ϕ_i and r_{bi} are an angle (°) and a distance (m), respectively, determined for i-th (i: 1-n) bottom-blown tuyere.

Table 2

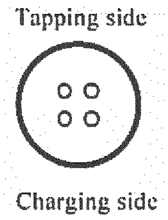
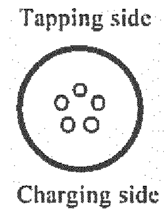
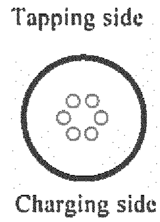
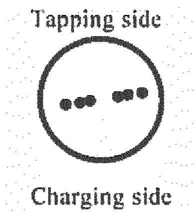
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Number of nozzles	4		5		6	
Nozzle tilting angle	14°	23°	14°	23°	14°	23°
Nozzle arrangement						
Number of bottom-blown tuyeres	6					
Bottom-blown tuyere arrangement						
interference rate (IR) (-)	0.37	0.44	0.50	0.58	0.56	0.95

Table 3

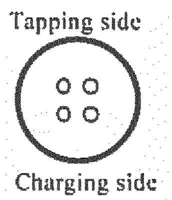
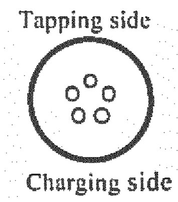
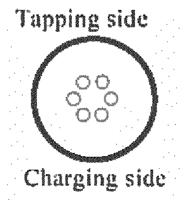
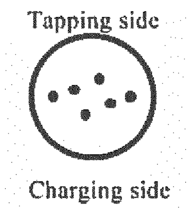
	Level 7	Level 8	Level 9	Level 10	Level 11	Level 12
Number of nozzles	4		5		6	
Nozzle tilting angle	14°	23°	14°	23°	14°	23°
Nozzle arrangement						
Number of bottom-blown tuyeres	6					
Bottom-blown tuyere arrangement						
Interference rate (IR) (-)	0.41	0.52	0.47	0.60	0.51	0.87

Table 4

	Level 13	Level 14	Level 15	Level 16	Level 17	Level 18
Number of nozzles	4		5		6	
Nozzle tilting angle	14°	23°	14°	23°	14°	23°

(continued)

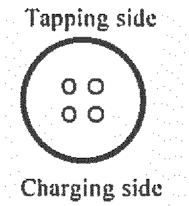
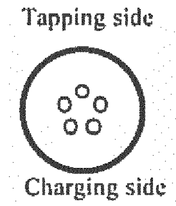
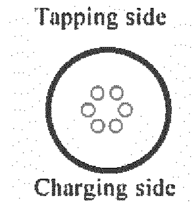
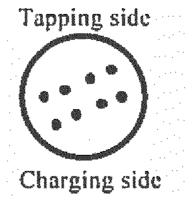
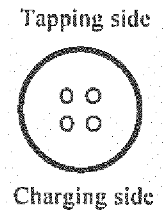
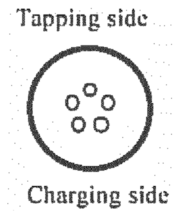
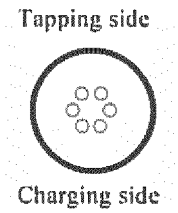
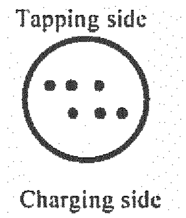
	Level 13	Level 14	Level 15	Level 16	Level 17	Level 18
Nozzle arrangement						
Number of bottom-blown tuyeres	6					
Bottom-blown tuyere arrangement						
Interference rate (IR)(-)	0.40	0.68	0.42	0.72	0.46	0.78

Table 5

	Level 19	Level 20	Level 21	Level 22	Level 23	Level 24
Number of nozzles	4		5		6	
Nozzle tilting angle	14°	23°	14°	23°	14°	23°
Nozzle arrangement						
Number of bottom-blown tuyeres	6					
Bottom-blown tuyere arrangement						
Interference rate (IR)(-)	0.56	0.70	0.47	0.60	0.48	0.82

[0033] When the experiment of decarburization refining is conducted in this manner, a dust concentration in an exhaust gas is measured to calculate a dust generation rate (kg/[minute · ton of molten iron]) by using the following equation (2). Moreover, an average value every each level of the experiment is used as a dust generation rate, a dust concentration in an exhaust gas and an exhaust gas flow rate in the equation (2). A relation between the average dust generation rate and the interference rate (IR) is shown in FIG. 2.

$$\text{Average dust generation rate (kg / (minute} \cdot \text{ton of molten iron))} = \text{[dust concentration in exhaust gas (kg / m}^3\text{ (Normal))]} \times \text{[exhaust gas flow rate (m}^3\text{ (Normal) / (minute} \cdot \text{ton of molten iron))]} \quad \ldots\ldots (2)$$

[0034] As seen from FIG. 2, the dust generation rate is decreased as the interference rate (IR) is decreased or the interference (involving degree) between the hot spot 4 and the agitating gas floating region 6 becomes smaller. When the interference rate (IR) is lower than 0.70, the dust generation rate becomes lower than the average value thereof at a maximum value 0.95 of the interference rate (IR) in this experiment. Moreover, when the interference rate (IR) is not more than 0.46, the average dust generation rate is largely decreased to not more than 1/2 of the maximum value of the average dust generation rate within a range of the interference rate in this experiment.

[0035] In this respect, the interference rate (IR) of 1.0 means a state of completely overlapping the hot spot 4 with the agitating gas floating region 6.

[0036] After the end of the experiment, the MgO concentration (mass%) in the slag is measured every each level of the experiment to calculate a refractory wear index by using the following equation (3). As seen from the equation (3), the refractory wear index in the level 18 becomes 1.0. A relation between the refractory wear index and the interference rate (IR) is shown in FIG. 3.

$$\text{Refractory wear index} = \text{MgO concentration in the slag after the end of the experiment (mass\%) / MgO concentration in the slag after the end of the experiment for the level 18 (mass\%)} \quad \ldots\ldots (3)$$

[0037] As seen from FIG. 3, an influence of the interference rate (IR) exerted to the refractory wear index is small and rather an influence of the nozzle tilting angel θ exerted thereto is large. That is, it can be seen that the refractory wear index in the decarburization refining with the top-blown multihole lance 1 having a nozzle tilting angle θ of 23° is increased as compared to the decarburization refining with the top-blown multihole lance 1 having a nozzle tilting angle θ of 14°, that is, the refractory wear is liable to be progressed.

[0038] From these experimental results, the interference rate (IR) is limited to not more than 0.70, preferably not more than 0.46 in the invention.

[0039] That is, in order to make the interference rate (IR) calculated by the equation (1) to a smaller value, it is understood that it is effective to arrange the bottom-blown tuyere 5 in a position apart from the top-blown multihole lance 1 (that is, each of the distances r_{bi} is made larger) or arrange the hot spot 4 and the agitating gas floating region 6 in positions apart from each other (that is, each of the angles ϕ_i is made larger).

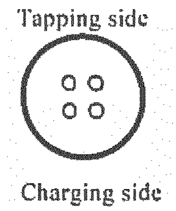
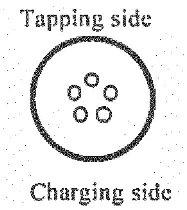
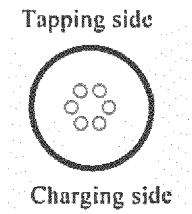
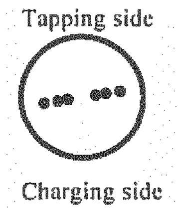
[0040] If the nozzle tilting angle θ is too large, there is caused a problem that a region of the hot spot 4 comes close to an inner wall of the top and bottom blowing converter and the wearing of the refractory is promoted. Therefore, the nozzle tilting angle θ is preferable to be less than 23°.

[0041] It is preferable that the number of the lance nozzles 2 arranged in the top-blown multihole lance 1 is not more than 5 (so-called 5 holes). The reason is that the size of the hot spot 4 can be made smaller by decreasing the number of the lance nozzles 2. As a result, a freedom in the arrangement of the bottom-blown tuyeres 5 can be increased and hence the angle ϕ can be enlarged easily. In the combinations of the top-blown multihole lance 1 and the bottom-blown tuyere arrangement used in the experiment, the number of nozzles in the top-blown multihole lance 1 capable of minimizing the interference rate (IR) is only 4 or 5 (see Table 2, Table 3, Table 4 and Table 5). In the top-blown multihole lance 1 having the nozzle number of 6, it is not possible to obtain an arrangement satisfying an interference rate (IR) $\leq$ 0.46. Therefore, it can be seen that it is preferable to use a top-blown multihole lance 1 having the nozzle number of not more than 5.

EXAMPLES

[0042] An experiment of operating a top and bottom blowing converter for decarburization refining of molten iron is conducted by using an actual top and bottom blowing converter (capacity: 350 tons). An arrangement of lance nozzles in the top-blown multihole nozzle and an arrangement of bottom-blown tuyeres in the top and bottom blowing converter used are shown in Table 6. As the lance nozzles are used a Laval nozzle. In the lance nozzle used in levels A and B, a throat diameter is 82.8 mm and an exit diameter is 87.1 mm. In the lance nozzle used in levels C and D, a throat diameter is 74.0 mm and an exit diameter is 77.8 mm. In the lance nozzle used in levels E and F, a throat diameter is 67.6 mm and an exit diameter is 71.1 mm. All of these lance nozzles are designed so as to make an adequate expanding pressure to 0.33 MPa.

Table 6

Experiment level	Level A (Invention Example 1)	Level B (Invention Example 2)	Level C (Invention Example 3)	Level D (Invention Example 4)	Level E (Inventive Example 5)	Level F (Comparative Example 3
Number of nozzles	4		5		6	
Nozzle tilting angle	14°	23°	14°	23°	14°	23°
Nozzle arrangement						
Number of bottom-blown tuyeres	6					
Arrangement of bottom-blown tuyeres						
Interference rate (IR)(-)	0.37	0.44	0.50	0.58	0.56	0.95

[0043] In the experimental operation, iron scraps are first charged into a top and bottom blowing converter and then molten iron (temperature: 1260-1280 °C) previously subjected to a dephosphorization treatment is charged into the top and bottom blowing converter. Thereafter, an oxygen jet is jetted onto a bath surface of molten iron from a top-blown multihole lance, while an agitating gas is supplied from bottom-blown tuyeres, and further quicklime is charged in such an amount that a basicity of slag in the converter is 2.5 as a flux, whereby the decarburization refining is conducted till a carbon concentration in molten iron is decreased to 0.05 mass%. Ingredients of molten iron are as shown in Table 7. Moreover, the basicity is a value calculated by the following equation (4).

$$\text{Basicity} = [\text{mass\% CaO}] / [\text{mass\% SiO}_2] \quad \text{.... (4)}$$

, wherein

[mass% CaO]: CaO concentration in slag inside the converter
[mass% SiO_2]: SiO_2 concentration in slag inside the converter.

Table 7

Molten iron temperature(°C) and chemical composition (mass%)						
Temperature	C	Si	Mn	P	S	Cr
1,260 - 1,280	3.9 - 4.2	0.01 - 0.04	0.12 - 0.25	0.016 - 0.036	0.006 - 0.015	tr

[0044] An oxygen gas is used for the oxygen jet and an argon gas is used as the agitating gas. Flow rates of the oxygen jet and the agitating gas and a lance height are shown in Table 8.

Table 8

Experiment level	C concentration in molten iron	Flow rate of top-blown oxygen gas jetted from top-blown multihole lance (m^3/minute (Normal))	Height of top-blown multihole lance (m)	Flow rate of agitating gas jetted from bottom-blown tuyere * (m^3/minute (Normal))
A and B	More than 0.4 mass %	1000	2.6	15
	Not more than 0.4 mass %	700	2.2	25
C and D	More than 0.4 mass %	1000	2.3	15
	Not more than 0.4 mass %	700	2.0	25
E and F	More than 0.4 mass %	1000	2.1	15
	Not more than 0.4 mass %	700	1.8	25
* Argon gas				

[0045] In the decarburization refining are examined a time required for refining (minute), T. Fe (mass%) in the slag at the blowing stop, a dust generation rate and a refractory wear index. The results are shown in Table 9. Interference rates (IR) calculated from the arrangement of the top-blown multihole lance and the bottom-blown tuyeres used are as shown in Table 9. These values are an average obtained by conducting decarburization refining at 3 charges every each level. Moreover, a dust generation rate is indicated as a relative value when a dust generation rate in level F is 1, and a refractory wear index is indicated as a relative value when a refractory wear index in level F is 1.

Table 9

Experiment level	Top-blown multihole lance				Bottom-blown tuyere	Interference rate (IR)	Decarburization refining				Remarks
	Number of nozzles	Throat diameter of nozzle (mm)	Exit diameter of nozzle (mm)	Nozzle tilting angle (°)	Number		Refining time (minute)	T.Fe at blowing stop (mass%)	Dust generation rate *3	Refractory wear index *4	
A	4	82.8	87.1	14	6	0.37	15.8	12.6	0.57	0.97	Invention Example
B	4	82.8	87.1	23	6	0.44	15.9	12.7	0.58	1.00	Invention Example
C	5	74.0	77.8	14	6	0.50	15.8	12.6	0.77	0.97	Invention Example
D	5	74.0	77.8	23	6	0.58	15.8	12.7	0.78	1.00	Invention Example
E	6	67.6	71.1	14	6	0.56	15.9	12.6	0.98	0.97	Invention Example
F	6	67.6	71.1	23	6	0.95	15.8	12.7	1.00	1.00	Comparative Example

*3 A relative value when a dust generation rate in level F is 1
*4 A relative value when a refractory wear index in level F is 1

[0046] As seen from the results shown in Table 9, when invention examples (levels A, B, C, D and E) are compared with comparative examples (level F), the dust generation rate can be largely decreased though the refining time and T. Fe in the slag at the blowing stop are equal. Especially, the wearing of the refractory can be suppressed in the level A.

DESCRIPTION OF REFERENCE SYMBOLS

[0047]

1 top-blown multihole lance
2 lance nozzle
3 oxygen jet
4 hot spot
5 bottom-blown tuyere
6 agitating gas floating region

Claims

1. A method of operating a top and bottom blowing converter by using a top-blown multihole lance having a plurality of lance nozzles for jetting oxygen gas to jet oxygen jets from the lance nozzles at a nozzle tilting angle θ (°) inclined with respect to a center axis of the top-blown multihole lance and arranging n bottom-blown tuyeres in a furnace bottom to blow an agitating gas from the bottom-blown tuyeres, **characterized in that** an interference rate (IR) indicated by a following equation (1) is not more than 0.7 with respect to a positional relation between a hot spot formed by impinging the top-blown oxygen jets jetted from the top-blown multihole lance onto a bath surface of molten iron and a floating region of an agitating gas blown from the bottom-blown tuyeres to molten iron and formed in a bath surface of molten iron when a point of intersecting a center axis of the top-blown multihole lance with a plane perpendicular to the center axis of the top-blown multihole lance at the bath surface of molten iron in the top and bottom blowing converter is a lance center point L_C and a point of intersecting a jetting direction of the oxygen jets jetted from the lance nozzle with the plane is a hot spot center point G_J and a point of intersecting a center axis of the bottom-blown tuyere with the plane is a tuyere center point M_C:

$$IR = \Sigma[(r_t / r_{bi}) \times (90 - \phi_i) / 90] / n \quad ..... (1)$$

, wherein

IR: interference rate;
n: an integer of 2 or more;
ϕ: an angle (°) between a line from the lance center point L_C to the hot spot center point G_J and a line from the lance center point L_C to the tuyere center point M_C;
r_t: a distance (m) between the lance center point L_C and the hot spot center point G_J;
r_b: a distance (m) between the tuyere center point M_C in each bottom blown tuyere and the lance center point Lc and
ϕ_i and r_{bi} are an angle (°) and a distance (m), respectively, determined for i-th (i: 1-n) bottom-blown tuyere.

2. The method of operating a top and bottom blowing converter according to claim 1, wherein the interference rate (IR) is not more than 0.46.

3. The method of operating a top and bottom blowing converter according to claim 1 or 2, wherein the lance nozzle is a Laval nozzle or a straight nozzle,

4. The method of operating a top and bottom blowing converter according to any one of claims 1 to 3, wherein the top-blown multihole lance has 2 to 5 lance nozzles.

5. The method of operating a top and bottom blowing converter according to any one of claims 1 to 4, wherein the top and bottom blowing converter is operated by arranging a combination of the top-blown lance and the bottom-blown tuyere so as to satisfy the interference rate (IR).

FIG. 1

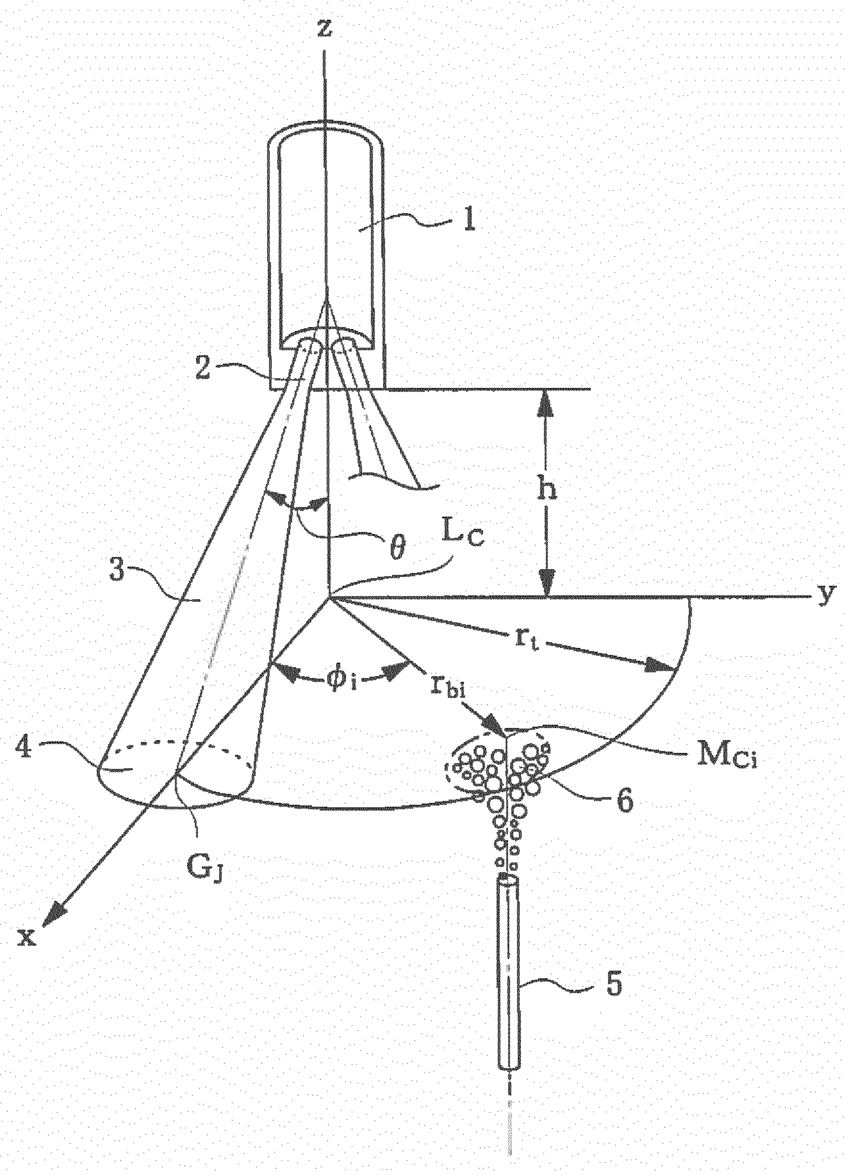


FIG. 2

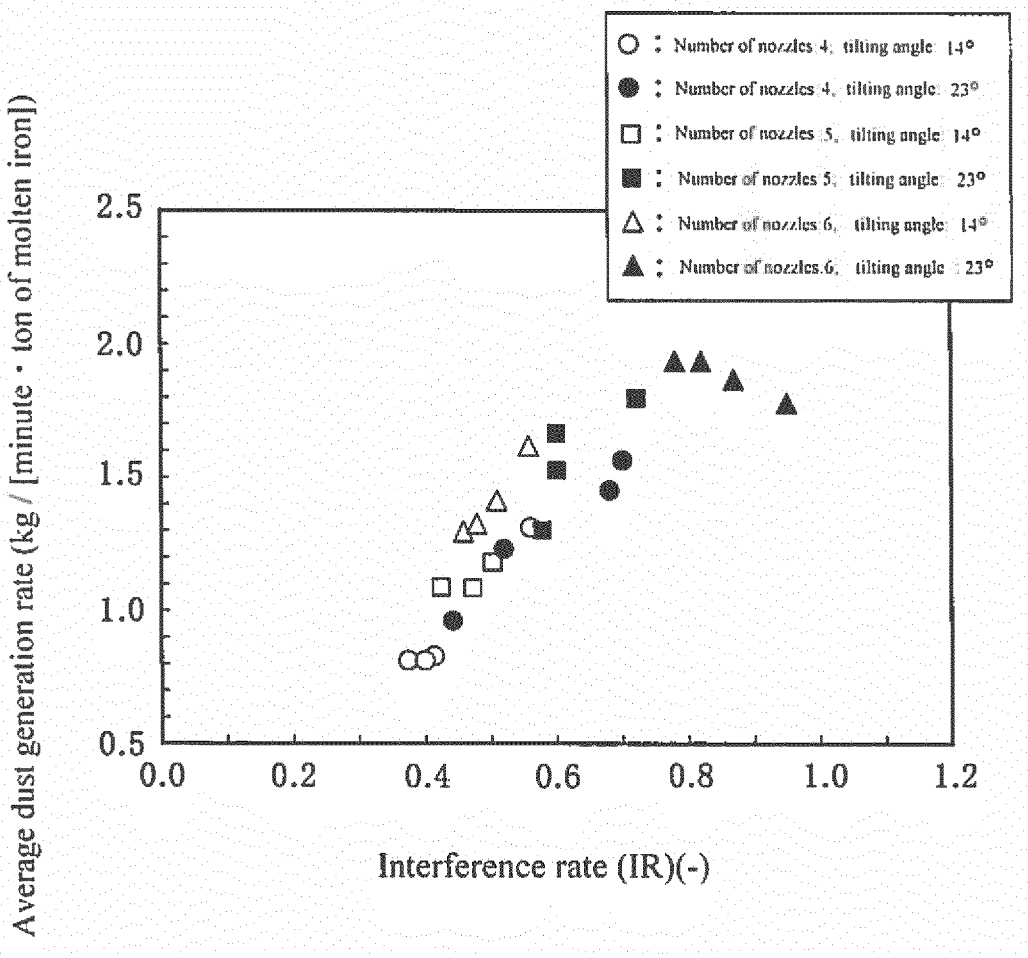
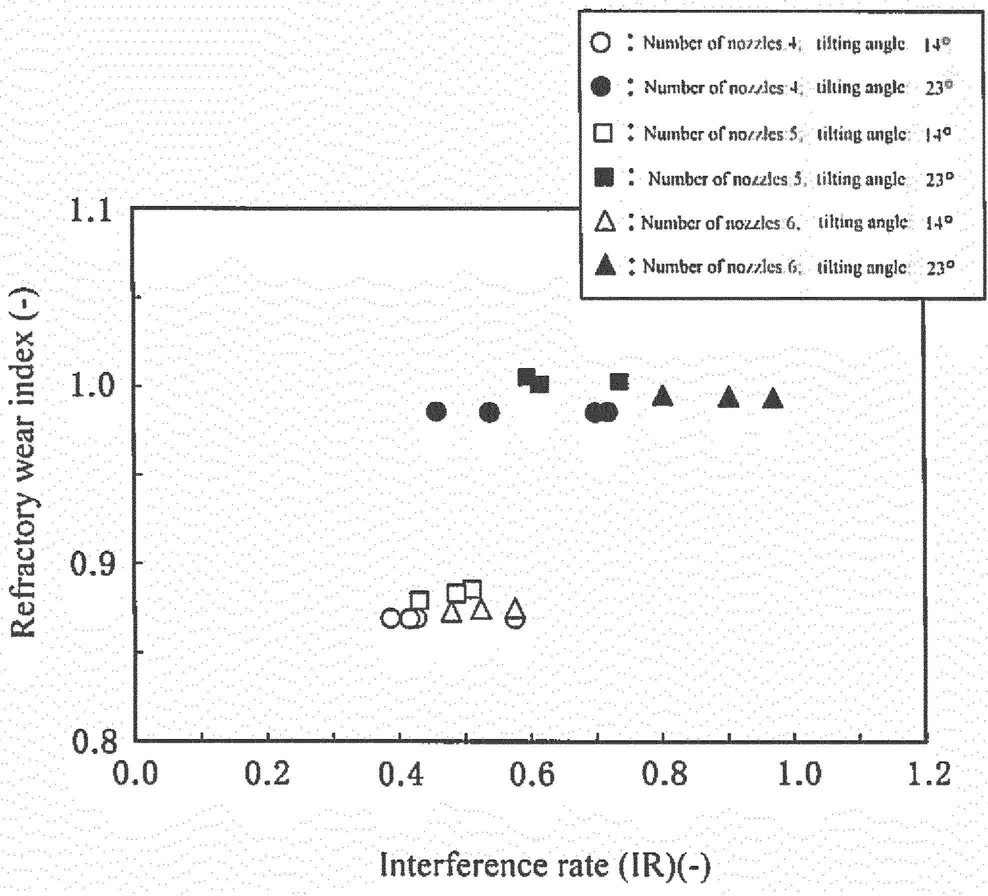

○ : Number of nozzles 4, tilting angle 14°
● : Number of nozzles 4, tilting angle 23°
□ : Number of nozzles 5, tilting angle 14°
■ : Number of nozzles 5, tilting angle 23°
△ : Number of nozzles 6, tilting angle 14°
▲ : Number of nozzles 6, tilting angle 23°
Average dust generation rate (kg / [minute • ton of molten iron])
2.5
2.0
1.5
1.0
0.5
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Interference rate (IR)(-)

FIG. 3


○ : Number of nozzles 4, tilting angle 14°
● : Number of nozzles 4, tilting angle 23°
□ : Number of nozzles 5, tilting angle 14°
■ : Number of nozzles 5, tilting angle 23°
△ : Number of nozzles 6, tilting angle 14°
▲ : Number of nozzles 6, tilting angle 23°
1.1
1.0
0.9
0.8
Refractory wear index (-)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Interference rate (IR)(-)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/059541

A. CLASSIFICATION OF SUBJECT MATTER
C21C5/35(2006.01)i, *C21C5/46*(2006.01)i, *C21C5/48*(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)
C21C5/35, C21C5/46, C21C5/48

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	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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 2002-105525 A (Kawasaki Steel Corp.), 10 April 2002 (10.04.2002), claim 1; paragraphs [0007], [0011], [0020]; fig. 1 to 2, 4 (Family: none)	1-5
A	JP 2000-309816 A (Sumitomo Metal Industries, Ltd.), 07 November 2000 (07.11.2000), (Family: none)	1-5

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

* Special categories of cited documents:
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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
06 April 2016 (06.04.16)	19 April 2016 (19.04.16)

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

Form PCT/ISA/210 (second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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