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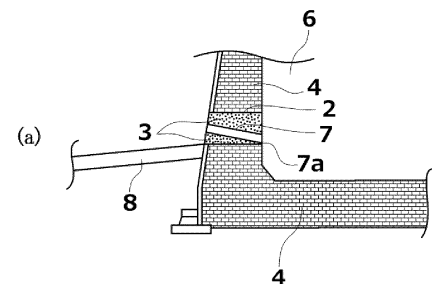
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(54) **BLAST FURNACE OPERATION METHOD**

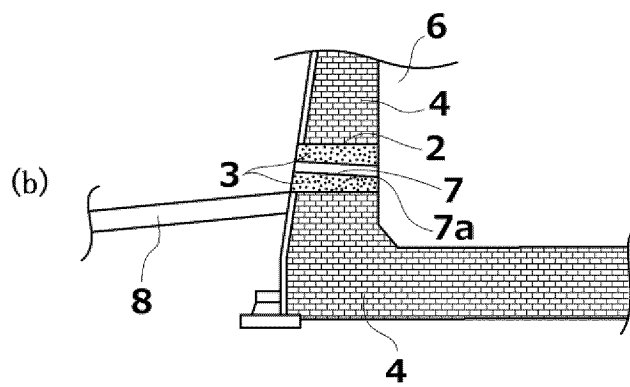
(57) Provided is a blast furnace operation method that can reduce the amount of melt remaining in a blast furnace before blasting is stopped more than conventional blast furnace operation methods without subjecting carbon bricks to wear damage. The blast furnace operation method is a method for restarting blasting after the blasting of a blast furnace is stopped, a furnace inner wall at the bottom of the blast furnace including a mud material 3 closing a tap hole 2 at a position where a through-hole 7 is to be opened, and carbon bricks 4 lining the other portions, the blast furnace operation method including, during reduced operation before blasting is stopped, in a portion where the mud material is provided in the tap hole, opening the through-hole such that a lower end 7a of an opening on the furnace inner wall surface of the through-hole is located at a position lower than a lower end of an opening on the furnace inner wall surface of a through-hole during normal operation and discharging a melt 6 through the through-hole.

[Fig. 2]



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[Fig. 2]



Description

Technical Field

- 5 **[0001]** The present invention relates to a blast furnace operation method for restarting blasting after the blasting of a blast furnace is stopped upon operation shutdown.

Background Art

- 10 **[0002]** When a blast furnace is forced to reduce the production of molten pig iron, the blasting rate is reduced. This may bring the furnace into a poor condition due to the inactivation of the furnace core. If the tapping ratio has become less than 1.5 due to a reduction in the production of molten pig iron, the operation will be continued at a coke ratio of over 400 kg/t. However, this is not economically reasonable since coke is an expensive raw material. Further, since the downward elasticity of the production of a blast furnace is limited, there may be cases where the operation of the blast furnace needs to
15 be stopped when the furnace is forced to significantly reduce the production of molten pig iron. In addition, to repair worn auxiliary equipment for a blast furnace, the blasting may be stopped for a period of time to allow molten pig iron slag to solidify in the furnace. To respond to such situations, there is a known technology called banking in which blasting is stopped for an extended period of time.

- [0003]** When banking is performed, it is necessary to lower the stock line of a raw material to the level of a tuyere and cool
20 the residual coke and the residual iron slag within the furnace to room temperature (for three months) as a preparation for blasting, and then load heavy equipment into the furnace for performing the operations of removing the residual coke and laying coke and sleepers inside the furnace (for 2.5 months). Thus, the furnace operation should be suspended for a period of at least 5.5 months. Therefore, it would be impossible to rapidly recover steel demand, or perform middle-stage repair work that is limited by the construction period, and thus adjust production to respond to the trend in steel demand.

- 25 **[0004]** As a technology for shortening the suspension period of a blast furnace, Patent Literature 1 discloses a method for extracting molten pig iron at the bottom of the furnace by tapping the molten pig iron from a furnace-bottom tap hole provided in a wall portion of the furnace at a level lower than the ordinary tap hole when blasting is ended. Meanwhile, Patent Literature 2 discloses a method for providing an opening in the lower wall of the furnace after blasting is ended and then removing from the furnace a residue at the furnace bottom remaining on the entire bottom surface of the furnace.
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Citation List

Patent Literature

- 35 **[0005]**

Patent Literature 1: JP-2006-137985A

Patent Literature 2: JP-H07-197112A

- 40 **Summary of Invention**

Technical Problem

- 45 **[0006]** However, each of the technologies disclosed in Patent Literature 1 and Patent Literature 2 has a problem that since a furnace-bottom tap hole or an opening is provided at a level lower than the respective tap hole, carbon bricks, which are the bottom bricks of the furnace, would suffer wear damage.

- [0007]** The present invention aims to solve such problems and provides a blast furnace operation method that can reduce the amount of melt remaining in a blast furnace before stopping blasting more than the conventional blast furnace operation method, without subjecting carbon bricks to wear damage.
50

Solution to Problem

- [0008]** A blast furnace operation method of the present invention has been developed to solve the above problems, and is a blast furnace operation method restarting blasting after the blasting of a blast furnace is stopped. The furnace inner wall
55 at a bottom of the blast furnace has a mud material closing a tap hole at a position where a through-hole is to be opened, and carbon bricks lining other portions. The blast furnace operation method includes, during reduced operation of the blast furnace before stopping blasting, in a portion where the mud material is provided in the tap hole, opening the through-hole such that a lower end of an opening on the furnace inner wall surface of the through-hole is located at a position lower than a

lower end of an opening on the furnace inner wall surface of a through-hole during normal operation; and discharging a melt through the through-hole.

[0009] Note that the blast furnace operation method of the present invention may include the following as a solution means that is considered to be more preferable.

(1) A plurality of tap holes are provided in a circumferential direction of a lower portion of the blast furnace, and the method includes, during reduced operation before stopping blasting, sequentially opening through-holes each of which has been closed with the mud material during normal operation such that the lower end of an opening on the furnace inner wall surface of the through-hole is located at a position lower than a lower end of an opening on the furnace inner wall surface of a through-hole opened during normal operation.

(2) Opening the through-hole so as to allow the lower end of the opening on the furnace inner wall surface of the through-hole to be located at a lower end of the tap hole on the inner wall surface side where the mud material is provided.

(3) Setting an angle of inclination of the through-hole to be larger than an angle of inclination of the through-hole during normal operation.

(4) Setting a blast pressure through a tuyere to 150 to 250 kPa so as to discharge the melt from the through-hole.

(5) After discharging the melt through the through-hole before stopping blasting, closing the through-hole with the mud material to stop blasting and opening a through-hole at a position for normal operation when restarting blasting to discharge a melt in the furnace through the through-hole, thereby suppressing a temperature drop of the melt when restarting blasting.

Advantageous Effects of Invention

[0010] According to the blast furnace operation method of the present invention, it is possible to reduce the amount of solidified melt remaining in a blast furnace after blasting is stopped without damaging bottom bricks of the furnace. This can reduce a temperature drop of a melt that is obtained when the blast furnace is restarted, and thus can achieve a smoother restart of the blast furnace.

Brief Description of Drawings

[0011]

[Fig. 1] Figs. 1(a) and 1(b) are schematic cross-sectional views each showing the state of a tap hole during normal operation of a blast furnace.

[Fig. 2] Figs. 2(a) and 2(b) are schematic cross-sectional views each showing the state of a tap hole when a blast furnace operation method according to the present invention is performed.

[Fig. 3] Fig. 3 is a schematic cross-sectional view for describing a state immediately before the end of a burden stock line lowering operation when the blast furnace operation method according to the present invention is performed.

[Fig. 4] Fig. 4 is a schematic cross-sectional view for describing a method for opening a tap hole in the blast furnace operation method according to the present invention.

Description of Embodiments

[0012] Hereinafter, an embodiment of the present invention will be specifically described. Note that the following embodiment only illustrates examples of an apparatus and a method for embodying the technical idea of the present invention. Thus, the configuration of the present invention is not limited thereto. That is, the technical idea of the present invention can be changed in various ways within the technical scope recited in the claims. In the following embodiment, an example of a blast furnace operation method that is a target of the present invention will be described first, and then, the features of the blast furnace operation method of the present invention will be described.

<One embodiment of normal operation of blast furnace as target of the present invention>

[0013] Figs. 1(a) and 1(b) are schematic cross-sectional views each showing the state of a tap hole during normal operation of a blast furnace. Figs. 1(a) and 1(b) each show part of the bottom of a blast furnace 1. A furnace inner wall at the bottom of the blast furnace includes a mud material 3 closing a tap hole 2 at a position where a through-hole 7 is to be opened, and carbon bricks 4 lining the other portions. Reference sign 5 denotes a tuyere.

[0014] The blast furnace 1 typically includes a plurality of tap holes 2, for example, four tap holes 2. Normal operation of the blast furnace is performed by alternately using the tap holes 2. Specifically, when attention is paid to a single tap hole 2,

the through-hole 7 is provided in the mud material 3 closing the tap hole 2 so as to connect the outside of the furnace to the inside of the furnace, whereby a melt 6 in the furnace is tapped through the through-hole 7, as shown in Fig. 1(a). Meanwhile, as shown in Fig. 1(b), another tap hole 2 through which the melt 6 in the furnace is not to be tapped is closed with the mud material 3 so that the melt 6 in the furnace is not discharged to the outside of the furnace through the tap hole 2.

After the completion of the tapping of the melt 6 in the furnace, the tap hole 2 is closed again with the mud material 3. Normal operation of the blast furnace is performed by repeating the operation continuously. It should be noted that reference sign 8 denotes a tap gutter for delivering the melt 6 tapped from the furnace to the outside of the furnace.

<One embodiment of blast furnace operation method according to the present invention>

[0015] When blasting is suspended for a long period (hereinafter also referred to as banking) to reduce the steel production or carry out repairs in the blast furnace 1, reduced operation is performed to lower the stock line of the raw material (melt 6) to the level of the tuyere 5, for example. In the blast furnace operation according to this embodiment, during reduced operation before blasting is stopped, in a portion where the mud material 3 is provided in the tap hole 2, the through-hole 7 is opened such that a lower end 7a (Fig. 2(a)) of an opening on the furnace inner wall surface of the through-hole 7 is located at a position lower than a lower end 7a (Fig. 2(b)) of an opening on the furnace inner wall surface of the tap hole 2 during normal operation, whereby the melt 6 is discharged through the through-hole 7.

[0016] Fig. 3 is a schematic cross-sectional view for describing a state immediately before the end of reduced operation when the blast furnace operation method according to the present invention is performed. As shown in Fig. 3, the melt 6 (slag 6a and molten pig iron 6b) remaining in the furnace solidifies during banking to form a solidified melt. Such a solidified melt would carry heat away from molten pig iron that is produced when blasting is restarted, which would lower the temperature of the melt and reduce the fluidity of the melt, disturbing a smooth restart of the furnace. In contrast, with the blast furnace operation method according to the present invention, as long as the amount of solidified melt remaining in a blast furnace after banking can be reduced, it is possible to suppress a temperature drop of a melt that is obtained when the blast furnace is restarted, thereby achieving a smooth restart of the blast furnace.

[0017] Fig. 4 is a schematic cross-sectional view showing a method for opening a tap hole in the blast furnace operation method according to the present invention. In the example shown in Fig. 4, a solid line represents a method of opening a through-hole 7 during tapping performed in normal operation by directing a rod of a drilling machine 11 toward the center of the mud material 3 in the tap hole 2. A broken line and a dashed and single-dotted line both represent a method of opening a through-hole 7 during reduced operation before blasting is stopped when the blast furnace operation method according to the present invention is performed, by inserting the rod of the drilling machine 11 through the mud material 3 in the tap hole 2 such that the opened through-hole 7 is located at a position lower than the through-hole 7 opened during normal operation. Herein, the example indicated by the broken line shows a state in which the carbon bricks 4 forming the tap hole 2 is hardly worn off when a hole is opened during reduced operation. Meanwhile, the example indicated by the single-dotted line shows a state in which the carbon bricks 4 forming the tap hole 2 is worn off when a hole is opened during reduced operation. Usually, the carbon bricks 4 is worn off by about 0.1°/year from the blowing-in to reduced operation. Therefore, even if the angle of the through-hole 7 opened by the rod of the drilling machine 11 is increased in accordance with the number of years elapsed from the blowing-in as in the example indicated by the dashed and single-dotted line, it is possible to obtain the maximum effect of removing a melt from the furnace without damaging the carbon bricks 4.

[0018] For example, during the tapping in normal operation indicated by the solid line, the through-hole 7 is opened with the rod of the drilling machine 11 by setting the angle of the through-hole 7 to the mud material 3 in the tap hole 2 to 10°. Meanwhile, during reduced operation indicated by the broken line, the through-hole 7 is opened with the rod of the drilling machine 11 by setting the angle of the through-hole 7 to the mud material 3 in the tap hole 2 to 13.8°. Further, during reduced operation indicated by the dashed and single-dotted line, the through-hole 7 is opened with the rod of the drilling machine 11 by setting the angle of the through-hole 7 to the mud material 3 in the tap hole 2 to 15°.

[0019] As in the example indicated by the broken line or the dashed and single-dotted line shown in Fig. 4, by setting the angle of inclination of the through-hole 7 to the mud material 3 in the tap hole 2 to be larger than that of the through-hole 7 opened during normal operation, it is possible to allow the lower end 7a of the through-hole 7 on the inner wall surface side of the furnace to be located at a level lower than the lower end 7a of the through-hole 7 opened during normal operation. Thus, to allow the lower end position 7a of the through-hole 7 on the inner wall surface side of the furnace to be located at a level lower than the lower end 7a of the through-hole 7 opened during normal operation, it is preferable to set the drilling angle of the drilling machine 11 to be larger than a conventional drilling angle. Although it is difficult to change the height of the drilling machine 11, changing the angle of inclination of the drilling machine 11, if possible, can easily lower the lower end of the through-hole on the inner wall surface side of the furnace.

[0020] Table 1 below shows the surface level of the melt 6, a drop in the surface level, the volume of the melt that has decreased, and the mass of the melt that has decreased when the angle of inclination of the through-hole 7 is changed. Herein, a through-hole angle of 10° indicates the angle of inclination of the through-hole 7 opened during normal operation. In addition, through-hole angles of 13.8° and 15° each correspond to the angle of inclination that allows the lower end 7a of

the through-hole 7 to be located at the lower end of the tap hole 2 provided with the mud material 3 on the inner side of the furnace. The effect of reducing the amount of melt when the through-hole angle is 13.8° or 15° has been determined by determining the reduced amount of melt as compared to the amount of melt when the through-hole angle is 10° during normal operation (which is assumed as 0).

[Table 1]

Item	Unit	Effect of Reducing Amount of Melt		
		Normal	Without Erosion Taken into Account	With Erosion Taken into Account
Through-hole Angle	°	10.0	13.8	150
Surface Level	mm	10838	10454	10372
Drop in Surface Level	mm	0	374	455
Volume of Melt	m ³	0	17.9	21.8
Mass of Melt	t	0	125	153

[0021] As shown in Table 1, as the angle of the through-hole 7 is increased to lower the lower end position 7a of the through-hole 7, the surface level of the melt decreases, thus reducing the volume and mass of the melt 6 remaining in the furnace. The lower limit of the lower end position 7a of the through-hole 7 corresponds to the lower end of the tap hole 2 provided with the mud material 3 on the inside of the furnace. For this reason, the through-hole 7 is preferably provided such that the lower end position 7a of the through-hole 7 is located at the lower end position of the tap hole 2 provided with the mud material 3 on the inner side of the furnace. This can minimize the melt 6 remaining in the furnace within the range in which the carbon bricks 4 do not break. This can further suppress a temperature drop of a melt 6 that is obtained when the blast furnace is restarted, and thus can achieve a smoother restart of the blast furnace. Note that in this embodiment, it is found that the angle of the through-hole 7 opened during reduced operation in the blast furnace operation method of the present invention is preferably set to 13.8° to 15°.

[0022] The blast pressure from the tuyere 5 of the blast furnace before reducing the operation is preferably 150 to 250 kPa. The level of the melt 6 inside the furnace is lower than the position of the through-hole 7 on the outer surface of the furnace. Thus, the melt 6 in the furnace is discharged via the through-hole 7 due to the pressure difference between high pressure (blast pressure) in the furnace and the atmospheric pressure. Therefore, it is preferable to set the blast pressure from the tuyere 5 of the blast furnace to 150 kPa or more to increase pressure in the furnace, and thus increase the pressure difference. This allows a further larger amount of the melt 6 to be discharged via the through-hole 7. Meanwhile, if the blast pressure is increased too much, the blast flow rate increases, increasing the amount of melt to be produced, which is unfavorable. Thus, the blast pressure through the tuyere 5 of the blast furnace is preferably 250 kPa or less.

[0023] After the melt 6 is discharged, banking is performed by closing the through-hole 7 with the mud material 3. To restart the blast furnace after the banking, it is preferable to form a through-hole 7 by forming an opening in the mud material 3 in the tap hole 2 so that the through-hole is located at a position in normal operation, and then discharge a melt in the furnace through the through-hole 7. In this manner, by setting the position of a through-hole opened during reduced operation to be lower than the position of a through-hole opened when the furnace is restarted, it is possible to secure a discharge space where no solidified melt is present in front of the through-hole when the furnace is restarted. This can further suppress a temperature drop of a melt when the blast furnace is restarted, thus achieving a smoother restart of the blast furnace.

[0024] Although the above description focused on a single tap hole 2, a blast furnace basically includes four tap holes. The number of tap holes that are used among the four tap holes is basically two, or three at most. The plurality of tap holes can be opened in the following order, for example.

[0025] First, one tap hole is opened, and then, a tap hole on the opposite side is opened. If three tap holes are used, another tap hole between the two tap holes that have been opened is opened. Such tap holes may be sequentially opened in the above order, for example, or other orders. That is, the order of opening tap holes is not limited to a particular order. For example, the order of opening tap holes may be determined by taking into consideration repairs to the gutter.

[0026] The time intervals for opening tap holes are not limited to a particular time, either, and are determined in accordance with the condition of the furnace and the volume of air at that time. Therefore, the time intervals for opening tap holes may vary, such as 5 minutes, 10 minutes, and 1 hour, and thus are not limited to a particular time.

Industrial Applicability

[0027] With the blast furnace operation method according to the present invention, it is possible to not only restart a blast furnace, but also provide a stable operation method for various vertical melting furnaces including those other than the blast furnace.

Reference Signs List

[0028]

- 1 blast furnace
- 2 tap hole
- 3 mud material
- 4 carbon bricks
- 5 tuyere
- 6 melt
- 6a slag
- 6b molten pig iron
- 7 through-hole
- 7a lower end
- 8 tap gutter
- 11 drilling machine

Claims

1. A blast furnace operation method for restarting blasting after the blasting of a blast furnace is stopped, **characterized in that**

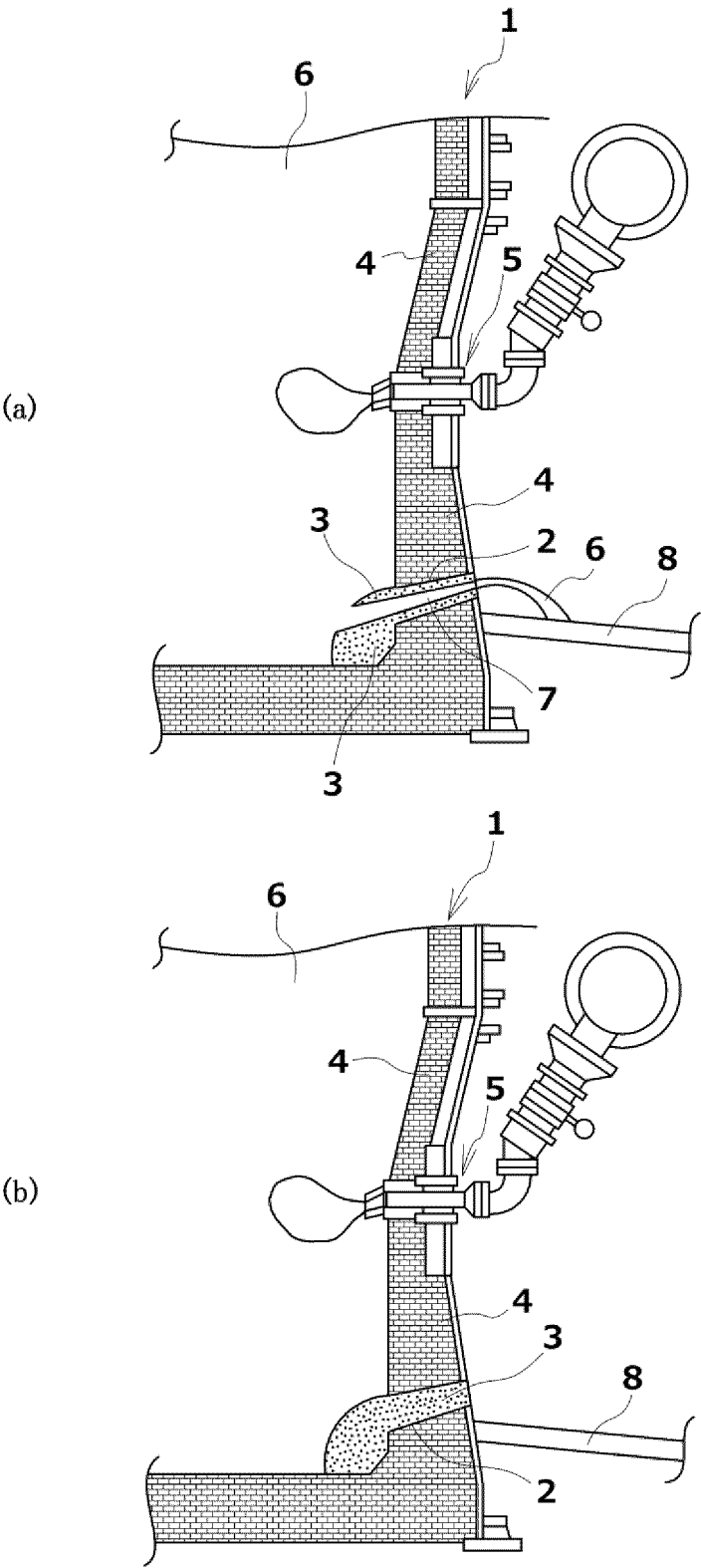
a furnace inner wall at a bottom of the blast furnace has a mud material closing a tap hole at a position where a through-hole is to be opened and carbon bricks lining other portions, and the blast furnace operation method comprises, during reduced operation of the blast furnace before stopping blasting, in a portion where the mud material is provided in the tap hole, opening the through-hole such that a lower end of an opening on the furnace inner wall surface of the through-hole is located at a position lower than a lower end of an opening on the furnace inner wall surface of a through-hole during normal operation; and discharging a melt through the through-hole.

2. The blast furnace operation method according to claim 1, wherein

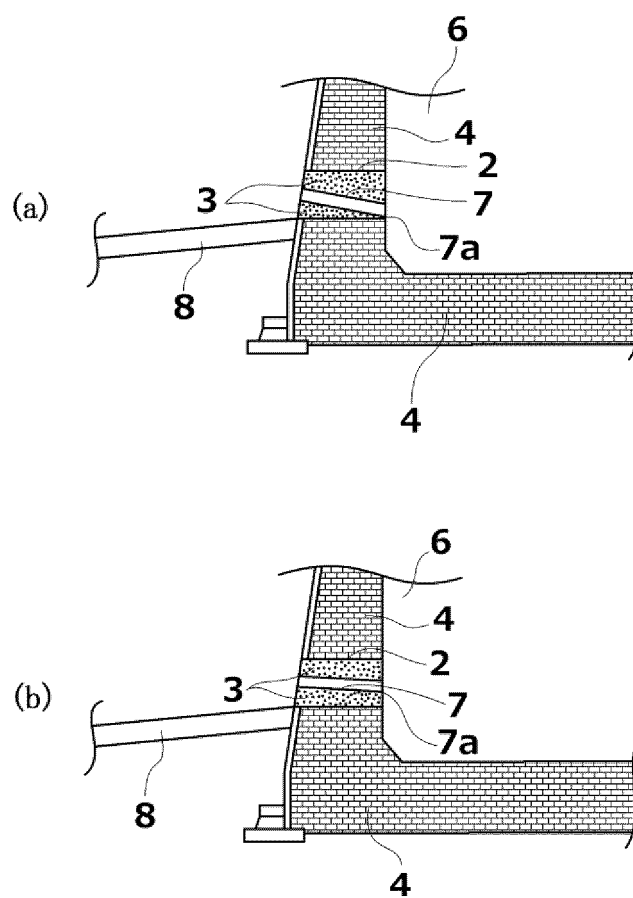
a plurality of tap holes are provided in a circumferential direction of a lower portion of the blast furnace, and the method comprises, during reduced operation before stopping blasting, sequentially opening through-holes each of which has been closed with the mud material during normal operation such that the lower end of an opening on the furnace inner wall surface of the through-hole is located at a position lower than a lower end of an opening on the furnace inner wall surface of a through-hole opened during normal operation.

3. The blast furnace operation method according to claim 1 or 2, comprising opening the through-hole so as to allow the lower end of the opening on the furnace inner wall surface of the through-hole to be located at a lower end of the tap hole on the inner wall surface side where the mud material is provided.
4. The blast furnace operation method according to claim 1 or 2, comprising setting an angle of inclination of the through-hole to be larger than an angle of inclination of the through-hole during normal operation.
5. The blast furnace operation method according to claim 1 or 2, comprising setting a blast pressure through a tuyere to 150 to 250 kPa so as to discharge the melt from the through-hole.
6. The blast furnace operation method according to claim 1 or 2, comprising after discharging the melt through the through-hole before stopping blasting, closing the through-hole with the mud material to stop blasting and opening a through-hole at a position for normal operation when restarting blasting to discharge a melt in the furnace through the through-hole, thereby suppressing a temperature drop of the melt when restarting blasting.

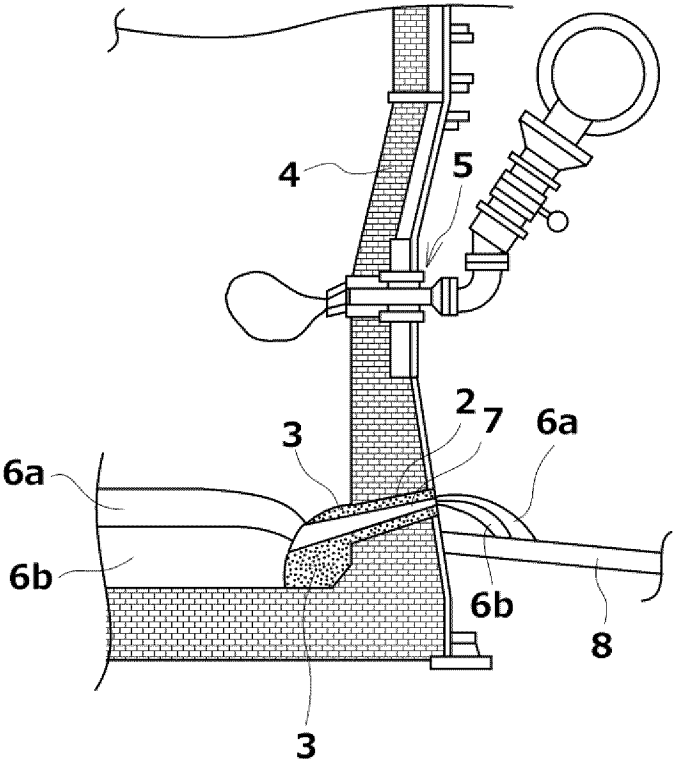
[Fig. 1]



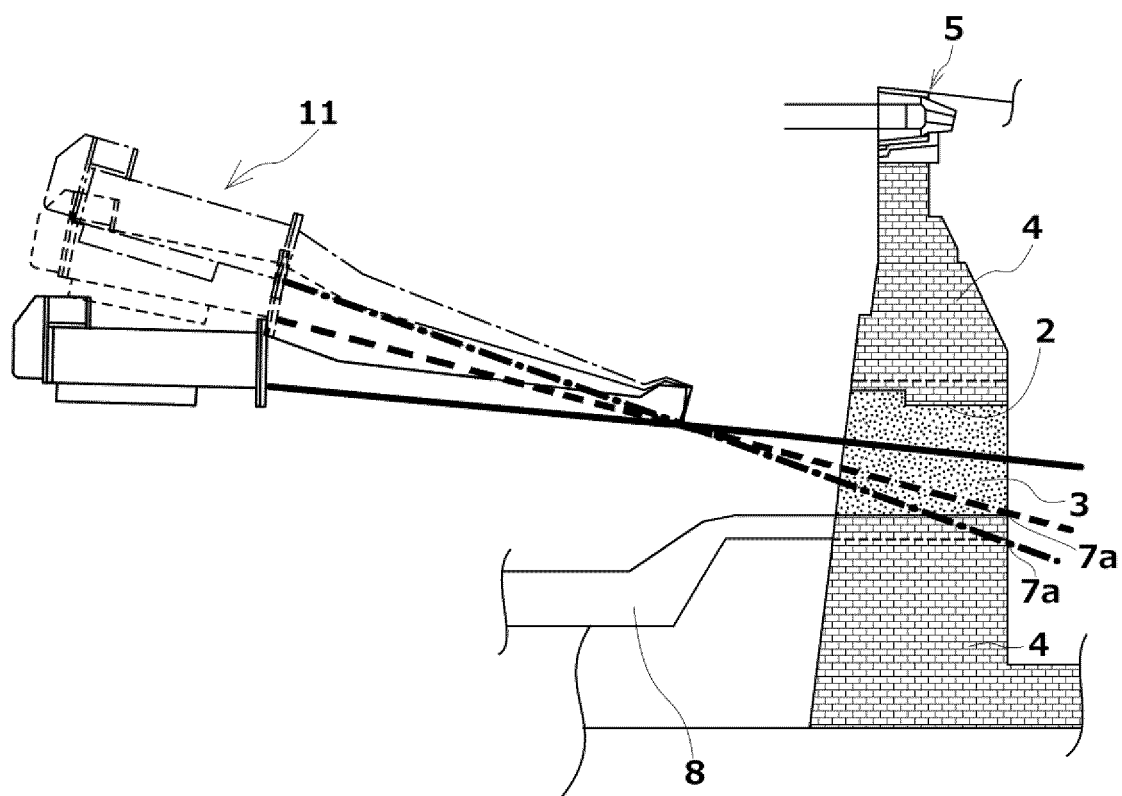
[Fig. 2]



[Fig. 3]



[Fig. 4]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2023/014825

A. CLASSIFICATION OF SUBJECT MATTER

C21B 5/00(2006.01)i; **C21B 7/00**(2006.01)i; **C21B 7/14**(2006.01)i
FI: C21B5/00 315; C21B7/14 301; C21B7/00 304

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; C21B7/14

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

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 1-96308 A (KAWASAKI STEEL CORP) 14 April 1989 (1989-04-14) claims, p. 2, upper left column, line 5 to lower left column, line 18, fig. 1	1-6
X	JP 3-90505 A (NIPPON STEEL CORP) 16 April 1991 (1991-04-16) p. 2, upper right column, line 14 to lower right column, line 15	1-4, 6
A		5
A	KR 10-2003-0021487 A (POSCO) 15 March 2003 (2003-03-15) entire text, all drawings	1-6
A	JP 57-177905 A (KAWASAKI SEITETSU KK) 01 November 1982 (1982-11-01) entire text, all drawings	1-6
A	JP 57-104605 A (SUMITOMO KINZOKU KOGYO KK) 29 June 1982 (1982-06-29) entire text, all drawings	1-6

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

* Special categories of cited documents:

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Date of the actual completion of the international search

21 June 2023

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/014825

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP	1-96308	A	14 April 1989	(Family: none)	
JP	3-90505	A	16 April 1991	(Family: none)	
KR	10-2003-0021487	A	15 March 2003	(Family: none)	
JP	57-177905	A	01 November 1982	(Family: none)	
JP	57-104605	A	29 June 1982	(Family: none)	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2006137985 A [0005]
- JP H07197112 A [0005]