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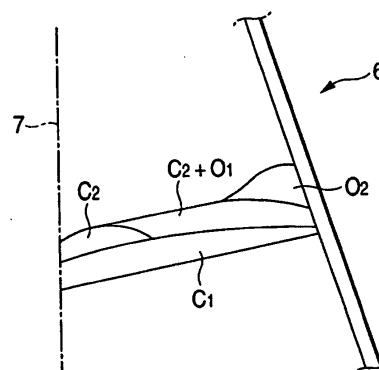
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(54) **RAW MATERIAL CHARGING METHOD FOR BELL-LESS BLAST FURNACE**

(57) A method for charging material in a bell-less blast furnace comprises the steps of : storing coke in at least one of furnace top bunkers; storing ore in at least one of furnace top bunkers; charging the stored cokes into the blast furnace while rotating a chute of the bell-less charging device and varying a inclination angle thereof; and charging the stored ore while rotating the chute of the bell-less charging device and varying the inclination angle thereof. Discharging of the stored in the at least one furnace top bunkers commences when the discharging amount of the coke stored in the at least furnace top bunker is 5 to 50 mass% relative to a coke amount of one batch. A mixed material of ore and coke is stored in one of furnace top bunkers, and the mixed material stored in the furnace top bunker is charged in the blast furnace while rotating the charging chute and changing a inclination angle of the charging chute.

FIG. 3



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Description**FIELD OF THE INVENTION**

5 **[0001]** The present invention relates to a method for charging material into a blast furnace, in particular, a method for charging iron ore and coke into a blast furnace by use of a bell-less charging device.

DESCRIPTION OF THE RELATED ARTS

10 **[0002]** In general, in a blast furnace that manufactures molten iron, from a furnace top, iron ores and coke are alternately charged, and thereby in an upper furnace part (hereinafter, referred to as shaft) a charged layer having a layer structure thereof is formed. Amounts of one layer of iron ores and one layer of coke are called one charge of iron ores and one charge of coke, respectively. Each of the one charge of iron ores and one charge of coke is not necessarily charged at one time into the furnace and, in some cases, is charged into the furnace divided into a plurality of times.

15 The divided ores and divided coke are respectively called as one batch of ores and one batch of coke. Furthermore, from a furnace bottom part of the blast furnace, air or oxygen-enriched air is blown into the furnace to burn the coke in the furnace, and, with a high temperature reducing gas generated by this burning, the iron ores in the shaft (hereinafter, simply referred to as ore) are reduced and molten. Accordingly, in order to improve the productivity of the blast furnace, it is very important to reduce the permeability resistance of the charged layer of ore and coke in the shaft.

20 **[0003]** As one means effective in reducing the permeability resistance in the shaft, so far, it is known to mix ore and coke and pile it in the furnace. For instance, Japanese Patent No.2820478 discloses a method in which by devising discharging timings and amounts of ore and coke from an ore hopper and a coke hopper, in a bell-less blast furnace, the coke is uniformly mixed in the ore.

25 **[0004]** Furthermore, as one means for inhibiting the permeability resistance in the blast furnace from increasing and thereby stably maintaining a gas flow in the blast furnace, it is known effective to charge coke in a center part of the blast furnace so that a flow rate distribution of a gas going up in the blast furnace may become large in the center part (this is called center flow tendency). For instance, JP-A No.60-56003 discloses a technology in which from 1.5 to 8% by weight of coke that is charged in one charge is intensively charged in the center part of a furnace. The center charge of coke has not only an effect of reducing the permeability resistance in the furnace but also an effect of avoiding or

30 reducing the deterioration of coke due to so-called solution loss reaction in which, since ore is not so much present in the center part of the furnace, carbon dioxide generated by the reduction of ore oxidizes coke. Furthermore, a strength control value of the coke itself can be lowered and thereby enabling to use cheap and low quality coal; accordingly, material coal for the manufacture of coke can be reduced in cost. Still furthermore, since a particle diameter of coke of a so-called furnace core (it is also called a dead-man) that is formed on a furnace bed can be inhibited from being

35 unnecessarily reduced, it is helpful in improving the liquid permeability of the molten iron at the furnace hearth. Accordingly, when the above-mentioned mix charge (hereinafter, simply referred to as mix charge) of ore and coke and the center charge of coke are combined, a synergy effect that the permeability resistance of the shaft part can be more than ever reduced and the productivity can be improved can be expected.

40 **[0005]** However, in order to combine the mix charge and the center charge of coke in the same charge, specifically, the discharge from a material hopper has to be carried out divided in three batches of a batch for normal charge of coke, a batch for center charge of coke and a batch for mix charge. This means that when the coke for one charge is charged into the furnace, the cokes have to be transported to a furnace top three times. That is, a time necessary for charging the coke for one charge becomes longer. Accordingly, even when the productivity of the blast furnace is necessary to increase, since the furnace top transporting capacity of material becomes deficient to a charge amount

45 of the material, a situation that the material cannot be charged in time occurs. In such a case, since the simultaneous implementation of the center charge and the mix charge of coke has to be abandoned, advantages due to the use of cheap material coal due to the implementation of both cannot be enjoyed.

50 **[0006]** In addition to the above, it is difficult to maintain various properties and states such as a particle size distribution and a content of moisture of ores and coke used in a blast furnace or blending ratios of ore kinds always at constant levels. For instance, when a blending ratio of a sticky ore in the ores varies, according to the technology disclosed in Japanese Patent No. 2820478, a behavior of a pile charged in a furnace top bunker varies, and a blending ratio of ore and coke in a material discharged from an outlet at a lower portion of the furnace top bunker varies.

55 **[0007]** As one means for making a particle diameter of the furnace core coke in the furnace bed larger and thereby improving the liquid permeability at the furnace bed, other than the center charge of the coke, it is considered to make a particle diameter of coke that is charged in the center part larger. That is, instead of inhibiting the ore from piling in the furnace center part in the coke center charge and thereby inhibiting the coke from being consumed owing to the solution loss reaction in the furnace center part, when a particle diameter of coke is made larger in the furnace center part than in a furnace periphery part, even when the solution loss reaction occurs, the particle diameter of coke can

be inhibited from being reduced in the furnace core of the furnace bed. When a coke charging device dedicated to the center charge of coke is used, by previously making larger the particle diameter of coke being charged through the charging device, the particle diameter of coke in such a furnace center part can be enlarged. However, installation of a charging device that is exclusively used for the center charge of coke and different from an ordinary material charging device requires large equipment expenses. Furthermore, even in the case of the coke large in the particle diameter being charged in the furnace center part through a bell-less charging device, at present, the coke large in the particle diameter is previously prepared in a batch different from a batch of coke having a normal particle diameter followed by transporting to a bunker disposed at the furnace top further followed by charging in the furnace. Accordingly, the number of batches of coke and ore that are charged in one charge increases. An increase in the number of batches by which material for one charge is charged in the furnace determines a rate when the productivity is improved; accordingly, it is a very large problem.

SUMMARY OF THE INVENTION

[0008] It is a first object of the present invention to provide a material charging method of a bell-less blast furnace wherein the center charge of coke and the mix charge of ore and coke can be always smoothly carried out.

[0009] It is a second object of the present invention to provide a material charging method of a bell-less blast furnace wherein ore and coke can be distributed at a blast furnace top part with a constant mixing ratio, and thereby a hot metal temperature and quality of molten iron can be inhibited from fluctuating, even when properties and states of various materials used in the blast furnace vary.

[0010] In the invention, a third object is to provide a material charging method of a bell-less blast furnace. According to the method, in center coke charge that uses a charging chute in a bell-less blast furnace, a particle diameter of coke is made largest at the furnace center part, thereby a gas flow in a furnace is formed at a furnace center part, and thereby a stable operation is enabled.

[0011] In the invention, a fourth object is to provide a material charging method of a bell-less blast furnace. According to the method, without separately disposing a charging device exclusive for coke and without increasing the number of batches of material, coke larger in the particle diameter than one being charged in a peripheral part can be selectively charged in a center part of the blast furnace.

[0012] In order to achieve the above objects, firstly, the invention provides a method of charging material in a bell-less blast furnace that is provided with a bell-less charging device, the method comprising the steps of:

- (a) storing coke in at least one of furnace top bunkers;
- (b) storing ore in at least one of the furnace top bunkers;
- (c) rotating a chute of the bell-less charging device while varying a inclination angle thereof, and thereby charging stored coke in a radius direction in the furnace from a furnace center part toward a furnace wall part;
- (d) rotating a chute of the bell-less charging device while varying a inclination angle thereof, and thereby charging stored ore in a radius direction in the furnace from a furnace center part toward a furnace wall part; and
- (e) controlling so that during a discharge amount of the coke stored in the at least one of furnace top bunkers being between 5 to 50% by mass of a coke charge amount for one batch, discharge of the ore stored in the at least one of furnace top bunkers may be begun.

[0013] Secondly, the invention provides a method of charging material in a bell-less blast furnace that is provided with a bell-less charging device, the method comprising the steps of:

- (a) storing a mixed material in which ore and coke are mixed in one of furnace top bunkers;
- (b) charging the mixed material stored in the furnace top bunker in the blast furnace while rotating a charging chute about a blast furnace neutral axis and sequentially varying a inclination angle of the charging chute; and
- (c) controlling so that during at least one reciprocation of the charging chute in a radius direction in the blast furnace the whole of the mixed material stored in the furnace top bunker may be charged in the blast furnace.

[0014] Thirdly, the invention provides a method of charging material in a bell-less blast furnace that is provided with a bell-less charging device, the method comprising the steps of:

- (a) starting charging coke by use of the charging chute of the bell-less charging device from a radius position corresponding to 0.1 to 0.4 relative to a dimensionless radius with a furnace center part of the bell-less blast furnace assigned to 0 and a furnace wall part assigned to 1; and
- (b) sequentially moving a inclination angle of the charging chute toward a furnace center part for each rotate thereof and thereby charging coke.

[0015] Fourthly, the invention provides a method of charging material in a bell-less blast furnace provided with a bell-less charging device, the method including a coke screening step where coke stored in at least two coke bins is discharged and the discharged coke is sifted with a screen disposed at a lower part of the bin; a weighing and storing step where coke of plus screen is weighed with a weighing hopper and stored in a bunker disposed at a furnace top; and a charging step where stored coke is charged through a chute of the bell-less charging device in a blast furnace while rotating the chute from a furnace center part toward a furnace wall side. The coke screening step includes a first screening step where the coke discharged with a screen having a larger screen mesh (A) is sifted; and a second screening step where the coke discharged with a screen having a more finer screen mesh (B) is sifted. In the weighing and storing step, firstly, a definite amount of coke from the first screening step is transferred to the weighing hopper, subsequently, coke from the second screening step is transferred followed by weighing coke for one batch further followed by storing in a bunker disposed at a furnace top.

[0016] Fifthly, the invention provides a material charging method of a bell-less blast furnace. In the method, in the fourth material charging method of a bell-less blast furnace, an amount of coke from the first screening step that sifts the coke that is discharged with a screen having a larger screen mesh (A) is in the range of 5 to 50% by mass of an amount of coke of the batch.

[0017] Sixthly, the invention provides a material charging method of a bell-less blast furnace provided with a bell-less charging device, the method comprising the steps of:

- (a) storing coke in at least one of furnace top bunkers;
- (b) storing ore in at least one of the furnace top bunkers;
- (c) storing a mixed material obtained by mixing ore and coke in one of the furnace top bunkers;
- (d) rotating a chute of the bell-less charging device while varying a inclination angle thereof, and thereby charging stored coke in a radius direction in the furnace from a furnace center part toward a furnace wall part;
- (e) rotating a chute of the bell-less charging device while varying a inclination angle thereof, and thereby charging stored ore in a radius direction in the furnace from a furnace center part toward a furnace wall part; and
- (f) controlling so that during a discharge amount of the coke stored in the at least one of furnace top bunkers being between 5 to 50% by mass of a coke charge amount for one batch, discharge of the ore stored in the at least one of furnace top bunkers may be begun;
- (g) charging the mixed material stored in the furnace top bunker in the blast furnace while rotating the charging chute and sequentially varying a inclination angle of the charging chute; and
- (h) controlling so that during at least one reciprocation of the charging chute in a radius direction in the blast furnace the whole of the mixed material stored in the furnace top bunker may be charged in the blast furnace.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

Fig. 1 is a sectional view for explaining a furnace top part of a bell-less blast furnace.

Figs.2A and 2B are conceptual diagrams for explaining a material charging method according to embodiment 1, Fig.2A showing a timing of charging ore, Fig.2B showing a charge position in a blast furnace.

Fig.3 is a sectional view showing a burden distribution in the furnace when a material charging method according to embodiment 1 is applied.

Fig.4 is a sectional view for explaining a furnace top part of a bell-less blast furnace according to embodiment 2.

Fig.5 is a sectional view schematically showing an example where mixed material is charged by applying a material charging method according to embodiment 2.

Fig.6 is a schematic diagram showing a position of a charging chute in a bell-less blast furnace according to embodiment 3.

Fig.7 is a schematic sectional view of a burden distribution in the furnace charged with a charging chute according to embodiment 3.

Fig.8 is a graph showing a distribution of the gas utilization efficiency in a blast furnace according to embodiment 3.

Fig.9 is a graph showing a distribution of coarse particle ratios of center coke due to difference of charge start positions according to embodiment 4.

Fig.10 is a diagram for explaining a material charging method according to embodiment 4.

Fig.11 is a diagram showing relationship between discharge amount (%) of coke from a bunker according to embodiment 4 and ratio (%) of 55 or more size in a sample coke.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0019] The inventors studied hard to achieve the above respective objects and embodied fruits thereof in the present invention.

[0020] That is, the invention is a method of charging material in a bell-less blast furnace (embodiment 1), the method being characterized in that when a chute of a bell-less charging device of a blast furnace is rotated with an inclination angle thereof varying and thereby coke or ore stored in a plurality of furnace top bunkers is charged from a furnace center part toward a furnace wall part in a radius direction in the furnace, from a predetermined time point where a discharge amount of coke stored in one of the furnace top bunkers is between 5 to 50% by mass of a coke charge amount for one batch, ore stored in another furnace top bunker is started to discharge, and thereby the coke and ore are simultaneously charged.

[0021] In the embodiment 1, the chute of the bell-less charging device of a blast furnace is rotated with an inclination angle thereof increasing sequentially and stepwise from zero that is a vertical state; when a discharge amount of coke stored in one of furnace top bunkers becomes in the range of 5 to 50% by mass of a coke charge amount for one batch, discharge of ore stored in another furnace top bunker is begun; and thereby the coke and ore are simultaneously charged. Accordingly, in the neighborhood of the furnace center part only the coke is filled; and on a furnace wall side in the surroundings thereof, a mixture of the coke and ore is filled. As a result, the mix charge of the coke and ore, without interrupting owing to the transporting capacity of material of the furnace top, can be always smoothly carried out.

[0022] The present invention is a method of charging material in a bell-less blast furnace (hereinafter referred to as embodiment 2), the method, in a material charging method of a bell-less blast furnace where by use of a bell-less charging device ore and coke as material are charged in a blast furnace, being characterized in that a mixed material obtained by mixing ore and coke is stored in one of furnace top bunkers; and, by rotating a charging chute about a blast furnace neutral axis and sequentially varying an inclination angle of the charging chute, during at least one reciprocation of the charging chute in a radius direction in the blast furnace, the whole amount of the mixed material stored in the furnace top bunker is charged in the blast furnace.

[0023] As a preferable mode in the embodiment 2, the charging chute preferably starts charging the mixed material either from a furnace wall side of the blast furnace or from a blast furnace center side.

[0024] The invention is a material charging method of a bell-less blast furnace (hereinafter referred to as embodiment 3), the method, in a material charging method of a bell-less blast furnace in which ore and/or coke is charged in a blast furnace as material by use of a bell-less charging device, being characterized in that when coke is charged in the center part of the bell-less blast furnace by use of a charging chute, with respect to a dimensionless radius where a furnace center part of the bell-less blast furnace is assigned to zero and a furnace wall part to 1, from a radius position corresponding to 0.1 to 0.4, the coke is begun charging followed by continuing charging while sequentially moving an inclination angle of the charging chute toward a furnace center side for each rotation thereof.

[0025] The invention is a material charging method of a bell-less blast furnace (hereinafter referred to as embodiment 4), the method being characterized in that when coke stored in a plurality of coke bins is discharged and sifted with a screen disposed at a lower part of each of the bins and coke above the screen is charged sequentially through a weighing hopper, a bunker disposed at the furnace top and a chute of a bell-less charging device into a blast furnace with the chute rotating from a furnace center part toward a furnace wall side, when screen mesh of screens disposed at lower parts of some of the coke bins is made larger than that of the other coke bins and the coke is transferred from these coke bins to the weighing hopper, after, firstly, a predetermined amount of the coke from the coke bins large in the screen mesh is transferred to the weighing hopper, subsequently the coke from the other coke bins is transferred followed by weighing the coke for one batch further followed by charging through the bunker into a blast furnace.

[0026] In this case, an amount of coke from the coke bins large in the screen mesh is preferably in the range of 5 to 50% by mass relative to the whole amount of coke of the batch (hereinafter referred to as embodiment 5).

[0027] According to embodiments 4 and 5, without separately disposing a charging device exclusive for coke but with an existing bell-less charging device, without increasing the number of batches of material, coke large in the particle diameter than one that is charged in the periphery part can be selectively charged in the center part of the blast furnace.

[0028] Preferably, in embodiments 1 through 5, in a material charging method of a bell-less blast furnace (hereinafter referred to as embodiment 6), at least three of the furnace top bunkers are disposed in parallel.

Embodiment 1

[0029] In what follows, embodiment 1 according to the present invention will be explained with reference to the drawings.

[0030] Firstly, a longitudinal sectional view of a furnace top part of a blast furnace provided with a bell-less charging device is shown in Fig. 1. Material 2 (ore or coke) stored in a furnace top bunker 1 falls through a gate that is called a

flow rate control gate 3 and controls a discharge amount with an opening thereof and is supplied through a vertical chute 4 into a chute that can freely rotate (usually called a charging chute 5). The charging chute 5 can rotate in a horizontal direction about a neutral axis 7 of a blast furnace 6 and can alter an inclination angle (θ) thereof relative to the neutral axis 7. When with the charging chute 5 rotating during charge of the material, the inclination angle θ is sequentially and stepwise varied, the material can be charged in the furnace with a wide pile surface formed. Usually, as the inclination angle θ , a large number of angles are previously set and notch numbers are assigned to the respective angles. Thereby, in charging the material 2 with the charging chute 5 rotating, when from the charge start the notches in the respective rotations are determined, the same kind of material can be always charged at a constant position. Furthermore, as to the furnace top bunker 1, two of 1a and 1b are shown in Fig.1; however, there are cases of three or more, and in each thereof material 2 for one batch can be transported and stored.

[0031] Embodiment 1 is a blast furnace material charging method that uses such bell-less charging device, in the method, coke is charged with an inclination angle sequentially varying from a furnace center side toward a furnace wall side, and, during the charge of the coke, also ore is simultaneously charged. Specifically, charge periods of ore and coke are as that shown in a conceptual diagram shown in Fig.2A. That is, coke is discharged from a furnace top bunker (for instance, 1a) where the coke is stored, and when a discharge amount of the coke from the furnace top bunker becomes 5 to 50% by mass of a coke charge amount for one batch stored in the furnace top bunker, from another furnace top bunker (for instance, 1b) where ore is stored the ore is begun discharging. Thereby, at the beginning, the center charge of coke, and, halfway on, the mix charge of coke and ore can be performed.

[0032] In Fig.3, an example of a burden distribution formed when such charge is carried out in the furnace is shown. Here, reference signs C and O in Fig.3, respectively, denote coke and ore, and subscripts denote a batch number. Fig. 3 shows a case where after firstly three rotations are carried out to charge coke, the mix charge of coke and ore is carried out. In this case, immediately after the coke charge, only the coke is charged on a furnace center side; accordingly, a deposit layer C_2 made only of coke is formed in the furnace center part. Thereafter, ore is charged together with the coke; accordingly, a mixed layer $C_2 + O_1$ of the coke and ore is formed. In this case, the coke charged in advance piles up in heap in the furnace center part, and thereafter a mixture of the coke and ore is charged to a more furnace wall side than that; accordingly, the mixture later charged does not flow on the heap of the coke in the furnace center part. Thereby, in the furnace center part, a center coke layer where only coke piles up is formed. Furthermore, the ore later charged piles up outside (on furnace wall side) of the center coke layer simultaneously with the coke; accordingly, in a predetermined position in a radius direction in the furnace, a mixed layer $C_2 + O_1$ having a predetermined thickness is formed.

[0033] In embodiment 1, the opening of the flow rate control gate 3 is preferably controlled so that the respective discharges of coke and ore may come to completion simultaneously. However, since the discharge times of the coke and ore from the furnace top bunker 1 vary depending on the respective particle diameters and moisture contents, the opening control of the flow rate control gate 3 may be appropriately carried out.

[0034] In an example shown in Fig.3, coke and ore are respectively divided into two batches, a second batch of the coke and a first batch of the ore are partially simultaneously discharged, and thereby the center coke and the mixed layer are formed. However, in the invention, without restricting to the above, when the respective one charges of coke and ore are charged into the furnace without dividing into batches, a charging method in which a layer of coke alone is formed in the furnace center part and in the surroundings thereof a mixed layer is formed may be adopted. Furthermore, a charging method where coke is divided into two batches, one batch of coke alone C_1 is charged over an entirety in the furnace, and thereafter from halfway of the second batch of the coke, ore for one charge is mixed and charged can be adopted.

[0035] Furthermore, in Embodiment 1, a timing of starting discharging ore that is mixed with coke from the furnace top bunker is set at during a period from a time when the discharge of coke alone from another furnace top bunker is started to a time when coke corresponding to 5 to 50% by mass of an amount of coke that is charged in the batch is discharged. The reason for this is as follows.

[0036] When an amount of discharge of coke alone is less than 5% by mass, since an amount of coke that is piled up in the furnace center part is excessively slight, the mixture of coke and ore that is charged later is mingled with a coke layer in the furnace center part; accordingly, an effect of the coke center charge cannot be obtained. Furthermore, when after coke alone is charged exceeding 50% by mass, the mixture of coke and ore is started charging, since an amount of coke in the mixture cannot be sufficiently increased, an effect of the mix charge is difficult to obtain. Still furthermore, in this case, in a wide range in the furnace center part, a portion where ore is not present is generated, that is, the inside of the furnace cannot be effectively used, on the contrary, the productivity cannot be improved.

Embodiment 2

[0037] Fig.4 is a sectional view schematically showing a furnace top part of a blast furnace (hereinafter, referred to as bell-less blast furnace) provided with a bell-less charging device. In Fig.4, an angle that a blast furnace neutral axis

and a rotation chute form (hereinafter referred to as inclination angle) is expressed with θ .

[0038] A bell-less blast furnace is provided with two or more furnace top bunkers 1, and in one of the furnace top bunkers 1 a mixed material 20 obtained by mixing coke and ore is stored. The mixed material 20 is discharged from a lower part of the furnace top bunker 1, controlled to a predetermined flow rate when passing through a flow rate control gate 3, and thereafter supplied through a vertical chute 4 to a charging chute 5.

[0039] With the charging chute 5 rotating about a blast furnace neutral axis and a inclination angle θ varying, the mixed material 20 is charged into the blast furnace 6. An arrow mark a in Fig.4 denotes the rotation of the charging chute 5 and an arrow mark b denotes a fall of the mixed material 20.

[0040] When the mixed material 20 is thus charged into the blast furnace 6, by rotating the charging chute 5 and sequentially varying the inclination angle θ , over a wide range on a material pile surface 8 at a furnace top part of a blast furnace 7, the mixed material 20 can be charged.

[0041] In Fig.4, a bell-less blast furnace provided with two furnace top bunkers 1 is shown; however, embodiment 2 can be applied also to a bell-less blast furnace provided with three or more furnace top bunkers 1.

[0042] In the present invention 2, a method of storing the mixed material 20 of ore and coke in the furnace top bunker 1 is not restricted to a particular method. For instance, a so far known method in which from a weighing hopper of ore (not shown in the drawing) and a weighing hopper of coke (not shown in the drawing), respectively, ore and coke are simultaneously discharged at a predetermined ratio and transferred through charge conveyers (not shown in the drawing) to the furnace top bunker 1 can be used.

[0043] However, owing to the difference of the characteristics of ore and coke, the mixed material 20 in the furnace top bunker 1 cannot be avoided from locally varying in the mixing ratio. That is, while an average particle diameter of ore is such small as substantially 15 mm, an average particle diameter of coke is such large as substantially 50 mm; accordingly, when the mixed material 20 is thrown into the furnace top bunker 1, coke relatively large in the particle diameter rolls toward a wall side of the furnace top bunker 1 and ore relatively small in the particle diameter tends to pile up at a position where it is thrown in.

[0044] Furthermore, when the mixed material 20 is discharged from a lower part of the furnace top bunker 1, of the mixed material 20 stored in the furnace top bunker 1, the mixed material 20 distributed in a vertical direction from a lower layer part positioned immediately above a discharge outlet to a surface part is predominantly discharged, on a portion immediately above the discharge outlet where a pile level is lowered, the mixed material 20 flows in from the surroundings thereof (so-called funnel flow), and thereby the discharge proceeds.

[0045] As a result, although, when the mixed material 20 is put in the furnace top bunker 1, ore and coke are previously mixed at a predetermined ratio, when the mixed material 20 is discharged from the furnace top bunker 1, the mixing ratio of the ore and coke varies. That is, at an initial stage of the discharge, the ratio of the ore increases and at the later stage of the discharge, the ratio of the coke increases. Thus, the mixing ratio cannot be avoided from varying when the mixed material 20 is thus discharged from the furnace top bunker 1.

[0046] Since the mixing ratio varies thus while the mixed material 20 is discharged from the furnace top bunker 1, when the mixed material 20 is charged through the charging chute 5 into the blast furnace 6, the ore and coke in the mixed material 20 cannot be uniformly distributed on a material pile surface 6, resulting in causing segregation in a particular region.

[0047] In this connection, in the present invention 2, in order to inhibit the segregation on the material pile surface 8 from occurring, during from the start of the charge of the mixed material 20 stored in one furnace top bunker 1 to the completion of the charge of the whole amount thereof, the charging chute 5 is rotated about the blast furnace neutral axis and the inclination angle θ is sequentially varied, and thereby the charging chute 5 is reciprocated at least once in a radius direction in the furnace. When the inclination angle θ is varied, at each of the inclination angles the charging chute 5 is rotated once.

[0048] That is, at a predetermined inclination angle θ , the charging chute 5 is rotated once about the blast furnace neutral axis to charge the mixed material 20, thereafter the inclination angle θ is varied and the mixed material 20 is charged. This is repeated until the charge of the whole amount of the mixed material 20 in the furnace top bunker 1 comes to completion, and, during this period, the charging chute 5 is reciprocated at least once in a radius direction in the blast furnace. Accordingly, during the charge of the whole amount of the mixed material 20 stored in one furnace top bunker 1, on an arbitrary position on the material pile surface 8, the mixed material 20 is charged twice or more.

[0049] In the operation of the bell-less blast furnace, usually, the inclination angle θ of the charging chute 5 is set at several steps and each of the steps is assigned to a number (hereinafter referred to as notch number). Accordingly, after the charging chute 5 is rotated once at a predetermined notch number and the mixed material 20 is charged, the notch number is changed to the subsequent notch number followed by continuing the charge of the mixed material 20, and thereby the embodiment 2 can be applied to an existing bell-less blast furnace.

[0050] Fig.5 is a sectional view schematically showing an example where the embodiment 2 is applied to charge a mixed material. In Fig.5, an example in which the charge of the mixed material 20 is begun from a furnace wall side, the mixed material 20 is continued charging with the inclination angle θ sequentially reducing, and, after the mixed

material 20 is charged in the center part of the blast furnace, the mixed material 20 is charged with the inclination angle θ sequentially increasing is shown. Accordingly, in Fig.5, a mixed material 20a that was charged at the first rotation (hereinafter referred to as the first rotation) of the charging chute 5 that began charging the mixed material 20 stored in the furnace top bunker 1 locates on a blast furnace wall side on a material pile surface 6, and a mixed material 20b charged at the twelfth rotation (hereinafter referred to as the twelfth rotation) of the charging chute 5 locates on the mixed material 20a charged at the first rotation.

[0051] Fig.5 shows a state when the charge of the whole amount of the mixed material 20 came to completion at the twelfth rotation. The charging chute 5 rotates once at a predetermined inclination angle θ about the blast furnace neutral axis; accordingly, in Fig.5, the mixed material 20 is charged on both sides of the blast furnace neutral axis. However, in Fig.5, only one side is shown.

[0052] In Fig.5, an example in which while the whole amount of the mixed material 20 stored in the furnace top bunker 1 is charged, the charging chute 5 is rotated twelve times is shown; however, in the embodiment 2, the number of rotation of the charging chute 5 is not restricted to a particular numerical value.

[0053] Furthermore, in Fig.5, an example in which while the whole amount of the mixed material 20 stored in the furnace top bunker 1 is charged, the charging chute 5 reciprocates once in a radius direction in the blast furnace is shown; in the embodiment 2, the charging chute 5 need only reciprocate at least once in a radius direction of the blast furnace. Accordingly, while the whole amount of the mixed material 20 stored in the furnace top bunker 1 is charged, the charging chute 5, after one reciprocation in a radius direction of the blast furnace, may rotate further several times, or may reciprocate two or more times.

[0054] That is, during the whole amount of the mixed material 20 stored in the furnace top bunker 1 being charged, the number of times of rotations of the charging chute 5 about a blast furnace neutral axis and the number of times of reciprocations of the charging chute 5 in a radius direction of the blast furnace may be appropriately set. The flow rate of the mixed material 20 discharged from the furnace top bunker 1 is controlled with the flow rate control gate 3.

[0055] In Fig.5, an example where the charge of the mixed material 20 is started from a blast furnace wall side is shown. However, the charge of the mixed material 20 may be started from the blast furnace center side and continued with the inclination angle θ sequentially increasing, and, after the mixed material 20 is charged on the blast furnace wall part, the mixed material 20 may be charged with the inclination angle θ sequentially diminishing.

[0056] When, during the whole amount of the mixed material 20 stored in the furnace top bunker 1 being thus charged, the mixed material 20 is charged twice or more on an arbitrary position on the material pile surface 6, even when the mixing ratio of the mixed material 20 at the first charge varies (an increase in the ratio of, for instance, ore), in the charge at second time and after, the mixing ratio exhibits a reverse behavior (an increase in the ratio of, for instance, coke). Accordingly, the ore and coke can be distributed on the material pile surface 8 with a definite mixing ratio. As a result, the gas permeability of a cohesive zone can be improved, a temperature fluctuation of the hot pig iron can be inhibited from occurring, and thereby the hot pig iron having uniform quality can be obtained.

[0057] In actuality, when the charge at a predetermined notch number is carried out once, the mixed material 20 piles up on the material pile surface 8 spreading in a radius direction; accordingly, when the charging chute 5 is reciprocated in a radius direction, there is no need of reciprocating at the same notch number. At a predetermined width in a radius direction, the charging chute 5 need only reciprocate at least once.

Embodiment 3

[0058] As shown in Fig.6, in a bell-less blast furnace 6 that has a charging chute 5, material such as ore and coke is charged from a furnace top through a charging chute 5, and thereby a burden distribution in the furnace 14 is formed.

[0059] The charging chute 5 is controlled so as to be θ in the inclination angle with respect to the furnace neutral axis in a furnace center part 6a and charges the material while rotating about the furnace neutral axis. Thereby, a material deposit surface having the point symmetry with the furnace center part 6a as a center is formed. Furthermore, the material being charged, when an angle of the charging chute is varied, can be put on an arbitrary position on a furnace top surface.

[0060] A charge position in a radius direction in the furnace can be controlled by controlling the inclination angle θ of the charging chute 5. Usually, in advance, corresponding notch numbers are assigned to predetermined inclination angles. When the material is charged while rotating about the furnace neutral axis, the notch number is previously determined for each rotation of the charging chute from the charge start of the material. When a pattern of the notch numbers is controlled, the charge control by which a pattern of the material charge into the furnace can be controlled is performed.

[0061] Falling positions of the material corresponding to the inclination angles of the charging chute are previously investigated when prior to the start of operation of a blast furnace material filling in the furnace is investigated. Alternatively, by mechanically calculating a dropping trajectory of the material by taking the centrifugal force and the gravity when the material flows down above the rotating charging chute, and an ascending flow of gas in the furnace into

consideration, a charging position of the material can be obtained.

[0062] When the charge of the center coke is considered, when the coke is charged by diminishing the inclination angle for each rotation from the beginning of charge, as shown in Fig. 7, a charge position of coke at the second rotation comes more toward the furnace center part than that of the first rotation. When the center coke is charged like this, the coke at the second rotation, after falling on the furnace center side more than the coke at the first rotation, flows into the furnace center side. At this time, among the coke at the second rotation, relatively coarser particles flow toward the furnace center side.

[0063] That is, when, as the rotation proceeds, the falling position of the coke is moved toward the furnace center side, the fallen coke flows from the falling position along an inclined plane toward the furnace center side; accordingly, the coarsest particles of the charged coke pile up at the furnace center part.

[0064] At this time, when the falling positions at the first and second rotations are the same, the coke at the second rotation flows divided in the furnace center side and the furnace wall side; accordingly, coarse particles of coke partially at the second rotation flow toward the furnace wall side and cause a problem. However, as in the embodiment 3, when, as the rotation proceeds, the falling position of the coke is moved toward the furnace center side, all of the coarse particles flow into the furnace center side. It is effective in view of the intensification of the segregation of the coarse coke at the furnace center part.

[0065] Furthermore, in the Embodiment 3, the charge start position of the center coke is preferably set at a radius position corresponding to 0.1 to 0.4 relative to a dimensionless radius with the furnace center part of the blast furnace assigned to 0 and the furnace wall part assigned to 1. When the charge start position is larger than 0.4, since when the charge of the center coke is begun, an amount of coke charged by one rotation becomes slight, the coke does not flow in the neighborhood of the furnace center part, resulting in less effective in the effect of charging coarser particles in the furnace center part. Still furthermore, when the charge start position is less than 0.1, since a distance through which the charged coke flows in becomes short, the effect of causing the particle segregation becomes less.

[0066] In order to examine a preferable range of the charge start position of the center coke, one-fifth scale model experiment of a furnace top charging device of a blast furnace having a furnace capacity of 5000 m³ was conducted and relationship between the ratio of coarse coke in a radius direction and the charge start position of the center coke was investigated. Results are shown in Fig.9. Here, the coarse coke particle ratio is defined as follows. That is, after the charge experiment was over, at each of the respective dimensionless radius positions, a predetermined amount was sampled and a particle size distribution of the coke was measured, and, with particles having particle diameter larger than a median diameter of the charged coke as coarse particles, a ratio of the coarse particles in each of the samples is obtained as the coarse coke particle ratio.

[0067] In each of the experiments, the coke was charged by 5 rotations. Here, in the case of the charge start positions being 0.05 and 0.1, after one rotation, the charge position was moved toward the furnace center side by 0.01 in terms of dimensionless radius to charge. Furthermore, in the case of the charge start position being 0.4 and 0.45, after one rotation, the charge position was moved toward the furnace center side by 0.05 in terms of the dimensionless radius to charge.

[0068] In the case of the charge start position being 0.05 in terms of dimensionless radius, since the coke after the second rotation overflowed on the contrary from the furnace center part toward the furnace wall part and piled up, in essence, there is no large difference from the case of direct charge to the furnace center part. Also in the particle size measurement, the coarse particle ratio results in increasing toward the furnace wall side rather than toward the furnace center side.

[0069] Furthermore, in the case of the charge start position being 0.45 in terms of the dimensionless radius, in the range of 0 to 0.3 in terms of the dimensionless radius, the coarse coke particle ratio does not so much vary, resulting in there being no large segregation. On the other hand, in the case of the charge start position being in the range of 0.1 to 0.4, in the range of 0 to 0.2 in terms of the dimensionless radius, 70% or more of the coke becomes coarse particles; that is, it is found that the segregation of the coarse particles in the neighborhood of the center part is intensified.

[0070] Subsequently, embodiments 4 and 5 will be explained. The present inventors found that when material is charged in a blast furnace by use of a bell-less charging device, as shown in Fig.1, material discharged from a furnace top bunker 1, when a charging chute 5 is rotated about a furnace neutral axis and an angle (θ) between the charging chute and the furnace neutral axis is altered for each rotation, can be charged uniformly in a furnace periphery direction and at an arbitrary position in a radius direction in the furnace. That is, when the charge of coke is started from a state where a inclination angle (θ) is almost zero, that is, the charging chute is almost vertical and θ is increased stepwise for each rotation, coke being piled up in the furnace can be piled up in the furnace center part at the charge start time and, with time, toward the furnace wall side. When this charge method is applied, when, of the coke for one batch that is discharged from the furnace top bunker into the furnace, the coke large in the particle diameter can be selectively discharged at the start of the discharge, the coke large in the particle diameter can be selectively charged in the center part in the blast furnace.

[0071] In order to make the particle diameter of the coke that is charged at the beginning of one batch larger than that of the coke that is subsequently charged, it need only do as follows.

[0072] Usually, to each of lower parts of a plurality of coke bins where blast furnace coke is stored, a screen 21 is disposed, and a screen mesh thereof is set at 35 mm. Here, the screen mesh of part of the coke bins is set at for instance 55 mm that is larger than that of the other coke bins. When thus disposed, as shown in Fig.10, when coke is transferred from these coke bins 22 to the weighing hopper 23, when, firstly, only a definite amount of coke 24a from the coke bin 22a that has the larger screen mesh is transferred to the weighing hopper 23, and subsequently, coke 24b from the other coke bin is transferred, in the weighing hopper 23, on a lower side, the coke 24a having a particle diameter of 55 mm or more, thereon the coke 24b having a particle diameter of 35 mm or more, in total for one batch of coke, can be piled. Subsequently, after weighing the coke for this one batch, the coke is discharged from a lower part of the hopper 3 and transferred to a bunker 1 at the furnace top. Even at this time, in the bunker 1, similarly to the above, on a lower side, the coke 24a having a particle diameter of 55 mm or more, thereon the coke 24b having a particle diameter of 35 mm or more, in total for one batch of coke, are piled. Here, as shown in Fig.1, when these cokes are charged from a furnace center part toward a furnace wall part, while reversely tilting, from the bunker 1 through the chute 5, the particle diameter of the coke piled up in the blast furnace becomes larger in average in the center part than in the periphery part.

[0073] In the Embodiments 4 and 5, an amount of the coke 24a that has a particle diameter of 55 mm or more is empirically inferred from a pile height in the weighing hopper 23. Furthermore, an amount thereof in one batch is preferably in the range of 5 to 50% by mass. When it is less than 5% by mass, since an amount of the coke that has a larger particle diameter is less in the furnace center part, it is insufficient for coke having an ordinary particle diameter to flow in the furnace center part to form a strong center flow. On the other hand, when it is more than 50% by mass, although it is sufficient to form a strong center flow, an amount of coke of minus screen that cannot be used increases, resulting in causing inconvenience.

[0074] The present invention exhibits effects in each of the above-explained embodiments 1 through 5. However, when these are combined, the distribution of the charge in the blast furnace can be more effectively optimized. For instance, in Fig.3, the embodiment 4 can be applied to the C_1 layer; the embodiment 3 to the C_2 layer; the embodiment 1 to the $C_2 + O_1$ layer; and the embodiment 2 to the O_2 layer.

Examples

(Example 1)

[0075] With a blast furnace that has a furnace capacity of 5000 m³ and is equipped with a bell-less charging device, experimental operations were carried out to improve the productivity thereof. In the blast furnace, the inclination angles of the charging chute, as shown in Table 3, correspond to the notch numbers. The larger the notch number is, the smaller is set the inclination angle. Accordingly, immediately after the start of the charge, the charging chute is at 20th notch and in an almost vertical state, thereafter, with the inclination angle gradually increasing, the charge is carried out.

[0076] Furthermore, in the experimental operations, by setting the productivity, a target in such blast furnace, of molten iron at three levels of 1.8, 2.0 and 2.1 (cases 1 through 3), an amount of production was sequentially increased. In the operations of the productivity of 1.8 and 2.0, a conventional charging method of material was adopted; and in the operation of the productivity of 2.1, a charging method according to the invention of material was adopted. Here, the productivity of molten iron denotes a numerical value obtained by dividing a tapping amount a day of the blast furnace (t/d) with a furnace capacity (m³). The larger productivity means an operation that intends a larger amount of production. Charge conditions of coke and ore in the experimental operations (kind of batch, charge amount of batch, the notch numbers of the charging chute and furnace top bunker used) are collectively shown in Table 1.

[0077] Firstly, in case 1, an operation with the productivity of 1.8, only coke was charged as C_1 , thereafter coke for center charge was charged as C_2 , and further thereafter coke of C_3 and ore of O_1 that were previously mixed and stored in a mixed state in a furnace top bunker were simultaneously charged to form a mixed layer. Thereafter, only ore was charged as O_2 on a furnace wall side and thereby a layer made of ore alone was formed. As the ore of O_2 , one having smaller particle diameter of the ores was charged particularly on the furnace wall side. With the sequence of operations as one charge, the charges were repeated. This operation is a conventional technology and corresponds to one in which the center charge of coke and the mix charge are separately carried out.

[0078] In order to increase the amount of production of the hot pig iron in the case 1, with an intension of increasing the productivity up to 2.0, an operation in which a blast volume to the blast furnace is increased to increase a reduced amount of ore per unit time was carried out. However, in the operation, since it took a long time to divide coke and ore for one charge into 5 batches each and to transport to the furnace top bunkers, material supply for keeping a pile surface in the furnace at a substantially constant level became difficult, resulting in necessity of shortening the transporting time.

[0079] As a result, the formation of the mixed layer due to the simultaneous charge of the coke and ore that are mixed in advance was abandoned; as case 2, an operation in which 4 batches are transported for one charge was adopted. Furthermore, at this time, as a countermeasure for improving the productivity, it was necessary to raise an agglomerated ore ratio (a ratio of sintered ore in ore) to 82% by mass to improve the reduction in the furnace.

[0080] An operation situation of case 2 is shown in Table 2. Although, in order to improve the productivity, the mix charge of case 1 was given up and the agglomerated ore ratio was raised, the permeability resistance index in the furnace rose from 1.05 to 1.17, that is, the gas permeability was more deteriorated than the case 1.

[0081] There, by applying the material charging method according to the invention, coke was charged as C₂ from the furnace center part to a furnace middle part during 13 rotations of the charging chute and from 6th rotations of 13 rotations and on ore was simultaneously charged. This means that at a time point when substantially 40% by mass of a total amount of charged coke of C₂ is charged, the mix charge of the coke and ore was begun. Operation results of the case 3 are shown in the Table 2 together with the case 1 and case 2.

[0082] In Table 2, the coke ratio and pulverized coal ratio, respectively, denote amounts (kg) of coke and pulverized coal used to produce 1 ton of molten iron. The agglomerated ore ratio is a numeral value that shows a mass ratio of sintered ore in ore and so on that are charged from the furnace top in terms of percentage. The coke strength TI is a tumbler index. The permeability resistance index can be expressed with the following equation.

$$\begin{aligned} & \{[(BP/98.0665 + 1.033) \times 10000]^2 - \{(TP/98.0665 + 1.033) \times \\ & 10000\}^2\} / (1.033 \times 10000 \times LSLOT) / (BGV/SAVE)^{1.7} \times 273 / \{(SGT + \\ & 273) / 2 + 273\} \end{aligned}$$

[0083] In the above equation,

BP: blast pressure [kPa]
TP: furnace top pressure [kPa]
LSLOT: distance between stockline and tuyere [m]
BGV: bosh gas volume [Nm³/min]
SAVE: average sectional area in blast furnace [m²]
SGT: gas temperature typical in shaft part: 1000 degree centigrade.

[0084] From Table 2, it is obvious that according to the invention, the productivity could be raised to 2.1. In this case, without interrupting the mix charge halfway, the coke center charge and the mix charge could be simultaneously carried out, and the permeability resistance index was also reduced to the level the same as case 1.

Table 1

	Furnace top bunker used	Content of batch*	Charge amount (t/ch)	Notch numbers to one rotation of charging chute	Note
Case 1	A	C ₁ (coke)	24	3 3 3 4 4 5 5 6 6 7 8 9 10	C ₃ and O ₁ are previously mixed and stored in a furnace top bunker, and discharged simultaneously.
	B	C ₂ (center coke)	5	16 17 18 19 20	
	A	C ₃ (coke)	10	16 15 15 14 13 12 11 10	
	B	O ₁ (ore)	103		
Case 2	B	O ₂ (ore)	54	5 6 7 8 9	This corresponds to the invention. O ₁ is discharged simultaneously from the middle of C ₂ .
	A	C ₁ (coke)	33	3 3 3 4 4 5 5 6 6 7 8 9 10	
	B	C ₂ (center coke)	6	16 17 18 19 20	
	A	O ₁ (ore)	105	16 15 14 13 12 11 10 9	
	B	O ₂ (ore)	54	5 6 7 8 9	
	B	C ₁ (coke)	24	3 3 3 4 4 5 5 6 6 7 8 9 10	
Case 3	A	C ₂ (coke)	15	20 20 19 18 17 16 15 14 13 12 11 10	This corresponds to the invention. O ₁ is discharged simultaneously from the middle of C ₂ .
	B	O ₁ (ore)	103	16 15 14 13 12 11 10	
	A	O ₂ (ore)	54	5 6 7 8 9	

* In each case, the charge is carried out sequentially from an upper batch to a lower batch.

Table 2

		Case 1	Case 2	Case 3
Blast furnace productivity	t/d/m ³	1.8	2.0	2.1
Coke center charge		Yes	Yes	Yes
Mix charge		Yes	None	Yes
Coke ratio	Kg/t - p	403	400	402
Pulverized coal ratio	Kg/t - p	101	99	97
Agglomerated ore ratio	mass %	74	82	74
Coke strength (TI)	%	84.5	85	84.5
Tap Si	mass %	0.27	0.31	0.25
Permeability resistance index		1.05	1.17	1.03

Table 3

Notch number.	Inclination angle
1	58°
2	57°
3	56°
4	55°
5	54°
6	53°
7	52°
8	51°
9	50°
10	49°
11	48°
12	46°
13	44°
14	42°
15	40°
16	38°
17	32°
18	26°
19	21°
20	15°

(Example 2)

[0085] In an operation where an ore layer and a coke layer are alternately formed in a bell-less blast furnace (furnace capacity of 5000 m³), in forming an ore layer, as shown in Fig. 5, a mixed material 20 in which coke is mixed in ore in advance was stored in one of furnace top bunkers 1. An amount of coke in the mixed material 20 was set at 16% by mass with respect to an amount of total coke for one cycle of the ore layer and coke layer.

[0086] In charging the mixed material 20 through a charging chute 5, in order that the whole amount of the mixed

material 20 in the furnace top bunker 1 may be charged during twelve rotations of the charging chute 5, a flow rate of the mixed material 20 that is discharged from the furnace top bunker 1 was adjusted with a flow rate control gate 3. That is, as shown in Fig. 5, the charge was begun from a blast furnace wall side (that is, the mixed material 20a charged at the first rotation), the mixed material 20 was charged with an inclination angle θ sequentially diminishing, after the mixed material 20 was charged up to a predetermined inclination angle in a blast furnace center direction, with the inclination angle θ sequentially increasing the mixed material 20 was charged. Thus, the charge was begun from the blast furnace wall side, the charging chute 5 reciprocated once in the radius direction in the blast furnace followed by charging again on the blast furnace wall side (that is, the mixed material 20b charged at the twelfth rotation), and thereby the charge of the whole amount of the mixed material 20 in the furnace top bunker 1 came to completion. This is an inventive example.

[0087] On the other hand, as a comparative example, in charging the mixed material 20 similarly to the inventive example, a flow rate control gate 3 was controlled so that the whole amount of the mixed material 20 in the furnace top bunker 1 may be charged during twelve rotations of the charging chute 5. The charge was begun from a blast furnace wall side, the mixed material 20 was charged with an inclination angle θ sequentially diminishing, and the charge of the whole amount of the mixed material 20 in the furnace top bunker 1 came to completion on the furnace center side.

[0088] The bell-less blast furnace used here is operated with the inclination angle θ of the charging chute 5 set with the notch number. The correspondence between the notch numbers and the inclination angles θ 's is the same as that shown in Table 3.

[0089] Furthermore, the setting of the notch numbers when the mixed material 20 was charged is shown in Table 5. The setting of the notch numbers in Table 5 denotes that the charging chute 5 made one rotation at each of the notch numbers. For instance, in the comparative example, the notch number [5] is written consecutively twice. This means that after the charging chute 5 was rotated twice at the notch number [5], the charging chute 5 was rotated at the subsequent notch number [6].

[0090] When the coke layer is formed, in both the inventive example and the comparative example, an amount corresponding to 10% by mass relative to the whole amount of coke for one cycle was charged to the blast furnace center part (so-called center coke), and remaining coke is evenly charged in a radius direction in the blast furnace. That is, the charge sequence was three-batch charge of coke-coke-ore (mixed material 20).

[0091] The inventive example and the comparative example, respectively, were operated for 5 days, and the coke ratio, pulverized coal ratio, blast temperature, hot metal temperature, and tap Si concentration were measured. Results thereof are shown together in Table 2. The coke ratio and the pulverized coal ratio in Table 4, respectively, are ratios of a total amount of used coke and a total amount of used pulverized coal to a total tapping amount of molten iron for 5 days. Furthermore, the blast temperature, hot metal temperature and Si concentration in the molten iron are average values of measurements obtained by periodically measuring (6 to 7 times a day). For the hot metal temperature and Si concentration in the molten iron, the dispersions of the measurements are also shown.

[0092] As obvious from Table 4, according to the inventive example, the dispersions of the hot metal temperatures and Si concentrations in the molten iron were reduced in comparison with that of the comparative examples. Accordingly, in the inventive example, even when the blast temperature was lowered by 30 degree centigrade in comparison with the comparative example, the stable operation was performed with the equivalent hot metal temperature maintained.

Table 4

		Comparative example	Inventive example
Setting of notch number at charge of mixed material		5 → 5 → 6 → 6 → 7 → 7 → 8 → 8 → 9 → 10	5 → 6 → 7 → 8 → 9 → 10 → 8 → 7 → 6 → 5
Coke ratio (kg/ton)		403	403
Pulverized coal ratio (kg/ton)		99	99
Blast temperature	Average value (°C)	1050	1020
Hot metal temperature	Average value (°C)	1496	1490
	Dispersion (°C)	6	3
Si concentration in molten iron	Average value (% by mass)	0.28	0.25
	Dispersion (% by mass)	0.07	0.05

(Example 3)

[0093] In a large blast furnace having a furnace capacity of 5000 m³, an operation was carried out under the operation conditions shown in Table 5. Here, in the comparative example, in charging the center coke, the charging chute was set at the inclination angle of 0° and thereby concentrated charge to the furnace center was performed. On the other hand, in the inventive example, the charge start position was set at 0.3 in terms of the dimensionless radius, and the charge position was moved toward the furnace center side by 0.03 in terms of the dimensionless radius for each rotation to charge the center coke.

[0094] During the respective operations, with a sonde disposed at a level 5 m below from a furnace top pile surface of a blast furnace shaft part feeding in a radius direction in the furnace, a gas in the furnace at each of the respective positions from the furnace wall to the furnace center part was sampled. These sampled gases were analyzed of CO gas and CO₂ gas. From their volume percents, the gas utilization efficiency was calculated.

[0095] The gas utilization efficiency is a value calculated from the following equation.

$$\text{Gas utilization efficiency (\%)} = \frac{\{\text{CO}_2 \text{ (volume \%)}\}}{\{\text{CO (volume \%)} + \text{CO}_2 \text{ (volume \%)}\}} \times 100$$

[0096] In the blast furnace, it is considered that at a portion where the gas utilization efficiency is large, a ratio of ore becomes relatively high.

[0097] Calculation results of the gas utilization efficiency are shown in Fig.8.

[0098] As shown in Fig.8, in the comparative example, the gas utilization efficiency at the furnace center part is higher than that in the periphery thereof (up to a position of substantially 0.2 in terms of dimensionless radius). This is considered that as a result of the center coke being charged concentrated at the furnace center part, coarser particles in the coke flowed in the periphery part of the furnace center, thereby the gas flow in the furnace in this part was intensified and ore charged in this part was blown up, and thereby an ore layer was collapsed and flowed in the furnace center part.

[0099] As a result thereof, in the operation of comparative example, the gas flow in the furnace center part became unstable, resulting in the fuel ratio of substantially 507 kg/t (molten iron).

[0100] On the other hand, in the inventive example, it is found that since the gas utilization efficiency at the furnace center part is such low as substantially 15%, a strong gas flow is formed in the furnace center part. Owing to the charge in the furnace being stably distributed, even when the fuel ratio is lowered to substantially 498 kg/t (molten iron), the production the same as that of comparative example or more can be achieved.

[0101] Furthermore, as obvious also from Table 5, in the inventive example, since pulverized coal less expensive in the cost in comparison with comparative example could be used much, and furthermore the total fuel ratio also could be reduced.

(Example 4)

[0102] With a test blast furnace that has a furnace capacity of substantially 10 m³ and is provided with a bell-less charging device, a charge test of material was conducted. As materials being charged, sintered ore was used as iron ore (sign O) and blast furnace coke that is usually used was used as coke (sign C). At this time, a mass ratio of ore to coke (O/C) was 3.2, 1 charge of ore was charged by one batch, and 1 charge of coke was charged by one batch. The charge of coke was carried out in two ways; that is, one is due to a material charging method involving the aforementioned present invention and the other one is due to a conventional material charging method (all screen mesh of coke bins was set at 35 mm).

[0103] The coke falling from the chute when the coke was charged was captured with a sampler at a definite time interval followed by measuring a particle diameter of the obtained sample. In Fig. 11, a horizontal axis shows an amount of coke discharged from a bunker in terms of % (a total amount is assigned to 100 %) and a vertical axis shows a ratio (%) of 55 or more in a sampled coke. From Fig.11, it is obvious that according to the present invention, a particle diameter of coke that piles up in the early stage of the charge, that is, in the furnace center part becomes larger in comparison with that of the conventional charging method.

Table 5

	Comparative example	Inventive example
Productivity of iron (t/d/m ³)	2.03	2.05
Coke ratio (kg/t)	405	378
Pulverized coal ratio (kg/t)	102	120
Fuel ratio (kg/t)	507	498
Agglomerated ore ratio (%)	78	78

Industrial Applicability

[0104] According to the embodiment 1, in carrying out an operation of high production amount with a bell-less blast furnace, the mix charge of coke and ore and the center charge of coke can be simultaneously carried out. Thereby, an increase in the pressure loss in the furnace that is likely to occur when the operation of high production amount is carried out can be effectively inhibited from occurring, and thereby without increasing an amount used of high quality materials such as sintered ore and reduced iron, the molten iron can be increased in amount of production.

[0105] According to the embodiment 2, even when properties and states such as the particle size distribution, moisture content and so on of various kinds of materials used in the blast furnace vary, on the material pile surface at the blast furnace top the ore and coke can be distributed with a constant mixing ratio, and thereby the hot metal temperature and the quality of molten iron can be inhibited from fluctuating.

[0106] According to the application of the embodiment 3, in the center charge of coke in the bell-less blast furnace with a charging chute, a particle diameter of coke could be made the largest at the furnace center part, and thereby a stable operation could be realized. Furthermore, at lower fuel ratios the production the same as ever or more could be achieved, that is, more favorable blast furnace operation could be realized.

[0107] According to the embodiments 4 and 5, even when an existing bell-less charging device is used without separately disposing a charging device exclusive for coke, without increasing the number of batches of materials, coke larger in the particle diameter than that charged in the periphery part can be selectively charged to the furnace center part. This suggests that when the invention is adopted in an actual blast furnace, a center flow of gas in the furnace can be stably secured, and thereby highly productive and economical smelting of the molten iron can be realized.

Claims

1. A method for charging a material in a bell-less blast furnace having a bell-less charging device, comprising the steps of:

- (a) storing coke in at least one furnace top bunker;
- (b) storing ore in the at least one furnace top bunker;
- (c) charging the stored coke from a furnace center part toward a furnace wall part in a radius direction in the blast furnace while rotating a chute of the bell-less charging device and varying an inclination angle thereof;
- (d) charging the stored ore from a furnace center part toward a furnace wall part in a radius direction in the furnace while rotating the chute of the bell-less charging device and varying a inclination angle thereof; and
- (e) controlling a discharge commencing time of the ore so that during a discharge amount of the coke stored in the at least one furnace top bunker being between 5 to 50 mass% of a charge amount of coke for one batch, discharge of the ore stored in the at least one furnace top bunker is begun.

2. A method for charging a material in a bell-less blast furnace having a bell-less charging device, comprising the steps of:

- (a) storing a mixed material in which ore and coke are mixed in one of furnace top bunkers;
- (b) charging the mixed material stored in the furnace top bunker in the blast furnace while rotating a charging chute about a blast furnace neutral axis and sequentially varying a inclination angle of the charging chute; and
- (c) controlling a discharge of the mixed material so that during at least one reciprocation of the charging chute in a radius direction in the blast furnace a whole amount of the mixed material stored in the furnace top bunker is charged in the blast furnace.

3. A method for charging a material in a bell-less blast furnace having a bell-less charging device, comprising the steps of:

(a) commencing charging coke by use of a charging chute of the bell-less charging device from a radius position corresponding to 0.1 to 0.4 with respect to a dimensionless radius in which a furnace center part of the bell-less blast furnace is assigned to 0 and a furnace wall part is assigned to 1; and

(b) charging the coke while sequentially varying an inclination angle of the charging chute toward a furnace center side for each rotation of the charging chute.

4. A method for charging a material in a bell-less blast furnace having a bell-less charging device, comprising the steps of:

discharging coke stored in at least two coke bins and screening the discharged coke with a screen disposed at a lower part of each of the bins;

weighing coke of plus screen with a weighing hopper and storing in a bunker disposed at a furnace top; and charging stored coke through a chute of the bell-less charging device in a blast furnace while rotating the chute from a furnace center toward a furnace wall side:

wherein the step of screening the coke comprises a first screening step of screening the coke discharged with a screen having a larger screen mesh (A); and a second screening step of screening the coke discharged with a screen having a finer screen mesh (B); and

the step of weighing and storing comprises firstly transferring a definite amount of coke from the first screening step to the weighing hopper, subsequently, transferring coke from the second screening step to weigh coke for one batch, and storing in a bunker disposed at a furnace top.

5. The method according to claim 4, wherein an amount of coke from the first screening step that screens the coke that is discharged with a screen having a larger screen mesh (A) is in the range of 5 to 50% by mass of an amount of coke of the batch.

6. A method of charging a material in a bell-less blast furnace having a bell-less charging device, comprising the steps of:

(a) storing coke in at least one of furnace top bunkers;

(b) storing ore in at least one of furnace top bunkers;

(c) storing a mixed material of ore and coke in one of furnace top bunkers;

(d) charging stored coke from a furnace center part toward a furnace wall part in a radius direction in the furnace while rotating a charging chute of the bell-less charging device and varying an inclination angle thereof;

(e) charging stored ore from a furnace center part toward a furnace wall part in a radius direction in the furnace while rotating a charging chute of the bell-less charging device and varying an inclination angle thereof; and

(f) controlling a discharge commencing time of the ore so that during a discharge amount of the coke stored in the at least one of furnace top bunkers being between 5 to 50% by mass of a charge amount of coke for one batch, discharge of the ore stored in the at least one of furnace top bunkers is begun;

(g) charging the mixed material stored in the furnace top bunker in the blast furnace while rotating the charging chute and sequentially varying an inclination angle of the charging chute; and

(h) controlling a discharge of the mixed material so that during at least one reciprocation of the charging chute in a radius direction of the blast furnace a whole amount of the mixed material stored in the furnace top bunker is charged in the blast furnace.

FIG. 1

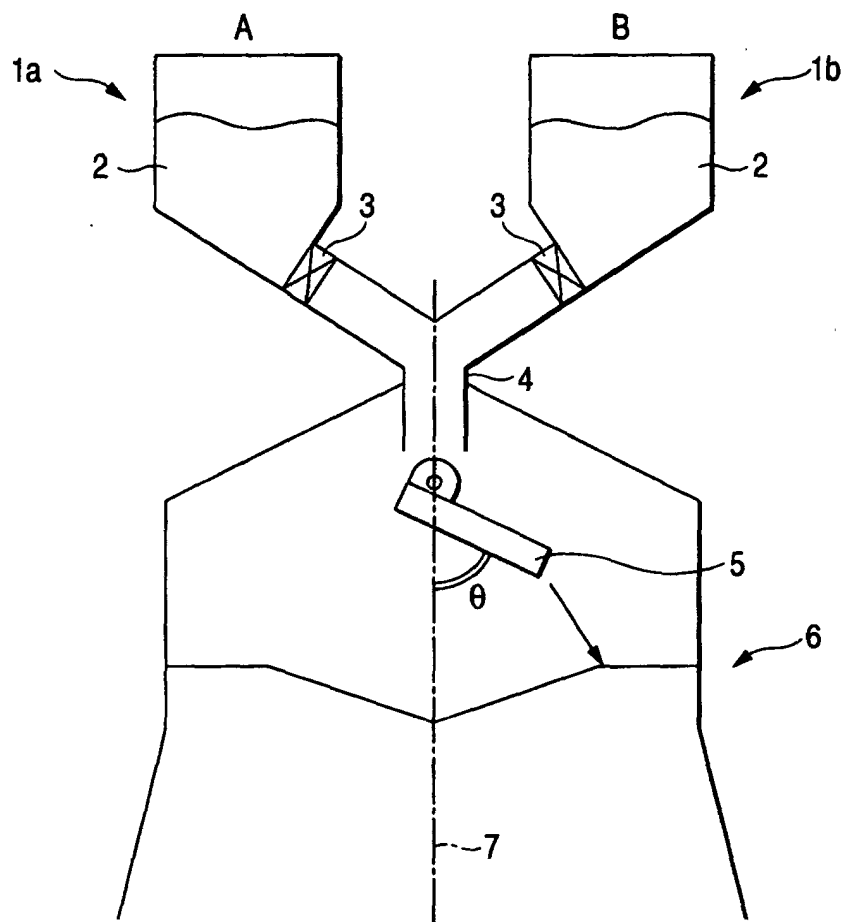


FIG. 2A

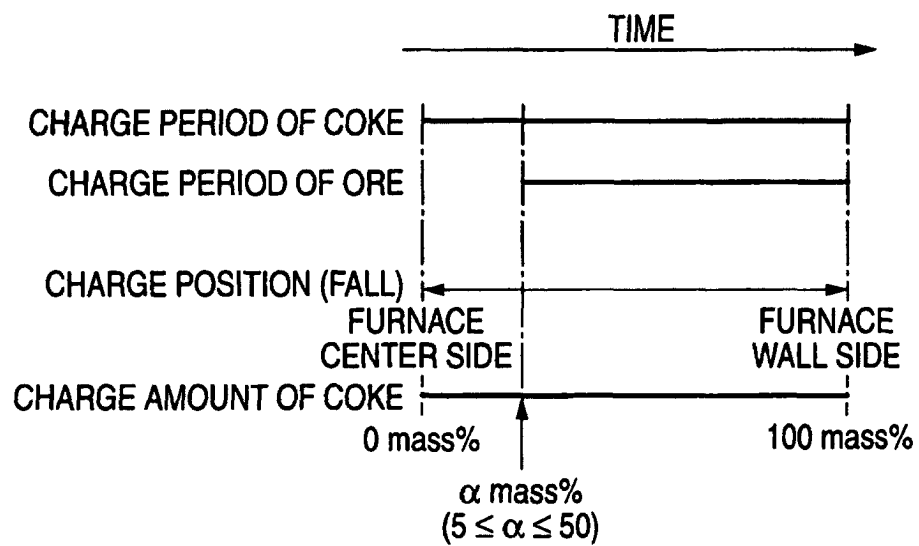


FIG. 2B

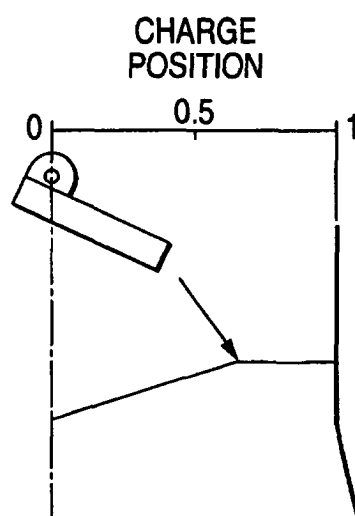


FIG. 3

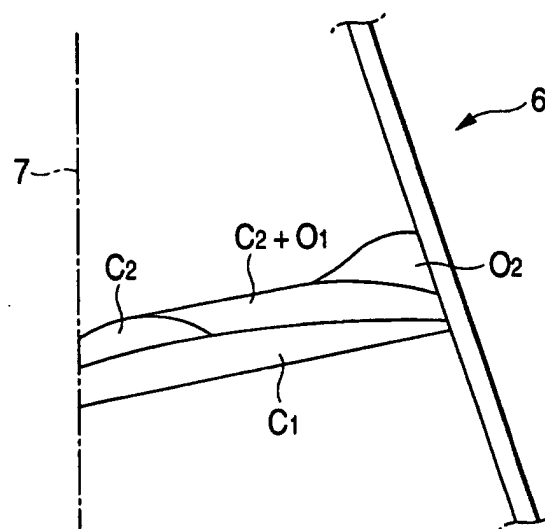


FIG. 4

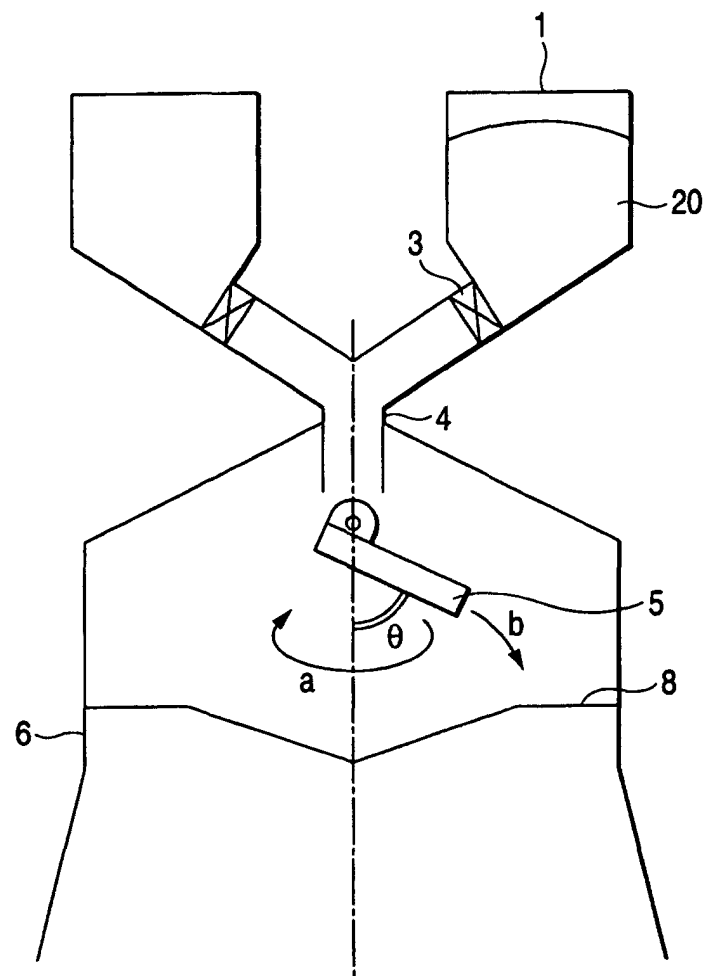


FIG. 5

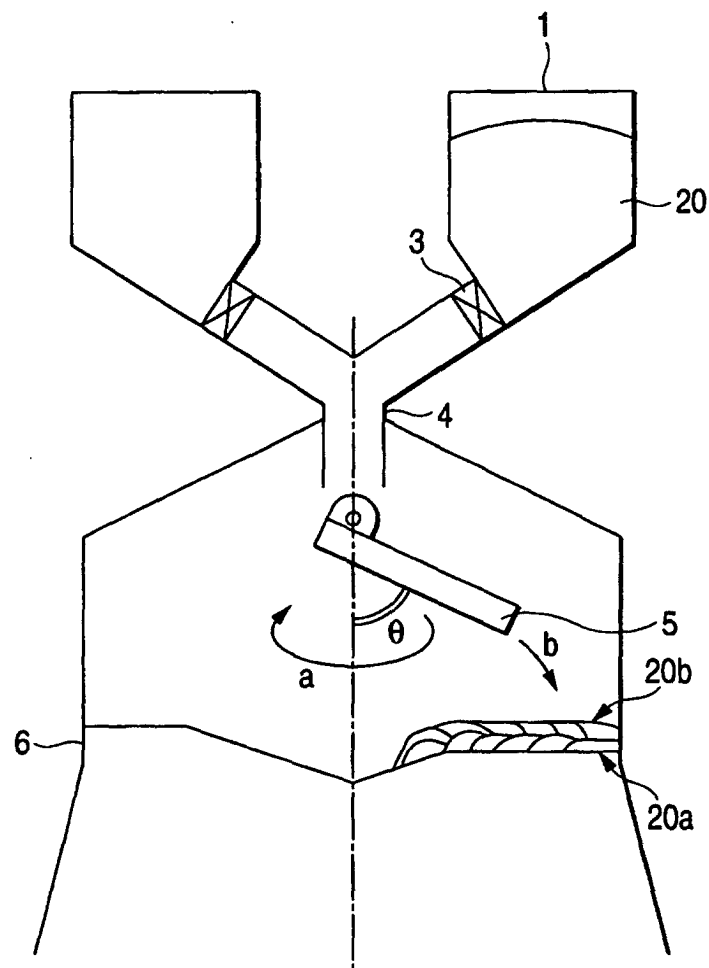


FIG. 6

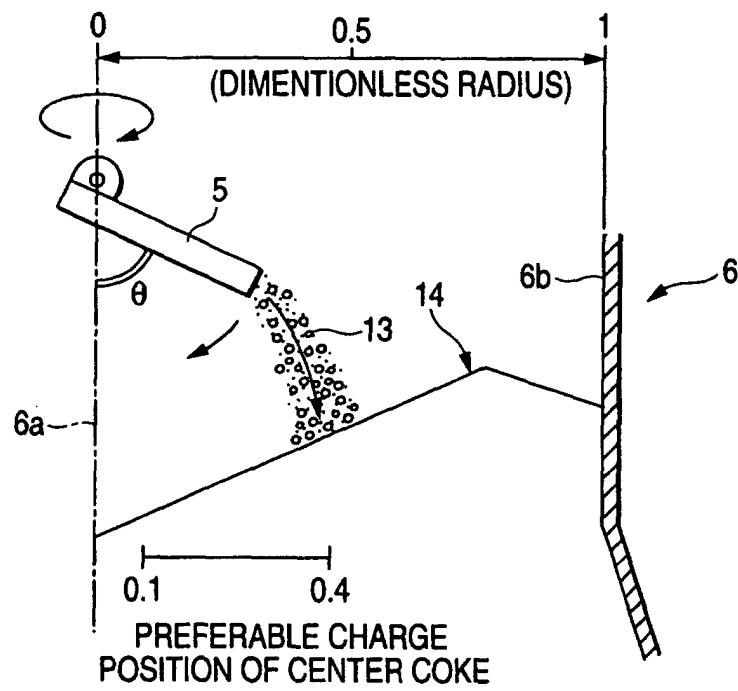


FIG. 7

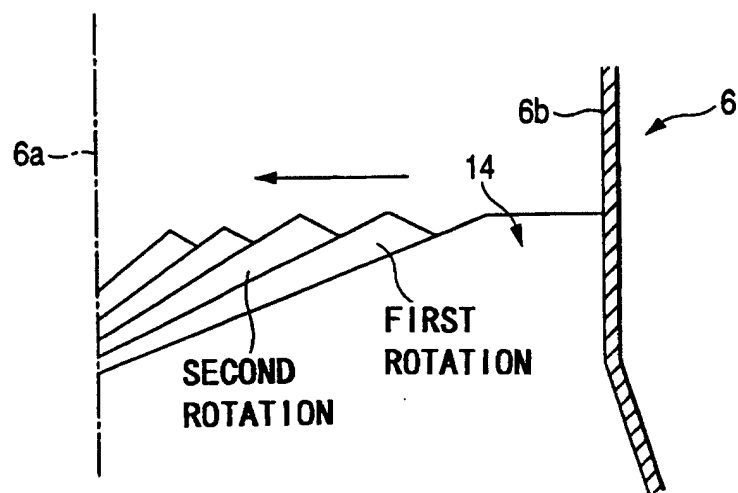


FIG. 8

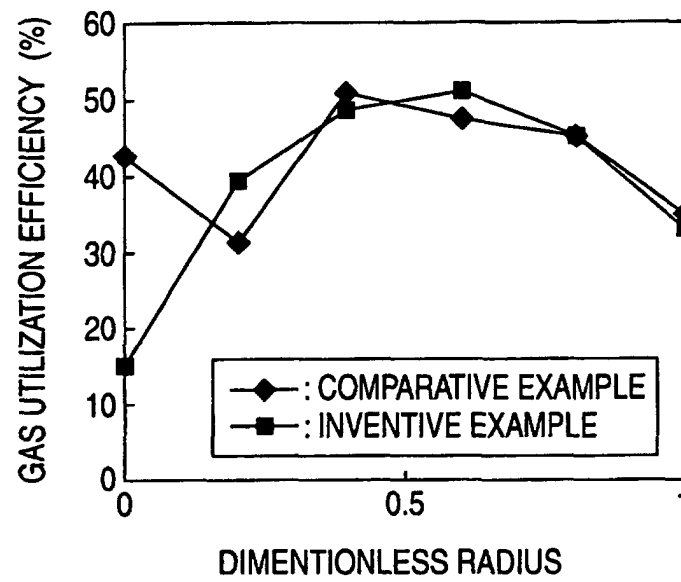
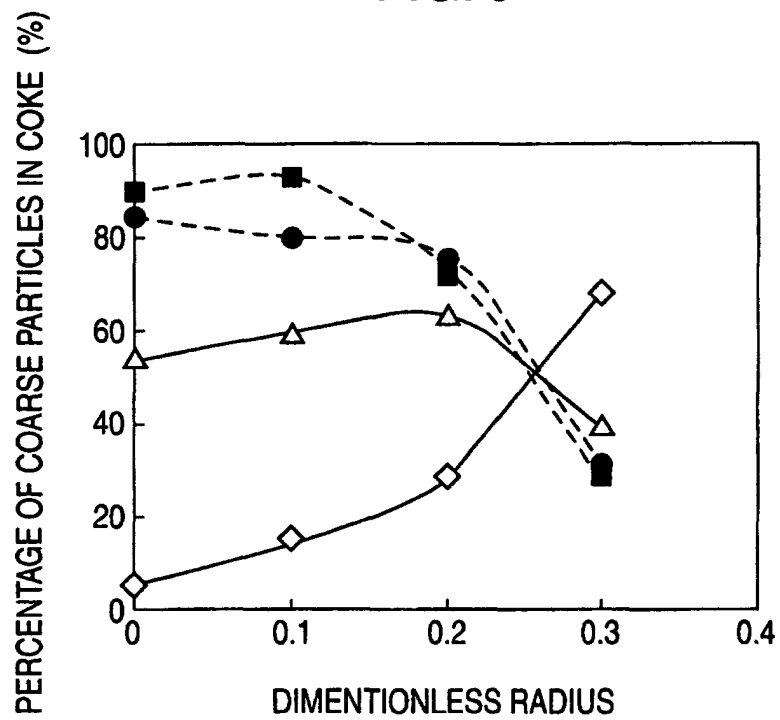


FIG. 9



◇ : CHARGE START POSITION 0.05
△ : CHARGE START POSITION 0.45
■ : CHARGE START POSITION 0.4
● : CHARGE START POSITION 0.1

FIG. 10

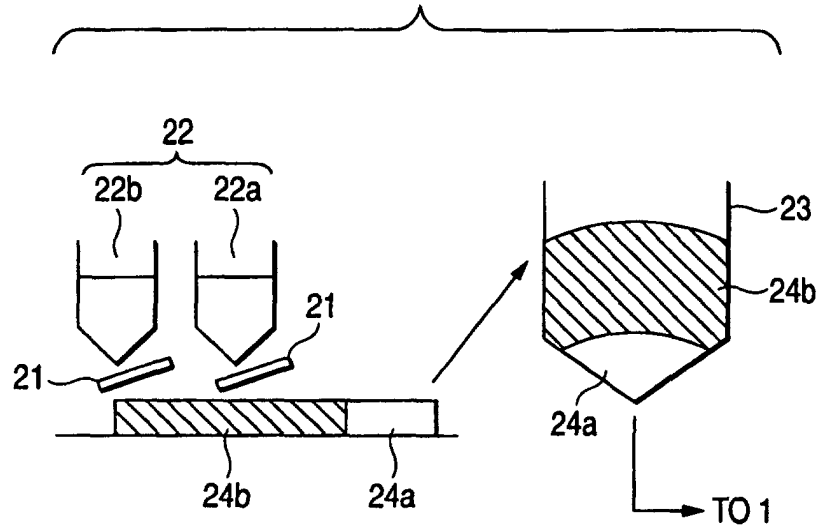
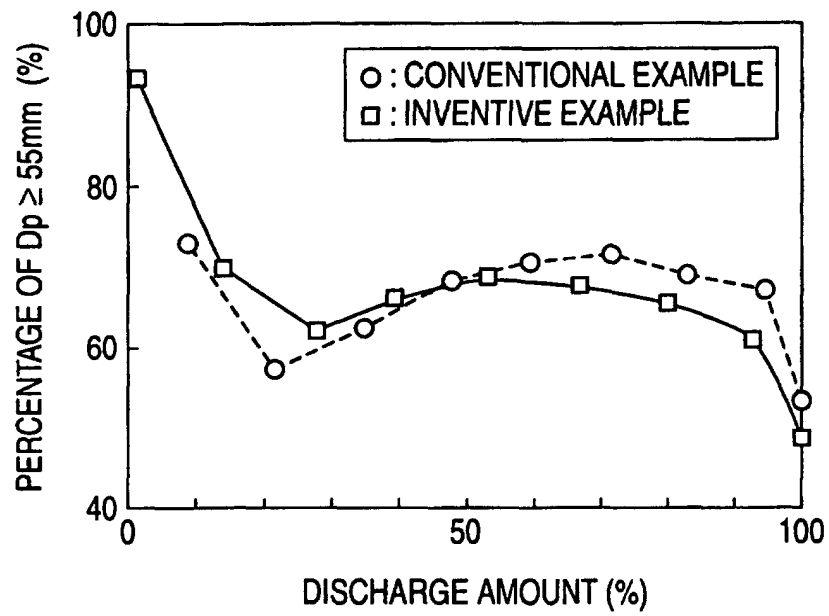


FIG. 11



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP03/10907

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl ⁷ C21B7/20, C21B5/00		
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) Int.Cl ⁷ C21B7/20, C21B5/00		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2003 Kokai Jitsuyo Shinan Koho 1971-2003 Jitsuyo Shinan Toroku Koho 1996-2003		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2002-60813 A (Kawasaki Steel Corp.), 28 February, 2002 (28.02.02), (Family: none)	1-6
A	JP 2001-262207 A (Kawasaki Steel Corp.), 26 September, 2001 (26.09.01), (Family: none)	1-6
A	JP 2-305911 A (Nippon Steel Corp.), 19 December, 1990 (19.12.90), (Family: none)	1-6
A	JP 60-208404 A (Kawasaki Steel Corp.), 21 October, 1985 (21.10.85), (Family: none)	1-6
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 26 November, 2003 (26.11.03)		Date of mailing of the international search report 09 December, 2003 (09.12.03)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP03/10907

Box I Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The feature common to Claims 1-6 is a raw material charging method for a bell-less blast furnace with a bell-less charging apparatus. However, the research has revealed that the feature is not novel because a raw material charging method for a bell-less blast furnace with a bell-less charging apparatus is described in document JP 2002-60814 A (Kawasaki Steel Corp.), 28 February 2002 (28.02.02). (continued to extra sheet)

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP03/10907

Continuation of Box No. II of continuation of first sheet(1)

Consequently, the common feature (a raw material charging method for a bell-less blast furnace with a bell-less charging apparatus) is not a special technical feature within the meaning of PCT Rule 13.2, second sentence, since the common feature makes no contribution over the prior art. Therefore, there is no feature common to all the claims. Because there exists no other common feature that can be considered as a special technical feature within the meaning of PCT Rule 13.2, second sentence, no technical relationship within the meaning of PCT Rule 13.2 between the different inventions can be found.

Consequently, it is apparent that Claims 1-6 do not satisfy the requirement of unity of invention.