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(54) QUASIPARTICLES FOR SINTERING AND METHOD OF PRODUCING SAME

QUASIPARTIKEL ZUM SINTERN UND VERFAHREN ZUR HERSTELLUNG DAVON

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DE-A1- 10 025 224 JP-A- 2002 322 514
JP-A- 2003 147 370 US-A- 3 975 183
US-A- 4 082 540 US-A1- 2005 050 995

- **None**

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Description

TECHNICAL FIELD

[0001] This disclosure relates to quasiparticles for sintering that are used as raw material for sintering to be placed on a palette of, e.g. a downward suction-type Dwight Lloyd sintering machine, for the purpose of producing sintered ore for blast furnaces, and to a method of producing the same.

BACKGROUND

[0002] In general, sintered ore that is used as raw material for blast furnaces is produced by a sintering raw material processing method as follows. Firstly, for example, as illustrated in FIG. 1, iron ore with a particle size of 10 mm or less, SiO₂-containing raw material with a particle size of 10 mm or less that is formed of silica stone, serpentinite, nickel slag, or the like, limestone-based raw material that contains powder CaO, and powder coke or solid fuel-based raw material such as anthracite as heat source, are placed in a drum mixer with addition of a suitable amount of water, then mixed and granulated to form granulated products called quasiparticles. Such mixed raw materials formed of the granulated products are charged on a palette of a Dwight Lloyd sintering machine to a suitable thickness, e.g. 500 mm to 700 mm, solid fuel in the surface layer is ignited, and after the ignition solid fuel is combusted while air is drawn downwardly. Consequently the mixed sintering raw materials are sintered by the heat of combustion, and sinter cake is formed. The sinter cake is crushed into uniformly-sized particles to obtain sintered ore with a particle size equal to or larger than a predetermined size. Other sintered ore with a smaller particle size is return ore, which is reusable as sintering raw material.

[0003] It is important for such sintered ore thus produced to exhibit, among other things, good reducibility, which greatly affects blast furnace operations. Reducibility of sintered ore is normally defined by JIS M8713 ("JIS" stands for Japanese Industrial Standard), and is denoted herein as JIS-RI. As illustrated in FIG. 2, there is a positive correlation between reducibility of sintered ore (JIS-RI) and gas utilization rate in a blast furnace (η_{CO}) and, as illustrated in FIG. 3, there is a negative correlation between gas utilization rate and fuel ratio in a blast furnace. From this follows that reducibility of sintered ore (JIS-RI) has a good negative correlation with fuel ratio via gas utilization rate (η_{CO}) in a blast furnace, and accordingly fuel ratio will decrease as reducibility of sintered ore improves in the blast furnace.

It this regard, gas utilization rate (η_{CO}) and fuel ratio are defined as:

$$\eta_{CO} = CO_2 (\%) / (CO (\%) + CO_2 (\%))$$

, where CO₂ (%) and CO (%) are both concentrations expressed in volume percent in the gas at the furnace top of the blast furnace.

$$\text{fuel ratio} = (\text{coal} + \text{coke consumption (kg/day)}) / \text{pig iron production (t/day)}$$

[0004] Cold strength of sintered ore is also an important factor in guaranteeing permeability in a blast furnace. Individual blast furnaces have lower limits on cold strength for proper operation.

Therefore, sintered ore that has excellent reducibility and high cold strength is desirable as blast furnace raw material. In this respect, Table 1 lists the reducibility and tensile strength (cold strength) of primary mineral structures forming sintered ore, calcium ferrite (CF): nCaO·Fe₂O₃, hematite (He): Fe₂O₃, FeO-containing calcium silicate (CS): CaO·xFeO·ySiO₂, and magnetite (Mg): Fe₃O₄. Note that tensile strength was measured by subjecting disk-shaped ore test pieces to splitting tensile test (radial compression test or Brazilian test). As can be seen from Table 1, hematite (He) shows high reducibility and calcium ferrite (CF) has high tensile strength.

[Table 1]

[0005]

Table 1

	Calcium Ferrite (CF)	Hematite (He)	Calcium Silicate (CS)	Magnetite (Mg)
Reducibility (%)	34	50	3	27
Tensile Strength (MPa)	102	49	19	58

[0006] Therefore, a sintering structure that is suitable for sintered ore is obtained by, as schematically illustrated in FIG. 4, forming calcium ferrite (CF), which is high in strength, on the surface of a lump and forming hematite (He), which is high in reducibility, inside the lump. It is preferable for such sintering structure to minimize the formation of FeO-containing calcium silicate (CS) low in reducibility and strength. In most conventional sintering machines, however, iron ore, SiO₂-containing raw material, limestone-based raw material, and solid fuel-based raw material are mixed at the same time as mentioned above and, as a consequence, in a quasiparticle structure obtained by mixing and granulating raw materials as illustrated in FIG. 5, powder ore, lime, and coke are present, in a mixed manner, on the circumference of coarse core ore. A sintered ore structure obtained by sintering such quasiparticles will include a mixture of four types of mineral structures: hematite (He), calcium ferrite (CF), calcium silicate (CS) containing FeO, and magnetite (Mg).

[0007] In such a situation, many attempts have been made to form more calcium ferrite (CF) and hematite (He). For example, considering the fact that FeO-containing calcium silicate (CS) forms more when sintered at high temperature, one technique is described in JPS63149331A (PTL 1) that involves granulating powder iron ore with addition of a binder or limestone, coating the surfaces of the granules with coke breeze as heat source to increase combustibility of coke, and performing sintering at low temperature to improve reducibility.

[0008] According to the conventional method proposed, however, CaO reside in close proximity to SiO₂ or SiO₂-based raw material in the iron-based raw material, which fact inevitably generates a large amount of FeO-containing calcium silicate (CS). Consequently, a structure that is formed mainly of calcium ferrite (CF) and hematite (He) may not always be provided.

[0009] To address the above problem, WO2001092588A (PTL 2) describes that by using as raw material such quasiparticles that does not require any large-scale apparatus as pretreatment for producing sintered ore and that have a layered structure in which iron ore raw material is separated from limestone-based raw material and solid fuel-based raw material, it becomes possible to produce sintered ore having the structure such that calcium ferrite (CF) with high strength is selectively formed on the surface of the sintered ore and hematite (He) with high reducibility is selectively formed on the inside of the sintered ore, and the sintered ore thus obtained exhibits improved cold strength and improved reducibility.

US 2005/0050995 A1 (PTL 3) discloses a method for manufacturing a sintering material including iron ore, a SiO₂-containing material, a limestone base powdery material and a solid fuel type powdery material. DE 100 25 224 A1 (PTL 4) discloses a process for producing sintered ore in which a small amount of a water-soluble compound (a sintering aid) is added to iron ore powder. US 3,975,183 (PTL 5) discloses the use of alkali metal silicates to reduce particulate emissions in sintering operations. US 4,082,540 (PTL 6) discloses the use of finely divided coke concentrated within a predetermined range in an outer shell layer of agglomerated particles as a material for sintering to emit a lesser amount of nitrogen oxide during sintering.

CITATION LIST

Patent Literature

[0010]

- PTL 1: JPS63149331A
- PTL 2: WO2001092588A
- PTL 3: US 2005/0050995 A1
- PTL 4: DE 100 25 224 A1
- PTL 5: US 3,975,183 (B)
- PTL 6: US 4,082,540 (B)

SUMMARY

(Technical Problem)

[0011] With the technique described in PTL 2, as illustrated in FIG. 6, if iron ore and SiO₂-containing raw material, each containing SiO₂ in large quantities, are used with quasiparticles that are separated from limestone-based raw material and from solid fuel-based raw material, in production of sintered ore, it becomes possible to delay reaction between CaO and SiO₂ during a sintering process, thereby reducing formation of calcium silicate (CS) containing FeO, which is poor in reducibility and low in cold strength. The resulting sintered ore has the structure such that calcium ferrite (CF) with high strength is selectively formed on the surface of the sintered ore and hematite (He) with high reducibility is selectively formed on the inside of the sintered ore.

[0012] By applying the quasiparticles for sintering as described in PTL 2, sintered ore with excellent reducibility and

high cold strength can be obtained. To achieve, however, low-reduction-agent-ratio operations of blast furnaces (low RAR (Reduction Agent Ratio) operations are operations with a reduction in the total amount of reducing agents blown in from tuyeres and coke charged in from the furnace top per 1 t of produced pig iron) by further improving reducibility of sintered ore in blast furnaces, there is a need for further improvement of reducibility (JIS-RI) of sintered ore.

(Solution to Problem)

[0013] Upon carefully examining, in particular, the way of improving reducibility of sintered ore that is produced with quasiparticles for sintering having a layered structure that are obtained by separating iron ore raw material from limestone-based raw material and from solid fuel - based raw material, we newly discovered that to include an alkali metal in iron ore raw material within a particular range is effective for increasing the advantages of quasiparticles for sintering having a layered structure.

[0014] We thus provide a quasiparticle for sintering and a method for manufacturing thereof according to the appended claims.

[0015] According to the invention the quasiparticle for sintering comprises a high-alkaline iron ore having an alkali metal content of 0.05 mass% or more. In this case, examples of the alkali metal include lithium, sodium, potassium, rubidium, and cesium; among these, sodium and potassium are suitably used as the iron ore raw material for sintered ore.

(Advantageous Effect)

[0016] According to the present disclosure, it is possible to provide quasiparticles that are optimal raw material for achieving further improvement of reducibility of sintered ore.

BRIEF DESCRIPTION OF THE DRAWING

[0017] In the accompanying drawings:

FIG. 1 is a diagram illustrating the flow of mixture and granulation of sintering raw material in a conventional example;
 FIG. 2 is a graph illustrating the relation between reducibility JIS-RI (%) of sintered ore and gas utilization rate η_{CO} (%) in a blast furnace;
 FIG. 3 is a graph illustrating the relation between gas utilization rate η_{CO} (%) and fuel ratio (kg/t-pig) in a blast furnace;
 FIG. 4 illustrates a desirable sintered ore structure;
 FIG. 5 illustrates a conventional quasiparticle structure and a conventional sintered ore structure;
 FIG. 6 illustrates a conventionally desirable quasiparticle structure;
 FIG. 7 illustrates a basic quasiparticle structure according to the disclosure;
 FIG. 8 illustrates a flow (process A) of mixture and granulation of sintering raw material according to the disclosure;
 FIG. 9 illustrates a flow (process B) of mixture and granulation of sintering raw material according to the disclosure; and
 FIG. 10 illustrates a flow (process C) of mixture and granulation of sintering raw material according to the disclosure.

DETAILED DESCRIPTION

[0018] In the following, quasiparticles for sintering according to the disclosure are described in detail with reference to the accompanying drawings.

[0019] As quasiparticles for sintering used to produce sintered ore with excellent reducibility and high cold strength, quasiparticles for sintering contain at least iron ore raw material, limestone-based raw material, and solid fuel-based raw material, and have a basic structure, as illustrated in FIG. 7, such that the iron ore raw material is contained as core 1, and layer 2 formed of the limestone-based raw material and solid fuel-based raw material is coated on the circumference of core 1.

[0020] In other words, such quasiparticles can be produced by containing iron ore raw material as core 1 in a state in which core 1 is separated from limestone-based raw material and does not contain limestone. Layer 2, which is formed of limestone-based raw material and solid fuel-based raw material and which covers the surface of core 1, enables a calcium ferrite (CF)-based melt to be formed during a sintering process at the interface between limestone-based raw material and iron ore so that the CF covers the circumference of the iron ore, thereby providing sufficient cold strength. The sintered ore that is obtained by using the above quasiparticles for sintering as sintering raw material has calcium ferrite (CF) with high strength on the surface and hematite (He) with high reducibility on the inside.

[0021] Note that layer 2 may be a mixed layer of limestone-based raw material and solid fuel-based raw material, or a lamination of a limestone-based raw material layer (inside) and a solid fuel-based raw material layer (outside). In either case, limestone contents in layer 2 allow calcium ferrite (CF) with high strength to be formed on the surface of the sintered

ore.

[0022] In this respect, it is important for the iron ore raw material of core 1 to contain iron ore having an alkali metal content of 0.05 mass% or more (also referred to hereinafter as "high-alkaline iron ore"). In other words, by containing high-alkaline iron ore in the iron ore raw material of core 1, a catalytic effect can be obtained via an alkali metal, and close arrangement of calcium ferrite can be achieved, thereby further improving reducibility of sintered ore. It is difficult to obtain the above effect if the alkali metal content of the high-alkaline iron ore is less than 0.05 mass%.

[0023] It is preferred, however, that the alkali metal content of the high-alkaline iron ore having an alkali metal content of 0.05 mass% or more is 0.30 mass% or less. The reason is that if the alkali metal content is excessively high, the proportion of the alkali metal obtained in the sintering machine increases even when the mix proportion is small, and the amount of the alkali metal in the blast furnace increases accordingly. This may cause accumulation of the alkali metal in the furnace, and formation of layers of alkali metals and adhesion to the furnace wall, thereby disturbing proper blast furnace operations. The dispersibility of the alkali metal in the sintered ore may also decrease, thereby reducing the above effect.

[0024] In the iron ore raw material, the mix proportion of the high-alkaline iron ore is preferably 20 mass% to 60 mass%. The reason is that a mix proportion of less than 20 mass% is less effective for improving reducibility, while a mix proportion of more than 60 mass% increases the proportion of the alkali metal in the sintered ore obtained in the sintering machine, which may result in an increase in alkali contents in the blast furnace, accumulation of the alkali metal in the furnace, and formation of alkali metal layers and adhesion to the furnace wall, which may adversely affect blast furnace operations. There is another concern that the reduction-disintegration index of the sintered ore may excessively increase, thereby deteriorating permeability in the blast furnace and resulting in an increased coke ratio. The remaining part of the iron ore raw material other than the high-alkaline iron ore is iron ore having an alkali metal content of less than 0.05 mass% (also referred to hereinafter as "general iron ore"). Moreover, SiO_2 raw material may optionally be added to the iron ore raw material.

[0025] The iron ore raw material preferably forms core 1 such that the core takes any of Forms I to III below. In each case, the above action can be provided by the alkali metal. Each form has the following characteristics.

Form I: Mixed layer of general iron ore and high-alkaline iron ore

[0026] In this Form A, a mixed layer of general iron ore and high-alkaline iron ore enables an alkali metal to be uniformly dispersed within the sintered ore. As a consequence, it becomes possible to increase reducibility by increasing the surface area of the alkali metal which exhibits catalytic action, and by enhancing the catalytic effect. Additionally, the strength of the sintered ore may also mitigate formation of a brittle zone, thereby ensuring cold strength.

Form II: Lamination of a first layer formed of general iron ore and a second layer formed of high-alkaline iron ore covering the surface of the first layer

[0027] In this Form B, an alkali metal which exhibits catalytic action is present on the surface side of the core. As a consequence, it becomes possible to fully make use of the catalytic effect of the alkali metal, thereby increasing reducibility.

Form III: Lamination of a first layer formed of high-alkaline iron ore and a second layer formed of general iron ore covering the surface of the first layer

[0028] In this Form C, high-alkaline iron ore is present inside the core of each quasiparticle before subjection to sintering, and the proportion of an alkali metal present in the calcium ferrite phase formed in the surface of the sintered ore is reduced. As a consequence, reduction disintegration properties can be improved without interfering with the catalytic action of the alkali metal.

[0029] It is also preferred that the high-alkaline iron ore has a mean particle size of 2 mm or more, and the general iron ore has a mean particle size of less than 2 mm. As used herein with respect to each iron ore, a mean particle size refers to an arithmetic mean of the weight ratio and the representative particle size of the iron ore when classified by particle size using a sieve.

[0030] Specifically, the high-alkaline iron ore preferably has a mean particle size of 2 mm or more for the following reason. During the process of granulating the raw material to be fed to the sintering machine into quasiparticles, ore having a relatively large particle size will be unevenly distributed in the center of each quasiparticle, which fact is advantageous for reducing the proportion of an alkali metal present in the calcium ferrite phase that is formed in the surface of iron ore after sintering the quasiparticles. If an alkali metal is contained in large quantities in the calcium ferrite phase, reduction disintegration properties deteriorate. Thus, setting the mean particle size of the high-alkaline iron ore to 2 mm or more is advantageous for producing sintered ore that has a low reduction-disintegration index.

[0031] On the other hand, the general iron ore preferably has a mean particle size of less than 2 mm for the following

reason.

[0032] Specifically, during the process of granulating into quasiparticles, ore having a small mean particle size will be unevenly distributed on the outside of quasiparticles, which fact may mitigate incorporation of large amounts of high-alkaline ore and calcium ferrite phase.

[0033] A method of producing quasiparticles for sintering according to the disclosure will now be described below.

[0034] Firstly, FIG. 8 illustrates an exemplary granulation flow (process A) for producing a desirable quasiparticle structure according to the disclosure. In this process A, the aforementioned high-alkaline iron ore 1a and general iron ore 1b, and optionally SiO_2 -containing raw material 1c are charged from the mixer inlet of a drum mixer 4. Then, limestone-based raw material 2a and solid fuel-based raw material 2b are added to the drum mixer 4 from the mixer outlet of the drum mixer 4 and granulated therein, and quasiparticles for sintering, in the form of Form I above, can be obtained with limestone-based raw material 2a and solid fuel-based raw material 2b adhered to the circumference of a core with mixture of the high-alkaline iron ore 1a and the general iron ore 1b.

[0035] In addition, FIG. 9 illustrates an exemplary granulation flow (process B) for producing quasiparticles according to the disclosure. In this process B, the following materials are subjected to pre-granulation using a granulator 3: high-alkaline iron ore and general iron ore, e.g. high-alkaline iron ore 1a that has an alkali metal content of approximately 0.05 mass% to 1.0 mass% and a mean particle size of 2 mm or more, and general iron ore 1b that has an alkali metal content of less than 0.05 mass% and a mean particle size of less than 2 mm; and, optionally, fine SiO_2 -containing raw material 1c (such as iron ore, silica stone, serpentinite, and Ni slag) that has a SiO_2 content of approximately 0.5 % to 5.0 % and a mean particle size of less than 2 mm, e.g. approximately 0.1 mm to 1.0 mm. In this pre-granulation, a first layer is formed by the general iron ore 1b and optionally added SiO_2 , and the high-alkaline iron ore 1a is caused to be adhered, as a second layer, to the circumference of the first layer.

[0036] By changing the order of granulation in the pre-granulation process, the layering order of the high-alkaline iron ore 1a and the general iron ore 1b can be altered. That is, opposite to the above, the high-alkaline iron ore 1a and optionally added SiO_2 may be formed as a first layer, and a second layer may be formed by adhering the general iron ore 1b to the circumference of the first layer.

[0037] Subsequently, limestone-based raw material 2a alone, or limestone-based raw material 2a and solid fuel-based raw material 2b as heat source (such as coke and anthracite) are further added to, and mixed and granulated in the drum mixer 4 to thereby obtain quasiparticles for sintering in Form II or III, as described above, such that limestone-based raw material 2a and solid fuel-based raw material 2b are adhered to the circumference of each core of the iron ore raw material that comprises a first layer formed of high-alkaline iron ore 1a and a second layer formed of general iron ore 1b adhered to the circumference of the first layer.

[0038] Further, FIG. 10 illustrates an exemplary granulation flow (process C) for producing another desirable quasiparticle structure according to the disclosure. In this process C, a plurality of (in this example, two) drum mixers are provided, and the aforementioned high-alkaline iron ore 1a and general iron ore 1b, and optionally SiO_2 -containing raw material 1c are charged from the inlet of the drum mixer 4 and granulated therein, limestone-based raw material 2a alone, or limestone-based raw material 2a and solid fuel-based raw material 2b are added from the inlet of the final stage drum mixer 4' located at the position pointed to by broken arrow, or from the outlet located at the position pointed to by solid arrow, and granulated. If only limestone-based raw material 2a is added, solid fuel-based raw material 2b may be added subsequently, and the limestone-based raw material 2a and the solid fuel-based raw material 2b may be granulated layer-by-layer. Note that if the limestone-based raw material 2a and the solid fuel-based raw material 2b have a mean particle size of 0.5 mm or less, preferably 0.25 mm or less, they can adhere to each other more easily, enabling the solid fuel-based raw material 2b to cover the surface of the limestone-based raw material 2a.

[0039] According to Process A, B, or C, iron ore raw material including high-alkaline iron ore may be formed as a core, and limestone-based raw material and solid fuel-based raw material as heat source may be adhered to the circumference of the core, so that the resulting quasiparticle can be coated and granulated with more than one layer. This configuration enables delaying the reaction between CaO and SiO_2 during a sintering process of sintering raw material formed of quasiparticles, mitigating the formation of calcium silicate (CS) with low cold strength, and causing calcium ferrite (CF) with high strength to be selectively formed on the surface of the lump and hematite (He) with high reducibility to be selectively formed on the inside of the lump. As a result, sintered ore that is rich in fine pores, excellent in reducibility, and high in cold strength may be stably produced.

EXAMPLES

[0040] Sintering raw materials were formulated as illustrated in Table 2, and quasiparticles for sintering were granulated by Process A or B in FIG. 8 or 9 according to the disclosure. The quasiparticles were transported to a Dwight Lloyd sintering machine and charged on a palette. For comparison, an operation was also conducted in which quasiparticles were granulated by the process of simultaneously mixing iron ore raw material, SiO_2 -containing raw material, limestone-based raw material, and coke powder, and the quasiparticles were transported to the Dwight Lloyd sintering machine

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and charged on the palette. Then sintering was performed on the palette, and measurement was made of the reducibility (JIS-RI), reduction-disintegration index (RDI), and sintering strength (TI) of the resulting sintered ore. The measurement results are shown in Table 3.

[0041] The reducibility (JIS-RI) was measured in conformance with JIS M8713. The reduction-disintegration index (RDI) was measured in accordance with JIS M8720. The sintering strength was determined by measuring the tumble strength (tumbler strength TI) of sintered ore products in accordance with JIS M8712.

[Table 2]

[0042]

Table 2

Formulation	Unit	a	b	c	d	e
High-alkaline Iron Ore	mass%	0	20	40	60	80
General Iron Ore	mass%	85	65	45	25	5
SiO ₂ -containing Raw Material	kg/t-sintered ore	15	15	15	15	15
Limestone-based Powder Raw Material	kg/t-sintered ore	13	13	13	13	13
Solid Fuel-based Powder Raw Material	kg/t-sintered ore	5	5	5	5	5
Notes: (1) In the formulation, the total amount of high-alkaline iron ore, genral iron ore, and SiO ₂ -containing raw material is taken as 100 %, excluding limestone-based raw material and solid fuel-based raw material. (2) As the SiO ₂ -containing raw material, limestone-based powder raw material, and solid fuel-based powder raw material, the following used: SiO ₂ -containing raw material: silica sand Limestone-based poweder raw material: limestone, quick lime Solid fuel-based powder raw material: coke, anthracite						

[Table 3-1]

[0043]

Table 3-1

No	Formulation	Form of Quasiparticle	Alkali Metal Content (mass%)		Mean Particle Size (mm)		Carbonaceous Material Coating (kg/t-sintered ore)		JIS-RI (%)	RDI (%)	TI (%)	Remarks
			High-alkaline Ore	General Ore	High-alkaline Ore	General Ore	Lime	Solid Fuel				
1	a	Simultaneous Mixing	-	0.02	-	1.4	(13)	(5)	56.5	35.2	90.2	Comparative Example 1
2	a	Form I	-	0.02	-	1.4	13	5	60.5	30.0	90.1	Comparative Example 2
3	a	Simultaneous Mixing	-	0.045	-	1.4	(13)	(5)	58.2	38.3	90.0	Comparative Example 3
4	a	Form I	-	0.045	-	1.4	13	5	61.1	31.4	90.1	Comparative Example 4
5	b	Simultaneous Mixing	0.1	0.02	1.4	1.4	(13)	(5)	58.9	39.2	90.2	Comparative Example 5
6	b	Form I	0.1	0.02	1.4	1.4	13	5	65.8	33.2	90.4	Example 1

Note: In "Carbonaceous Material Coating," parentheses indicate simultaneous mixing of lime, solid fuel, and ore (Form of Quasiparticle corresponds to "Simultaneous Mixing").

[Table 3-2]

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[0044]

Table 3-2

No	Formulation	Form of Quasiparticle	Alkali Metal Content (mass%)		Mean Particle Size (mm)		Carbonaceous Material Coating (kg/t-sintered ore)		JIS-RI (%)	RDI (%)	TI (%)	Remarks
			High-alkaline Ore	General Ore	High-alkaline Ore	General Ore	Lime	Solid Fuel				
7	b	Form I	0.12	0.02	2.5	1.4	13	5	65.3	32.2	89.8	Example 2
8	b	Form II	0.12	0.02	2.5	1.4	13	5	63.3	33.4	89.9	Example 3
9	b	Form III	0.12	0.02	2.5	1.4	13	5	66.5	32.6	90.1	Example 4
10	c	Form I	0.12	0.02	2.5	1.4	13	5	66.2	30.7	90.1	Example 5
11	c	Form II	0.12	0.02	2.5	1.4	13	5	64.3	31.8	90.0	Example 6
12	c	Form III	0.12	0.02	2.5	1.4	13	5	67.4	31.4	90.0	Example 7
13	d	Form I	0.12	0.02	2.5	1.4	13	5	65.8	31.4	90.1	Example 8
14	d	Form II	0.12	0.02	2.5	1.4	13	5	63.7	32.7	89.8	Example 9
15	d	Form III	0.12	0.02	2.5	1.4	13	5	66.8	32.1	89.9	Example 10
16	e	Form I	0.3	0.02	2.5	1.4	13	5	65.3	40.2	90.1	Example 11
17	e	Form II	0.3	0.02	2.5	1.4	13	5	63.3	41.7	90.1	Example 12
18	e	Form III	0.3	0.02	2.5	1.4	13	5	66.2	41.4	90.1	Example 13

[Table 3-2]

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[0045]

Table 3-3

No	Formulation	Form of Quasiparticle	Alkali Metal Content (mass%)		Mean Particle Size (mm)		Carbonaceous Material Coating (kg/t-sintered ore)		JIS-RI (%)	RDI (%)	TI (%)	Remarks
			High-alkaline Ore	General Ore	High-alkaline Ore	General Ore	Lime	Solid Fuel				
19	c	Form III	0.05	0.02	2.5	1.4	13	5	66.3	29.4	89.8	Example 14
20	c	Form III	0.10	0.02	2.5	1.4	13	5	67.1	31.1	90.0	Example 15
21	c	Form III	0.15	0.02	2.5	1.4	13	5	67.7	32.0	89.8	Example 16
22	c	Form III	0.30	0.02	2.5	1.4	13	5	69.6	33.4	90.1	Example 17
23	c	Form III	0.35	0.02	2.5	1.4	13	5	69.2	38.4	89.8	Example 18
24	c	Form III	0.12	0.02	0.5	1.0	13	5	62.3	34.9	89.8	Example 19
25	c	Form III	0.12	0.02	1.0	1.0	13	5	62.6	34.8	89.9	Example 20
26	c	Form III	0.12	0.02	1.5	1.0	13	5	62.7	34.7	89.8	Example 21
27	c	Form III	0.12	0.02	2.0	1.0	13	5	63.5	33.3	89.9	Example 22
28	c	Form III	0.12	0.02	2.5	1.0	13	5	64.5	31.6	90.0	Example 23

[0046] It can be seen from Table 3 that Nos. 6 to 15 and 19 to 28, in which limestone-based raw material and coke powder were coated on the circumference of each core formed of iron ore raw material according to the present disclosure, were all improved in reducibility (JIS-RI) over Nos. 1, 3, and 5, in which iron ore raw material, SiO₂-containing raw material, limestone-based raw material, and coke powder were mixed simultaneously. Moreover, Nos. 6 to 15 and 19 to 28 differ from Nos. 2 and 4, in which limestone-based raw material and coke powder were also coated on the circumference of each core formed of iron ore raw material, in that Nos. 6 to 15 and 19 to 28 contained high-alkaline iron ore in each core formed of the iron ore raw material. This difference contributes to improved reducibility. Note that Nos. 16 to 18 do not form part of the invention.

Claims

1. A quasiparticle for sintering comprising, at least, iron ore raw material, limestone-based raw material, and solid fuel-based raw material, each being used to produce sintered ore for blast furnaces,

wherein the iron ore raw material forms a core of the quasiparticle, and the limestone-based raw material and the solid fuel-based raw material are coated on the circumference of the core, and
 wherein the core formed of the iron ore raw material contains high-alkaline iron ore having an alkali metal content of 0.05 mass% or more and general iron ore having an alkali metal content of less than 0.05 mass%,
 wherein the iron ore raw material contains the high-alkaline iron ore having an alkali metal content of 0.05 mass% or more in an amount of 20 mass% or more.

2. The quasiparticle for sintering according to claim 1, wherein the core formed of the iron ore raw material comprises:

a first layer that is formed of general iron ore having an alkali metal content of less than 0.05 mass%; and
 a second layer that is formed of the high-alkaline iron ore having an alkali metal content of 0.05 mass% or more and that covers the surface of the first layer.

3. The quasiparticle for sintering according to claim 1, wherein the core formed of the iron ore raw material comprises:

a first layer that is formed of the high-alkaline iron ore having an alkali metal content of 0.05 mass% or more; and
 a second layer that is formed of the general iron ore having an alkali metal content of less than 0.05 mass% and that covers the surface of the first layer.

4. The quasiparticle for sintering according to any one of claims 1 to 3, wherein the high-alkaline iron ore having an alkali metal content of 0.05 mass% or more has a mean particle size of 2 mm or more, and the general iron ore having an alkali metal content of less than 0.05 mass% has a mean particle size of less than 2 mm.

5. The quasiparticle for sintering according to any one of claims 1 to 4, wherein the alkali metal content of the high-alkaline iron ore having an alkali metal content of 0.05 mass% or more is 0.30 mass% or less.

6. The quasiparticle for sintering according to any one of claims 1 to 5, wherein the limestone-based raw material and the solid fuel-based raw material are coated layer-by-layer on the circumference of the core.

7. The quasiparticle for sintering according to any one of claims 1 to 6, wherein a mixed layer of the limestone-based raw material and the solid fuel-based raw material is coated on the circumference of the core.

8. A method of producing a quasiparticle for sintering, the method comprising:

when mixing and granulating, at least, iron ore raw material, limestone-based raw material, and solid fuel-based raw material, each being used to produce sintered ore for blast furnaces,
 mixing and granulating the iron ore raw material containing high-alkaline iron ore having an alkali metal content of 0.05 mass% or more and general iron ore having an alkali metal content of less than 0.05 mass% to obtain a granulated particle; and
 causing the limestone-based raw material and the solid fuel-based raw material to be adhered to the granulated particle and, subsequently, performing granulation,
 wherein the iron ore raw material contains the high-alkaline iron ore having an alkali metal content of 0.05 mass% or more in an amount of 20 mass% or more.

9. A method of producing a quasiparticle for sintering according to claim 8, the method comprising:

when mixing and granulating, at least, iron ore raw material, limestone-based raw material, and solid fuel-based raw material, each being used to produce sintered ore for blast furnaces,
 5 mixing and granulating general iron ore having an alkali metal content of less than 0.05 mass% and SiO₂-containing raw material to form a first layer;
 causing high-alkaline iron ore having an alkali metal content of 0.05 mass% or more to be adhered to the surface of the first layer, and subsequently performing granulation to form a second layer; and
 10 causing the limestone-based raw material and the solid fuel-based raw material to be adhered to the surface of the second layer and, subsequently, performing granulation.

10. A method of producing a quasiparticle for sintering according to claim 8, the method comprising:

when mixing and granulating, at least, iron ore raw material, limestone-based raw material, and solid fuel-based raw material, each being used to produce sintered ore for blast furnaces,
 15 mixing and granulating high-alkaline iron ore having an alkali metal content of 0.05 mass% or more to form a first layer;
 causing general iron ore having an alkali metal content of less than 0.05 mass% to be adhered to the surface of the first layer, and subsequently performing granulation to form a second layer; and
 20 causing the limestone-based raw material and the solid fuel-based raw material to be adhered to the surface of the second layer and, subsequently, performing granulation.

11. The method of producing a quasiparticle for sintering according to any one of claims 8 to 10, wherein the high-alkaline iron ore having an alkali metal content of 0.05 mass% or more has a mean particle size of 2 mm or more,
 25 and the general iron ore having an alkali metal content of less than 0.05 mass% has a mean particle size of less than 2 mm.

12. The method of producing a quasiparticle for sintering according to any one of claims 8 to 11, wherein mixed powder of the limestone-based raw material and the solid fuel-based raw material is adhered and, subsequently, granulation
 30 is performed.

13. The method of producing a quasiparticle for sintering according to any one of claims 8 to 11, wherein after the adhering of the limestone-based raw material, the solid fuel-based raw material is adhered to an outer surface of a layer of the limestone-based raw material and, subsequently, granulation is performed.
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Patentansprüche

1. Quasiteilchen zum Sintern, das wenigstens Eisenerz-Rohmaterial, Rohmaterial auf Basis von Kalkstein sowie Rohmaterial auf Basis von Festbrennstoff umfasst, die jeweils zum Herstellen von gesintertem Erz für Hochöfen verwendet werden,
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wobei das Eisenerz-Rohmaterial einen Kern des Quasiteilchens bildet und das Rohmaterial auf Basis von Kalkstein sowie das Rohmaterial auf Basis von Festbrennstoff als Beschichtung auf den Umfang des Kerns aufgebracht sind, und
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der aus dem Eisenerz-Rohmaterial gebildete Kern hochalkalisches Eisenerz mit einem Alkalimetall-Gehalt von 0,05 Masse-% oder mehr und allgemeines Eisenerz mit einem Alkalimetall-Gehalt von weniger als 0,05 Masse-% enthält,

wobei das Eisenerz-Rohmaterial das hochalkalische Eisenerz mit einem Alkalimetall-Gehalt von 0,05 Masse-% oder mehr in einer Menge von 20 Masse-% oder mehr enthält.
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2. Quasiteilchen zum Sintern nach Anspruch 1, wobei der aus dem Eisenerz-Rohmaterial gebildete Kern umfasst:

eine erste Schicht, die aus allgemeinem Eisenerz mit einem Alkalimetall-Gehalt von weniger als 0,05 Masse-% besteht; und
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eine zweite Schicht, die aus dem hochalkalischen Eisenerz mit einem Alkalimetall-Gehalt von 0,05 Masse-% oder mehr gebildet wird und die die Oberfläche der ersten Schicht bedeckt.

3. Quasiteilchen zum Sintern nach Anspruch 1, wobei der aus dem Eisenerz-Rohmaterial gebildete Kern umfasst:

eine erste Schicht, die aus dem hochalkalischen Eisenerz mit einem Alkalimetall-Gehalt von 0,05 Masse-% oder mehr gebildet wird; und
eine zweite Schicht, die aus dem allgemeinen Eisenerz mit einem Alkalimetall-Gehalt von weniger als 0,05 Masse-% oder mehr gebildet wird und die die Oberfläche der ersten Schicht bedeckt.

4. Quasiteilchen zum Sintern nach einem der Ansprüche 1 bis 3, wobei das hochalkalische Eisenerz mit einem Alkalimetall-Gehalt von 0,05 Masse-% oder mehr eine mittlere Teilchengröße von 2 mm oder mehr hat und das allgemeine Eisenerz mit einem Alkalimetall-Gehalt von weniger als 0,05 Masse-% eine mittlere Teilchengröße von weniger als 2 mm hat.

5. Quasiteilchen zum Sintern nach einem der Ansprüche 1 bis 4, wobei der Alkalimetall-Gehalt des hochalkalischen Eisenerzes mit einem Alkalimetall-Gehalt von 0,05 Masse-% oder mehr 0,30 Masse-% oder weniger beträgt.

6. Quasiteilchen zum Sintern nach einem der Ansprüche 1 bis 5, wobei das Rohmaterial auf Basis von Kalkstein und das Rohmaterial auf Basis von Festbrennstoff Schicht für Schicht auf den Umfang des Kerns aufgebracht werden.

7. Quasiteilchen zum Sintern nach einem der Ansprüche 1 bis 6, wobei eine gemischte Schicht aus dem Rohmaterial auf Basis von Kalkstein und dem Rohmaterial auf Basis von Festbrennstoff als Beschichtung auf den Umfang des Kerns aufgebracht wird.

8. Verfahren zum Herstellen eines Quasiteilchens zum Sintern, wobei das Verfahren umfasst:

beim Mischen und Granulieren wenigstens von Eisenerz-Rohmaterial, Rohmaterial auf Basis von Kalkstein sowie Rohmaterial auf Basis von Festbrennstoff, die jeweils zum Herstellen von gesintertem Erz für Hochöfen verwendet werden,

Mischen und Granulieren des Eisenerz-Rohmaterials, das hochalkalische Eisenerz mit einem Alkalimetall-Gehalt von 0,05 Masse-% oder mehr und allgemeines Eisenerz mit einem Alkalimetall-Gehalt von weniger als 0,05 Masse-% enthält, um ein granuliertes Teilchen zu gewinnen Veranlassen, dass das Rohmaterial auf Basis von Kalkstein und das Rohmaterial auf Basis von Festbrennstoff an dem granulierten Teilchen haften, und anschließend Durchführen von Granulation, wobei das Eisenerz-Rohmaterial das hochalkalische Eisenerz mit einem Alkalimetall-Gehalt von 0,05 Masse-% oder mehr in einer Menge von 20 Masse-% oder mehr enthält.

9. Verfahren zum Herstellen eines Quasiteilchens zum Sintern nach Anspruch 8, wobei das Verfahren umfasst:

beim Mischen und Granulieren wenigstens von Eisenerz-Rohmaterial, Rohmaterial auf Basis von Kalkstein sowie Rohmaterial auf Basis von Festbrennstoff, die jeweils zum Herstellen von gesintertem Erz für Hochöfen verwendet werden,

Mischen und Granulieren von allgemeinem Eisenerz mit einem Alkalimetall-Gehalt von weniger als 0,05 Masse-% und SiO₂-haltigem Rohmaterial, um eine erste Schicht auszubilden;

Veranlassen, dass hochalkalisches Eisenerz mit einem Alkalimetall-Gehalt von 0,05 Masse-% oder mehr an der Oberfläche der ersten Schicht haftet, und anschließend Durchführen von Granulation, um eine zweite Schicht auszubilden; und

Veranlassen, dass das Rohmaterial auf Basis von Kalkstein und das Rohmaterial auf Basis von Festbrennstoff an der Oberfläche der zweiten Schicht haften, und anschließend Durchführen von Granulation.

10. Verfahren zum Herstellen eines Quasiteilchens zum Sintern nach Anspruch 8, wobei das Verfahren umfasst:

beim Mischen und Granulieren wenigstens von Eisenerz-Rohmaterial, Rohmaterial auf Basis von Kalkstein sowie Rohmaterial auf Basis von Festbrennstoff, die jeweils zum Herstellen von gesintertem Erz für Hochöfen verwendet werden,

Mischen und Granulieren von hochalkalischem Eisenerz mit einem Alkalimetall-Gehalt von 0,05 Masse-% oder mehr, um eine erste Schicht auszubilden;

Veranlassen, dass allgemeines Eisenerz mit einem Alkalimetall-Gehalt von weniger als 0,05 Masse-% an der Oberfläche der ersten Schicht haftet, und anschließend Durchführen von Granulation, um eine zweite Schicht auszubilden; und

Veranlassen, dass das Rohmaterial auf Basis von Kalkstein und das Rohmaterial auf Basis von Festbrennstoff an der Oberfläche der zweiten Schicht haften, und anschließend Durchführen von Granulation.

- 5 11. Verfahren zum Herstellen eines Quasiteilchens zum Sintern nach einem der Ansprüche 8 bis 10, wobei das hochalkalische Eisenerz mit einem Alkalimetall-Gehalt von 0,05 Masse-% oder mehr eine mittlere Teilchengröße von 2 mm oder mehr hat und das allgemeine Eisenerz mit einem Alkalimetall-Gehalt von weniger als 0,05 Masse-% eine mittlere Teilchengröße von weniger als 2 mm hat.
- 10 12. Verfahren zum Herstellen eines Quasiteilchens zum Sintern nach einem der Ansprüche 8 bis 11, wobei gemischtes Pulver aus dem Rohmaterial auf Basis von Kalkstein und dem Rohmaterial auf Basis von Festbrennstoff zum Haften gebracht wird und anschließend Granulation durchgeführt wird.
- 15 13. Verfahren zum Herstellen eines Quasiteilchens zum Sintern nach einem der Ansprüche 8 bis 11, wobei nach dem Haften des Rohmaterials auf Basis von Kalkstein das Rohmaterial auf Basis von Festbrennstoff an einer äußeren Fläche einer Schicht des Rohmaterials auf Basis von Kalkstein zum Haften gebracht wird und anschließend Granulation durchgeführt wird.

Revendications

- 20 1. Quasi-particule pour frittage comprenant, au moins, une matière première de minerai de fer, une matière première à base de calcaire, et une matière première à base de combustible solide, chacune étant utilisée pour produire du minerai fritté pour des hauts fourneaux,
 - 25 dans laquelle la matière première de minerai de fer forme un noyau de la quasi-particule, et la matière première à base de calcaire et la matière première à base de combustible solide sont revêtues sur la circonférence du noyau, et
 - 30 dans laquelle le noyau formé de la matière première de minerai de fer contient un minerai de fer hautement alcalin ayant une teneur en métal alcalin de 0,05 % en masse ou plus et un minerai de fer général ayant une teneur en métal alcalin inférieure à 0,05 % en masse,
 - 35 dans laquelle la matière première de minerai de fer contient le minerai de fer hautement alcalin ayant une teneur en métal alcalin de 0,05 % en masse ou plus selon une quantité de 20 % en masse ou plus.
- 40 2. Quasi-particule pour frittage selon la revendication 1, dans laquelle le noyau formé de la matière première de minerai de fer comprend :
 - une première couche qui est formée de minerai de fer général ayant une teneur en métal alcalin inférieure à 0,05 % en masse ; et
 - 45 une seconde couche qui est formée du minerai de fer hautement alcalin ayant une teneur en métal alcalin de 0,05 % en masse ou plus et qui recouvre la surface de la première couche.
- 50 3. Quasi-particule pour frittage selon la revendication 1, dans laquelle le noyau formé de la matière première de minerai de fer comprend :
 - 45 une première couche qui est formée du minerai de fer hautement alcalin ayant une teneur en métal alcalin de 0,05 % en masse ou plus ; et
 - une seconde couche qui est formée du minerai de fer général ayant une teneur en métal alcalin inférieure à 0,05 % en masse et qui recouvre la surface de la première couche.
- 55 4. Quasi-particule pour frittage selon l'une quelconque des revendications 1 à 3, dans laquelle le minerai de fer hautement alcalin ayant une teneur en métal alcalin de 0,05 % en masse ou plus a une taille de particule moyenne de 2 mm ou plus, et le minerai de fer général ayant une teneur en métal alcalin inférieure à 0,05 % en masse a une taille de particule moyenne inférieure à 2 mm.
5. Quasi-particule pour frittage selon l'une quelconque des revendications 1 à 4, dans laquelle la teneur en métal alcalin du minerai de fer hautement alcalin ayant une teneur en métal alcalin de 0,05 % en masse ou plus est de 0,30 % en masse ou moins.

6. Quasi-particule pour frittage selon l'une quelconque des revendications 1 à 5, dans laquelle la matière première à base de calcaire et la matière première à base de combustible solide sont revêtues couche par couche sur la circonférence du noyau.

7. Quasi-particule pour frittage selon l'une quelconque des revendications 1 à 6, dans laquelle une couche mixte de la matière première à base de calcaire et de la matière première à base de combustible solide est revêtue sur la circonférence du noyau.

8. Procédé de production d'une quasi-particule pour frittage, le procédé comprenant les étapes consistant à :

lors du mélange et de la granulation, au moins, d'une matière première de minerai de fer, d'une matière première à base de calcaire, et d'une matière première à base de combustible solide, chacune étant utilisée pour produire du minerai fritté pour des hauts fourneaux, mélanger et granuler la matière première de minerai de fer contenant un minerai de fer hautement alcalin ayant une teneur en métal alcalin de 0,05 % en masse ou plus et un minerai de fer général ayant une teneur en métal alcalin inférieure à 0,05 % en masse pour obtenir une particule granulée ; et amener la matière première à base de calcaire et la matière première à base de combustible solide à adhérer à la particule granulée et, ensuite, effectuer une granulation, dans lequel la matière première de minerai de fer contient le minerai de fer hautement alcalin ayant une teneur en métal alcalin de 0,05 % en masse ou plus selon une quantité de 20 % en masse ou plus.

9. Procédé de production d'une quasi-particule pour frittage selon la revendication 8, le procédé comprenant les étapes consistant à :

lors du mélange et de la granulation, au moins, d'une matière première de minerai de fer, d'une matière première à base de calcaire, et d'une matière première à base de combustible solide, chacune étant utilisée pour produire du minerai fritté pour des hauts fourneaux, mélanger et granuler un minerai de fer général ayant une teneur en métal alcalin inférieure à 0,05 % en masse et une matière première contenant SiO_2 pour former une première couche ; amener le minerai de fer hautement alcalin ayant une teneur en métal alcalin de 0,05 % en masse ou plus à adhérer à la surface de la première couche, et effectuer ensuite une granulation pour former une seconde couche ; et amener la matière première à base de calcaire et la matière première à base de combustible solide à adhérer à la surface de la seconde couche et, ensuite, effectuer une granulation.

10. Procédé de production d'une quasi-particule pour frittage selon la revendication 8, le procédé comprenant les étapes consistant à :

lors du mélange et de la granulation, au moins, d'une matière première de minerai de fer, d'une matière première à base de calcaire, et d'une matière première à base de combustible solide, chacune étant utilisée pour produire du minerai fritté pour des hauts fourneaux, mélanger et granuler un minerai de fer hautement alcalin ayant une teneur en métal alcalin de 0,05 % en masse ou plus pour former une première couche ; amener le minerai de fer général ayant une teneur en métal alcalin inférieure à 0,05 % en masse à adhérer à la surface de la première couche, et effectuer ensuite une granulation pour former une seconde couche ; et amener la matière première à base de calcaire et la matière première à base de combustible solide à adhérer à la surface de la seconde couche et, ensuite, effectuer une granulation.

11. Procédé de production d'une quasi-particule pour frittage selon l'une quelconque des revendications 8 à 10, dans lequel le minerai de fer hautement alcalin ayant une teneur en métal alcalin de 0,05 % en masse ou plus a une taille de particule moyenne de 2 mm ou plus, et le minerai de fer général ayant une teneur en métal alcalin inférieure à 0,05 % en masse a une taille de particule moyenne de moins de 2 mm.

12. Procédé de production d'une quasi-particule pour frittage selon l'une quelconque des revendications 8 à 11, dans lequel une poudre mélangée de la matière première à base de calcaire et de la matière première à base de combustible solide est adhérente et, ensuite, une granulation est effectuée.

13. Procédé de production d'une quasi-particule pour frittage selon l'une quelconque des revendications 8 à 11, dans

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lequel, après l'adhérence de la matière première à base de calcaire, la matière première à base de combustible solide est adhérente à une surface extérieure d'une couche de la matière première à base de calcaire et, ensuite, une granulation est effectuée.

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FIG. 1

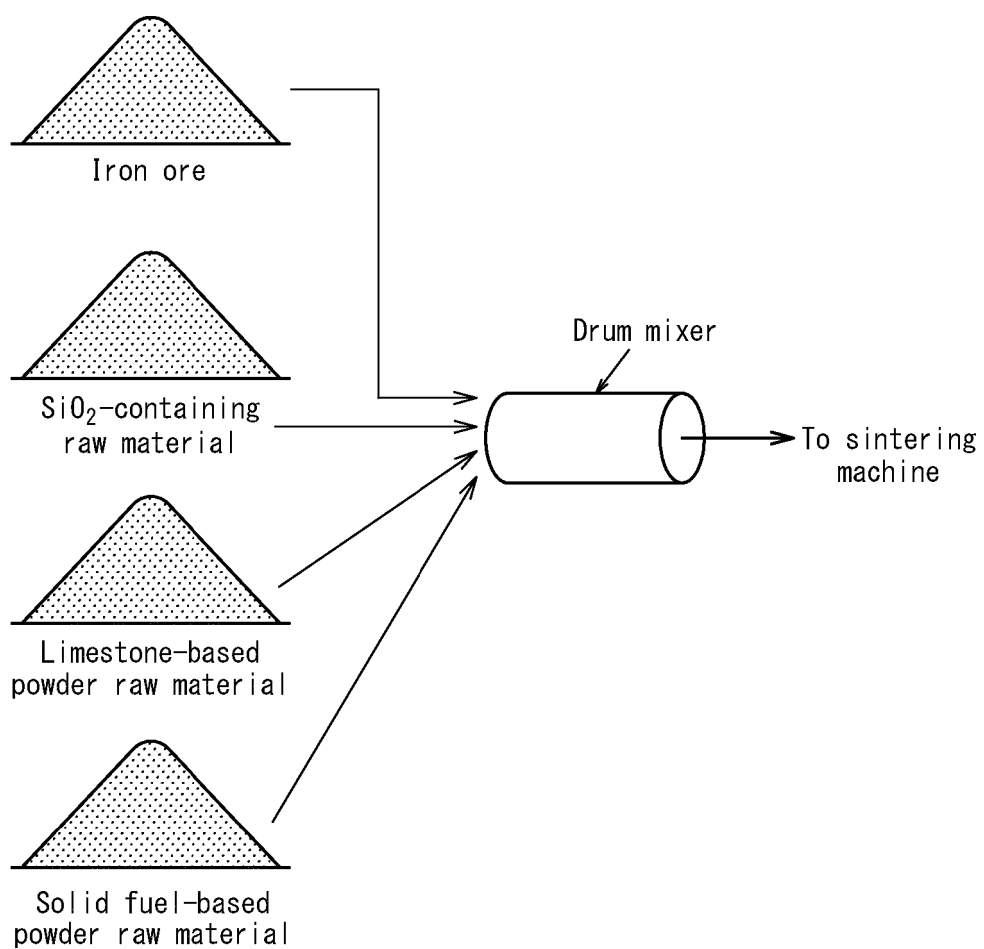


FIG. 2

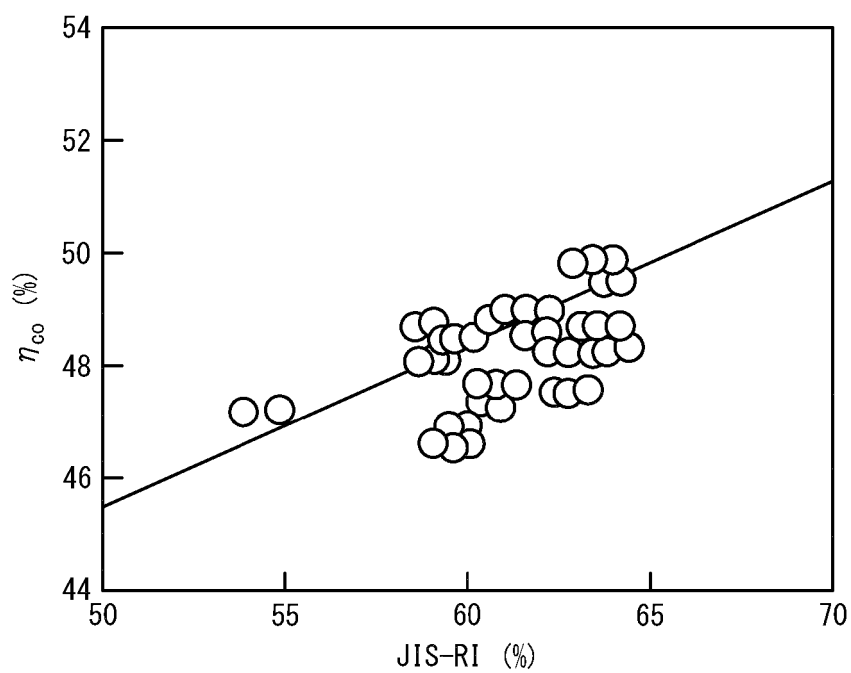


FIG. 3

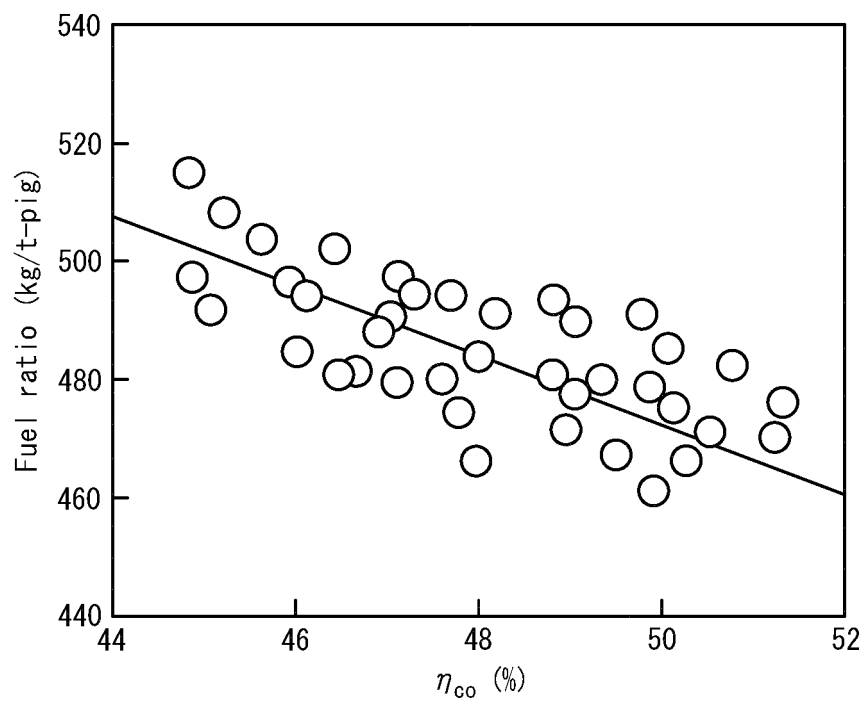


FIG. 4

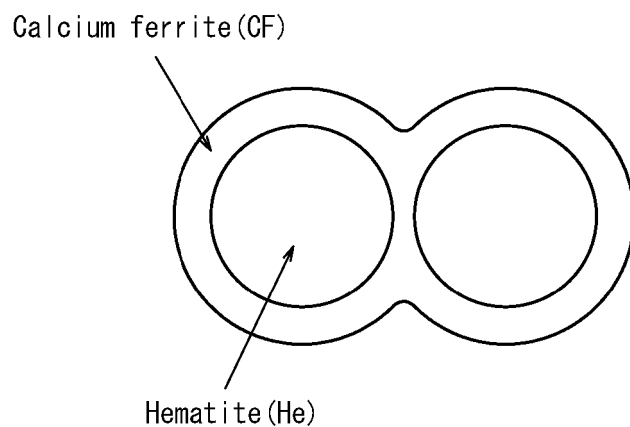


FIG. 5

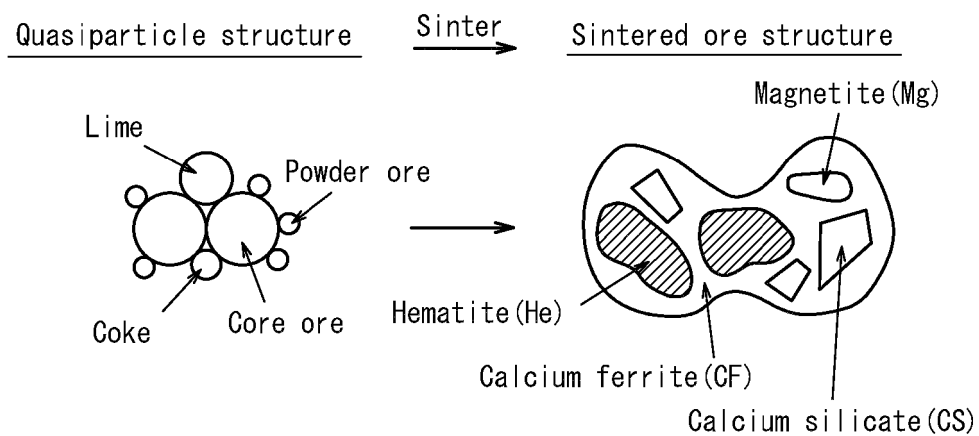
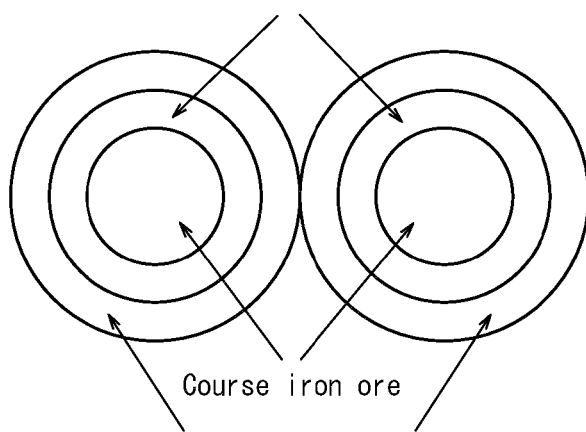


FIG. 6

Fine iron ore and SiO₂-containing raw material

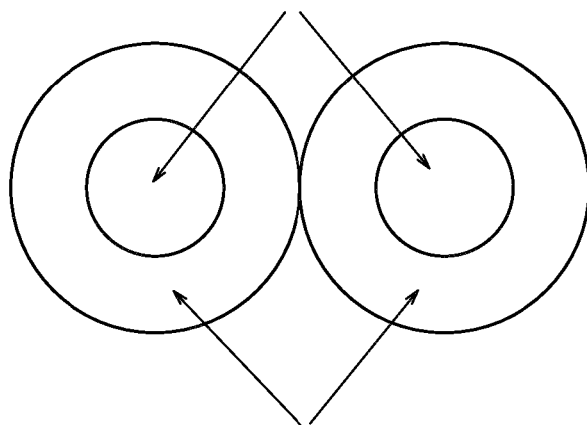


Course iron ore

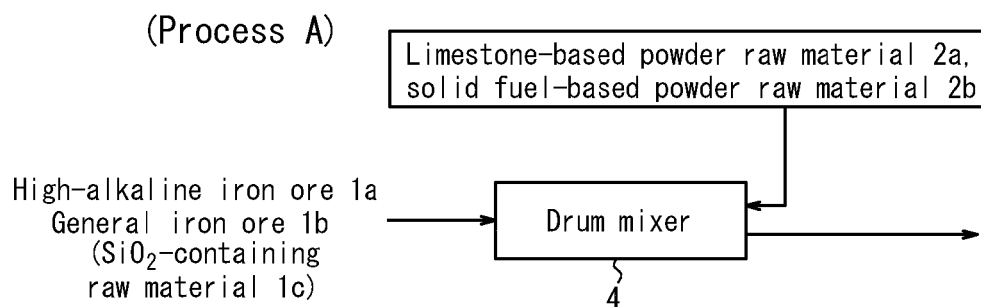
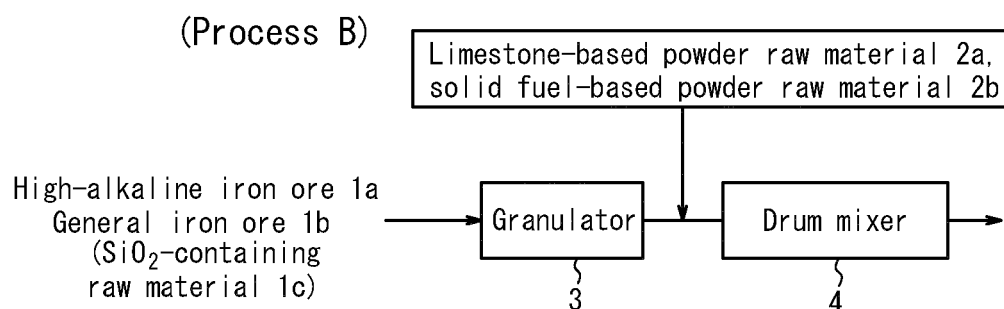
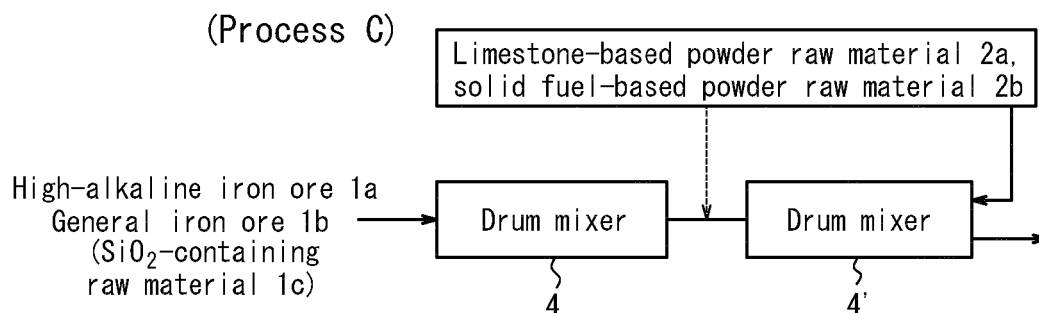
Limestone raw material + solid fuel raw material

FIG. 7

1 (Iron ore raw material)



2 (Limestone raw material + solid fuel raw material)

FIG. 8*FIG. 9**FIG. 10*

REFERENCES CITED IN THE DESCRIPTION

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