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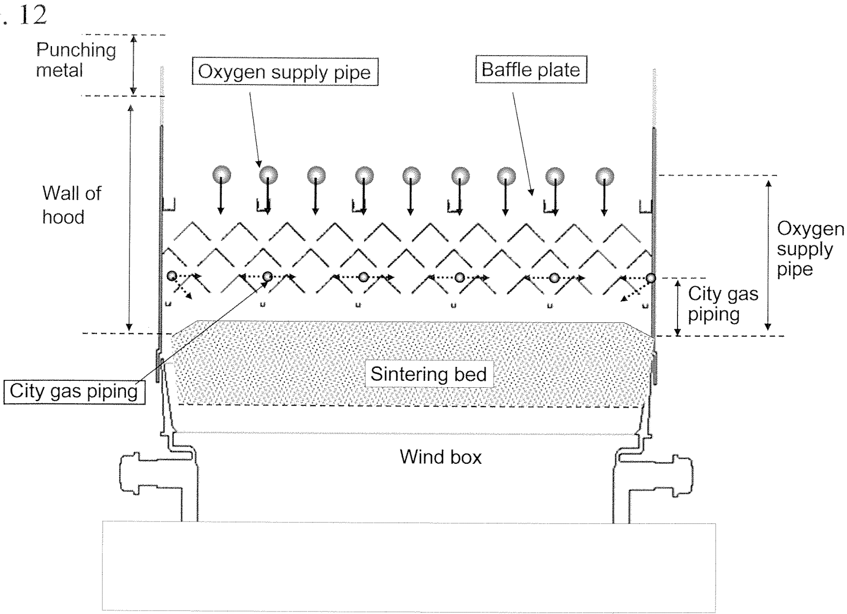
(54) OXYGEN-GAS FUEL SUPPLY DEVICE FOR SINTERING MACHINE

(57) An oxygen- gaseous fuel supply apparatus for a sintering machine by blowing oxygen into air inside a hood disposed above a raw material bed at a downstream side of an ignition furnace to enrich oxygen, and further sucking air supplied with a gaseous fuel diluted to not more than a lower flammable limit by wind boxes arranged below a pallet and introducing into the bed, and combusting the gaseous fuel and carbonaceous material in the bed to produce a sintered ore, wherein baffle plates each made of a chevron plate material are arranged in plural rows at intervals in the horizontal direction and in plural steps in the vertical direction so as to arrange the intervals in a zigzag form in a vertical mid position of the hood, and gaseous fuel supply pipes for supplying the gaseous fuel into air are arranged below the baffle plates, and oxygen supply pipes for blowing oxygen into air are arranged above the baffle plates.

FIG. 12



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Description

TECHNICAL FIELD

[0001] This invention relates to an oxygen-gaseous fuel supply apparatus in a downdraft type Dwight-Lloyd sintering machine which produces high-quality sintered ore as a raw material for a blast furnace by enriching oxygen and supplying gaseous fuel.

RELATED ART

[0002] In general, a sintered ore as a main raw material for a blast furnace iron-making method is produced through a process flow as shown in FIG. 1. The raw material for the sintered ore includes fine iron ore, undersize granules of the sintered ore, recovery powder produced in an ironworks, a CaO-containing auxiliary material such as limestone, dolomite or the like, a granulation auxiliary agent such as quicklime or the like, coke breeze, anthracite and so on, which are cut out from respective hoppers 1 onto a conveyer at a predetermined ratio. The cut-out raw materials are added with a proper amount of water, and mixed and granulated in drum mixers 2 and 3 to form quasi-particles having a mean particle size of 3~6 mm as a sintering raw material. Then, the sintering raw material is charged onto an continuous type sintering machine pallet 8 at a thickness of 400~800 mm from surge hoppers 4 and 5 disposed above the sintering machine through a drum feeder 6 and a cutout chute 7 to form a bed 9 also called as a sintering bed. Thereafter, carbonaceous material in a surface part of the bed is ignited by an ignition furnace 10 disposed above the bed 9, while air above the bed is sucked downward through wind boxes 11 located just beneath the pallet 8 to thereby combust the carbonaceous material in the bed sequentially, and the sintering raw material is melted by combustion heat generated at this time to obtain a sintered cake. The thus obtained sintered cake is then crushed and granulated, and agglomerates of about not less than about 5 mm in size are collected as a product sintered ore and supplied into the blast furnace.

[0003] In the above production process, the carbonaceous material in the bed ignited by the ignition furnace 10 is continuously combusted by air sucked from top down through the bed to form a combustion melting zone having a certain width in a thickness direction (hereinafter referred to as "combustion zone" simply). The molten portion of the combustion zone obstructs the flow of the sucked air, which is a factor of causing an extension of the sintering time to deteriorate the productivity. Also, the combustion zone is gradually moved from the upper part to the lower part of the bed as the pallet 8 moves downstream, and a sintered cake layer finishing the sintering reaction (hereinafter referred to as "sintered layer" simply) is formed in a portion after the passing of the combustion zone. Further, as the combustion zone is transferred from the upper part to the lower part, moisture included in the sintering raw material is vaporized by combustion heat of the carbonaceous material and condensed into the sintering raw material in the lower part not yet raising the temperature to form a wet zone. When the water concentration exceeds a certain degree, voids among the particles of the sintering raw material as a path of the gas sucked are filled with water, which is a factor of increasing airflow resistance like the melting zone.

[0004] FIG. 2 shows distributions of pressure drop and temperature in the bed when a combustion zone moving in the bed of 600 mm in thickness is located at a position of about 400 mm above the pallet in the bed (200 mm below the surface of the bed). The pressure drop distribution shows 60% in the wet zone and 40% in the combustion zone.

[0005] The production volume by the sintering machine (t/hr) is generally determined by productivity (t/hr • m^2) × area of the sintering machine (m^2). That is, the production volume by the sintering machine is varied depending on width and length of the sintering machine, thickness of a bed of the raw material, bulk density of the sintering raw material, sintering (combustion) time, yield and the like. In order to increase the production volume of the sintered ore, therefore, it is considered that it is effective to shorten the sintering time by improving air permeability of the bed (pressure drop) or to increase the yield by increasing the cold strength of the sintered cake before crushing.

[0006] FIG. 3 shows a transition of temperature and time at a certain point in the bed at high productivity and low productivity of the sintered ore, or at fast moving speed and slow moving speed of the sintering machine pallet, respectively. The time kept at a temperature of not lower than 1200°C starting the melting of sintering raw material particles is represented by T_1 in case of the low productivity and T_2 in case of the high productivity, respectively. In case of the high productivity, the moving speed of the pallet is fast, so that the high-temperature zone retention time T_2 becomes short as compared with T_1 in case of the low productivity. However, as the time kept at a high temperature of not lower than 1200°C is shortened, the sintering becomes insufficient, and hence the cold strength of the sintered ore is decreased to lower the yield. Consequently, in order to produce the high-strength sintered ore in a short time with a high yield and a good productivity, it is required to take some measures for prolonging the time kept at a high temperature of not lower than 1200°C to increase the cold strength of the sintered ore.

[0007] FIG. 4 is a schematic view illustrating a process wherein the carbonaceous material in the surface part of the bed ignited by the ignition furnace is continuously combusted by the sucked air to form the combustion zone, which is moved from the upper part to the lower part of the bed sequentially to form the sintered cake. Also, FIG. 5(a) is a schematic view illustrating a temperature distribution when the combustion zone is existent in each of an upper part, a middle part and a lower part of the bed within a thick frame shown in FIG. 4. The strength of the sintered ore is affected by the product of the temperature of not lower than 1200°C and the time kept at this temperature, and as the value becomes larger, the strength of the sintered ore becomes higher. Accordingly, the middle part and the lower part in the bed are pre-heated by combustion heat of the carbonaceous material in the upper part of the bed carried with the sucked air and thus kept at a high temperature for a long time, whereas the upper part of the bed is lacking in the combustion heat due to no preheating and hence combustion melting reaction required for sintering (sintering reaction) is liable to be insufficient. As a result, the yield of the sintered ore in the widthwise section of the bed becomes smaller at the upper part of the bed as shown in FIG. 5(b). Moreover, both widthwise end portions of the pallet are supercooled due to heat dissipation from the side walls of the pallet or a large amount of air passed, so that the high-temperature zone retention time required for sintering cannot be secured sufficiently and the yield is also lowered.

[0008] As to these problems, it has hitherto been performed to increase the amount of the carbonaceous material (coke breeze) added in the sintering raw material. However, it is possible to raise the temperature in the sintered layer and prolong the time kept at not lower than 1200°C by increasing the addition amount of coke as shown in FIG. 6, while at the same time, the highest achieving temperature in the sintering exceeds 1400°C and the decrease of the reducibility and cold strength of the sintered ore is caused by the reason as described below.

[0009] In Table 1 of Non-patent Document 1 are shown tensile strength (cold strength) and reducibility of various minerals generated in the sintered ore during the sintering. In the sintering process, a melt starts to be generated at 1200°C to produce calcium ferrite having the highest strength and a relatively high reducibility among constitutional minerals of the sintered ore as shown in FIG. 7. This is the reason why the sintering temperature is required to be not lower than 1200°C. However, when the temperature is further raised and exceeds 1400°C, precisely 1380°C, calcium ferrite starts to be decomposed into an amorphous silicate (calcium silicate) having the lowest cold strength and reducibility and a secondary hematite of a skeleton-crystal form easily causing reduction degradation. Also, the secondary hematite constituting a start point of the reduction degradation of the sintered ore raises the temperature up to a zone of Mag. ss + Liq. and is precipitated in the cooling as shown in a phase diagram of FIG. 8 from the results of the mineral synthesis test, so that the production of the sintered ore through a path (2) instead of a path (1) shown in the phase diagram is considered to be important for suppressing the reduction degradation.

Table 1

Type of mineral	Tensile strength (MPa)	Reducibility (%)
Hematite	49	50
Magnetite	58	22
Calcium ferrite	102	35
Calcium silicate	19	3

[0010] That is, Non-patent Document 1 discloses that the control of the highest achieving temperature, the high-temperature zone retention time and the like during combustion is a very important control item for ensuring a quality of the sintered ore and the quality of the sintered ore is substantially determined depending on these controls. Therefore, in order to obtain a sintered ore having a high strength and excellent reduction degradation index (RDI) and reducibility, it is important that calcium ferrite produced at a temperature of not lower than 1200°C is not decomposed into calcium silicate and secondary hematite. To this end, it is necessary that the highest achieving temperature in the bed during sintering does not exceed 1400°C, preferably 1380°C, while the temperature in the bed is kept at not lower than 1200°C (solidus temperature of calcium ferrite) for a long time. In the invention, the time kept in the temperature range of not lower than 1200°C but not higher than 1400°C is hereinafter called as "high-temperature zone retention time".

[0011] Moreover, there are proposed some techniques for improving the aforementioned deterioration of the yield in the upper part of the bed to increase productivity. For example, Patent Document 1 proposes a technique for improving the strength, productivity and yield as a product of the sintered ore by adding pyrogenic gas to air sucked into the sintering raw material in addition to coke added in the sintering raw material and combusting them at the sintering zone in the production of the sintered ore. In the technique of Patent Document 1, however, there is a problem causing deterioration of reducibility (RI) of a product sintered ore because it is attempted to improve the strength, productivity and yield of the sintered ore by combusting coke and gaseous fuel to raise the highest achieving temperature in the sintering.

[0012] Patent Document 2 proposes a technique wherein a mass flow rate of an oxygen-containing gas supplied into the bed is set to 1.01~2.6 times of a mass flow rate of an oxygen-containing gas supplied in an area calcining the upper part of the bed at the time of sufficiently calcining the upper part of the bed to thereby increase differential pressure in the bed and violently accelerate the moving speed of the combustion melting zone, whereby the productivity is increased and a product with a high yield and excellent quality is obtained. In the technique of Patent Document 2, however, the thickness of the bed and the moving speed of the pallet can be increased to improve the productivity of the sintering machine, while the moving speed of the combustion melting zone and the highest achieving temperature are also increased, so that there is a problem causing the deterioration of the reducibility of the product sintered ore.

[0013] Patent Document 3 proposes an oxygen-enriching operation method wherein an oxygen concentration in air sucked into the bed for combustion is enriched to not less than 35% during the sintering of the upper part of the bed on the pallet to increase the productivity and the product yield. In the technique of Patent Document 3, however, combustibility of coke is improved and the highest achieving temperature is increased by enriching the oxygen concentration in combustion air to not less than 35%, while there is a problem that the high-temperature zone retention time of not lower than 1200°C required for sintering is short by the improvement of the combustibility.

[0014] As a technique for solving the above problems, the inventors have proposed techniques in Patent Documents 4~6 and so on, wherein the amount of the carbonaceous material added into the sintering raw material is decreased and various gaseous fuels diluted to not more than the lower flammable limit are introduced into the bed from above the pallet to combust the gaseous fuels in the bed at downstream side of the ignition furnace of the sintering machine to thereby control both of the highest achieving temperature and the high-temperature zone retention time in the bed to adequate ranges.

[0015] When the techniques of Patent Documents 4~6 are applied to decrease the amount of the carbonaceous material added into the sintering raw material and introduce the gaseous fuels diluted to not more than the lower flammable limit to combust the gaseous fuels in the bed, the gaseous fuels are combusted in the bed (in the sintered layer) after the combustion of the carbonaceous material as shown in FIG. 9, so that the width of the combustion melting zone can be enlarged in the thickness direction without exceeding the highest achieving temperature over 1400°C, and hence the high-temperature zone retention time can be effectively extended.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0016]

Patent Document 1: JP-B-S46-027126

Patent Document 2: WO98/07891

Patent Document 3: JP-A-H02-073924

Patent Document 4: JP-A-2008-095170

Patent Document 5: JP-A-2010-047801

Patent Document 6: JP-A-2008-291354

NON-PATENT DOCUMENT

[0017] Non-patent Document 1: 'Mineral engineering', edited by Hideki IMAI, Sukune TAKENOUCHI, Yoshinori FUJIKI, (1976), p. 175, Asakura Publishing Co., Ltd.

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0018] In the conventional techniques of Patent Document 4~6, however, it is not sufficiently disclosed how long to keep the high-temperature zone of not lower than 1200°C but not higher than 1400°C and which region to supply the diluted gaseous fuel in order to produce the high-quality sintered ore having a high strength and an excellent reducibility.

[0019] Further, it should be noted in the techniques of Patent Documents 4~6 that air containing 21 vol% of oxygen as a combustible gas combusting the carbonaceous material or gaseous fuel is used as it is in the determination of ranges of the highest achieving temperature and the high-temperature zone retention time suitable for the sintering. Because, the atmosphere in the bed during the actual sintering is supposed to be different from atmospheric air due to the combustion reaction of the carbonaceous material or gaseous fuel, and gaseous atmosphere in the bed is varied depending on the change in the ingredient or composition of the combustible gas, and hence the highest achieving temperature and the high-temperature retention time during the sintering are naturally varied. Accordingly, it is necessary to change the operating conditions of the sintering machine depending on the characteristics of the combustible gas. In the conventional techniques, however, influences of the characteristics of the combustible gas, especially the oxygen amount included in air upon the sinterability and the quality of the sintered ore are not hardly studied.

[0020] Therefore, the inventors have revealed the high-temperature zone retention time required for the sintering and determined an adequate region to be supplied with the gaseous fuel and also studied the influence of the combustible gas upon the highest achieving temperature and high-temperature zone retention time in the sintering, and consequently developed a method for producing a sintered ore with a high strength and an excellent reducibility by supplying the gaseous fuel to a region where the high-temperature retention time in the sintering by combustion heat of the carbonaceous material is less than 150 seconds to prolong the high-temperature zone retention time and enriching the oxygen concentration in air to more than 21 vol% but less than 35 vol% in the region supplied with the gaseous fuel, which is filed as Japanese patent application No. 2011-058651.

[0021] In the technique proposed in Japanese patent application No. 2011-058651, oxygen is enriched by arranging an oxygen supplying pipe in a hood disposed above the bed in the region supplied with the gaseous fuel and blowing oxygen into air. However, it is not sufficiently disclosed how to supply oxygen in the hood in order to prevent leakage to the outside and enrich oxygen efficiently and safely.

[0022] Also, since the oxygen supplying pipe is not especially limited, when a pipe made of a rolled steel material for general structure (SS steel), for example, used as general city gas piping is used as the oxygen supplying pipe, if an oxygen blowing port (nozzle or opening port) of the oxygen supply pipe is ignited for some reason, there is a fear that the pipe is burned out instantly by a high-purity oxygen flowing in the pipe to cause serious operation troubles.

[0023] It is, therefore, an object of the invention to provide an oxygen-gaseous fuel supply apparatus suitable for use in a sintering machine supplying a gaseous fuel and simultaneously conducting a sintering operation for enriching oxygen and without a fear of burning out by oxygen.

MEANS FOR SOLVING PEOBLEM

[0024] The inventors have made various studies for solving the above problems. As a result, it has been found out that it is most preferable to arrange a plurality of baffle plates in plural rows in the horizontal direction and in plural steps in the vertical direction at intervals in a vertical mid position of the hood disposed in the apparatus supplying the gaseous fuel and to arrange gaseous fuel supply pipes below the baffle plates so as to supply the gaseous fuel, and also to arrange oxygen supply pipes above the baffle plates to blow oxygen into air downwardly from the horizontal line, and also that a portion with the risk of burnout is constituted with a pipe made of copper alloy and/or Ni alloy in order to prevent the burnout of the oxygen supply pipe for supplying oxygen to the sintering machine due to oxygen, and hence the invention has been accomplished.

[0025] That is, the invention is an oxygen-gaseous fuel supply apparatus for a sintering machine by blowing oxygen into air inside a hood disposed above a raw material bed at a downstream side of an ignition furnace to enrich oxygen, and further sucking air supplied with a gaseous fuel diluted to not more than a lower flammable limit by wind boxes arranged below a pallet and introducing into the bed, and combusting the gaseous fuel and carbonaceous material in the bed to produce a sintered ore, characterized in that baffle plates each made of a chevron plate material are arranged in plural rows at intervals in the horizontal direction and in plural steps in the vertical direction so as to arrange the intervals in a zigzag form in a vertical mid position of the hood, and gaseous fuel supply pipes for supplying the gaseous fuel into air are arranged below the baffle plates, and oxygen supply pipes for blowing oxygen into air are arranged above the baffle plates.

[0026] The oxygen-gaseous supply apparatus according to the invention is characterized in that the oxygen supply pipes are arranged so as to set the blowing direction of oxygen downwardly from the horizontal line.

[0027] Also, the oxygen-gaseous supply apparatus according to the invention is characterized in that each of the oxygen supply pipe is arranged above an interval between the baffle plates so as to direct the blowing direction of oxygen toward the interval between the baffle plates.

[0028] Further, the oxygen-gaseous supply apparatus according to the invention is characterized in that each of the oxygen supply pipe is arranged above a top of the baffle plate so as to direct the blowing direction toward the interval between the baffle plates.

[0029] Furthermore, the oxygen-gaseous supply apparatus according to the invention is characterized in that at least a portion of the oxygen supply pipes disposed in the hood is made of a copper alloy and/or Ni alloy.

[0030] In addition, the oxygen-gaseous supply apparatus according to the invention is characterized in that at least a portion of the oxygen supply pipes disposed in the hood is made of a copper alloy containing not less than 60 mass% of copper and/or Ni alloy containing not less than 60 mass% of Ni.

[0031] The oxygen-gaseous supply apparatus according to the invention is characterized in that the oxygen supply pipe is provided with a flashback arrester disposed outside of the hood and in the vicinity of the hood.

EFFECT OF THE INVENION

[0032] According to the invention, it is possible to prevent burnout of the oxygen supply pipe by oxygen and to enrich oxygen by supplying oxygen into air in the hood of the gaseous fuel supply apparatus without leaking oxygen to the outside in the production of the sintered ore by supplying the gaseous fuel with a downdraft type Dwight-Lloyd sintering machine, so that a high-quality sintered ore as a raw material for a blast furnace having a high strength and an excellent reducibility can be produced safely and stably.

BRIEF DESCRIPTION OF DRAWINGS

[0033]

FIG. 1 is a schematic view illustrating a sintering process.
FIG. 2 is a graph showing a temperature distribution and a pressure drop distribution in a sintered layer.
FIG. 3 is a view showing a temperature distribution in a bed at a high productivity and a low productivity, respectively.
FIG. 4 is a schematic view illustrating a change inside a bed with the advance of the sintering progress.
FIG. 5 is a view illustrating a temperature distribution when a combustion zone is existent in each position of an upper part, a middle part and a lower part of a bed and a yield distribution of a sintered ore in a widthwise section of the bed.
FIG. 6 is a view illustrating a temperature change in a bed in accordance with a change (increase) in an amount of a carbonaceous material.
FIG. 7 is a view illustrating a sintering reaction.
FIG. 8 is a phase diagram illustrating a process of producing a secondary hematite of a skeleton-crystal form.
FIG. 9 is a view illustrating a change of a temperature distribution in a sintered layer by supplying a gaseous fuel.
FIG. 10 is a schematic view illustrating an example of the oxygen-gaseous fuel supply apparatus for supplying gaseous fuel and oxygen.
FIG. 11 is a schematic view analyzing an influence of a blowing direction of oxygen upon leakage of oxygen.
FIG. 12 is a view illustrating an embodiment of a method for supplying oxygen.
FIG. 13 is a view illustrating another embodiment of a method for supplying oxygen.
FIG. 14 is a view qualitatively showing an influence of a concentration and a flow rate of oxygen upon burnout of an oxygen supply pipe.
FIG. 15 is a schematic view illustrating a piping system of an oxygen-gaseous fuel supply apparatus for supplying gaseous fuel and oxygen.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0034] The method for producing a sintered ore by applying the technique of the invention is the same as the techniques disclosed in Patent Documents 4~6 in a point that sintered ore is produced by charging a sintering raw material containing fine iron ore and carbonaceous material on a circularly-moving pallet with a downdraft type sintering machine to form a bed, igniting the carbonaceous material on the surface of the bed in an ignition furnace, sucking air containing gaseous fuel diluted to not more than a lower flammable limit in a hood arranged above the bed in the downstream of the ignition furnace with wind boxes arranged below the pallet to introduce in the bed, and combusting the gaseous fuel and the carbonaceous material in the bed.

[0035] Accordingly, it is preferable that the gaseous fuel is supplied in a region that the high-temperature zone retention time kept at not lower than 1200°C is insufficient when sintering is conducted by combustion heat of the carbonaceous material and the amount of carbonaceous material added in the sintering raw material is reduced depending on the amount of the gaseous fuel supplied so as to prevent the highest achieving temperature from exceeding 1400 °C.

[0036] As the gaseous fuel supplied in the bed can be preferably used, for example, a by-product gas of an ironworks such as blast furnace gas (B gas), coke oven gas (C gas), a mixed gas of blast furnace gas and coke oven gas (M gas) or the like, a flammable gas such as LNG (natural gas), city gas, methane gas, ethane gas, propane gas or the like and a mixture gas thereof. Moreover, unconventional natural gas (shale gas) collected from a shale layer and different from the conventional natural gas can be used like LNG.

[0037] The gaseous fuel supplied in the bed is preferable to be diluted to not more than the lower flammable limit thereof. When the concentration of the diluted gaseous fuel is higher than the lower flammable limit, it is combusted above the bed, so that there is a fear of losing the supplying effect of the gaseous fuel or causing explosion. On the other hand, when the concentration of the diluted gaseous fuel is high, it is combusted in a low-temperature zone and hence there is a fear that the gaseous fuel may not contribute to the extension of the high-temperature retention time effectively. Therefore, the concentration of the diluted gaseous fuel is preferably not more than 3/4 of the lower flammable limit at room temperature in air, more preferably not more than 1/5 of the lower flammable limit, further preferably not more than 1/10 of the lower flammable limit. However, when the concentration of the diluted gaseous fuel is less than 1/100 of the lower flammable limit, the heat generation amount by the combustion is short and the effects of increasing the strength of sintered ore and improving the yield cannot be obtained, so that the lower limit is set to be 1% of the lower flammable limit. With regard to the natural gas (LNG), since the lower flammable limit of LNG at room temperature is 4.8 vol%, the concentration of the diluted gaseous fuel is preferably in a range of 0.05~3.6 vol%, more preferably in a range of 0.05~1.0 vol%, further preferably in a range of 0.05~0.5 vol%.

[0038] The method for producing sintered ore by applying the technique of the invention is characterized by supplying the gaseous fuel and enriching oxygen like that of Japanese Patent Application No. 2011-058651. Because, a gaseous atmosphere in the sintering is shifted to an oxidation direction by enriching oxygen to increase a ratio of calcium ferrite produced in the sintered ore through sintering and decrease a ratio of calcium silicate formed, whereby a sintered ore with a high strength and an excellent reducibility can be obtained, while not only the sintering reaction can be increased to shorten the sintering time but also the combustion position of the carbonaceous material in the gaseous fuel and the sintering raw material can be moved to a lower temperature side to expand a base of temperature distribution curve in the bed by simultaneously conducting the supply of the gaseous fuel and the enrichment of oxygen, whereby the high-temperature zone retention time can be extended, and hence the quality of the sintered ore can be improved while increasing the productivity.

[0039] The effect by the enrichment of oxygen can be obtained even in small amounts when the oxygen concentration included in air to be sucked in the bed is more than the oxygen concentration in air (21 vol %), but oxygen is preferably enriched to not less than 24.5 vol%. While, when the oxygen concentration in air is not less than 35 vol%, the cost required for the oxygen enrichment exceeds the benefit obtained. Therefore, it is preferable to add oxygen to be enriched so that the oxygen concentration in air is set to a range of more than 21 vol% but less than 35 vol%. It is more preferably a range of 24.5~30 vol%, further preferably a range of 24.5~28 vol%.

[0040] As a method (apparatus) for enriching oxygen as mentioned above, it is necessary as shown in FIG. 10 that baffle plates are disposed in plural rows at intervals in the horizontal direction and in plural steps in the vertical direction so as to arrange the intervals in a zigzag form in the vertical mid portion of the hood arranged above a raw material bed supplying a gaseous fuel, and gaseous fuel supply pipes for supplying the gaseous fuel into air are disposed below the baffle plates, whereby raw gaseous fuel is blown into air at a high speed causing a blow-out phenomenon to instantly form a diluted gaseous fuel of not more than the lower flammable limit, or a gaseous fuel diluted to not more than the lower flammable limit is blown into air to supply the gaseous fuel into air, while oxygen supply pipes are disposed above the baffle plates to blow oxygen into air for enrichment.

[0041] The reason why the gaseous fuel is supplied to the lower portions of the baffle plates as described above is that since the gaseous fuel such as LNG or the like is generally lighter than air, the leakage of the gaseous fuel from above the hood is prevented by disposing the baffle plates or by throttling air blown downward between the intervals of the baffle plates to increase the flow rate.

[0042] Also, the baffle plate is not especially limited as long as the gaseous fuel supplied in the lower portion thereof is prevented from being leaked upward and air containing oxygen enriched above can be smoothly flown downward. However, it is desirable that plate materials formed into a chevron shape (mountain-like shape) are arranged in plural rows at intervals in the horizontal direction and in plural steps so as to render the intervals into a zigzag form (in a tournament form) or a labyrinth form in the vertical direction as shown in FIG. 10. As to the specification of the baffle plate, for example, when a sintering machine has a machine width of 6 m, it is desirable that the width of the baffle plate is approximately 200~500 mm, and the interval between the baffle plates is approximately 50~200 mm in the horizontal direction and approximately 50~200 mm in the vertical direction, and the number of steps is approximately 2~5. Moreover, it is preferable to arrange the baffle plates so as to render pressure drop in the opening port into approximately not more than 10 mmAq from a viewpoint of preventing the leakage of the gaseous fuel above the hood.

[0043] In FIG. 10 is illustrated an example of blowing the gaseous fuel from the gaseous fuel supply pipes in the horizontal direction. However, the blowing direction is not particularly limited and may be horizontal or downward as long as the gaseous fuel is uniformly mixed with air and diluted to not more than the lower flammable limit before introduction into the bed.

[0044] The reason why oxygen is blown above the baffle plates is that since a specific gravity of oxygen is higher than that of air, a ratio of leaking outside of the hood is low, or if leakage is caused, oxygen has no danger like the gaseous fuel, and since oxygen blown from the supply pipes is uniformly diluted to a target concentration while passing through the interval between the baffle plates and then mixed with the gaseous fuel, direct contact between oxygen of high concentration and the gaseous fuel can be prevented.

[0045] Moreover, oxygen supplied from the supply pipes is not necessarily pure oxygen. However, the amount of oxygen supplied is extraordinarily large as compared to the gaseous fuel, so that it is not preferable that the oxygen concentration is decreased since the amount of oxygen blown from the pipes is increased.

[0046] As the direction of blowing oxygen from the oxygen supply pipes, however, the downward direction is preferable as compared to the horizontal line from a viewpoint of preventing the leakage of oxygen outside of the hood. In FIG. 11 are shown simulation results of an amount of oxygen leaked outside of the hood through a cross wind of 10 m/s between the horizontal direction and the downward direction of blowing oxygen when oxygen is blown from the oxygen supply pipes into air above the baffle plates in the hood to concentrate the oxygen concentration from 21 vol% to 27 vol%. As seen from this figure, when oxygen is blown in the horizontal direction, there is a tendency of easily causing leakage of oxygen.

[0047] When the direction of blowing oxygen from the oxygen supply pipes is downward, the oxygen supply pipes may be arranged above the interval between the baffle plates to blow oxygen toward the interval between the baffle plates as shown in FIG. 12. In this oxygen blowing method, since oxygen jet is directly blown between the baffle plates, there is a merit that oxygen can be sucked smoothly to suppress the leakage upward.

[0048] Alternatively, the oxygen supply pipes may be arranged above the tops of the baffle plates to blow oxygen toward the interval (spacing part) between the baffle plates as shown in FIG. 13. In this oxygen blowing method, since oxygen can be supplied from one oxygen supply pipe toward two intervals, there is a merit of decreasing the number of the oxygen supply pipes depending on conditions.

[0049] Next, there will be explained prevention from burnout of the oxygen supply pipe in the gaseous fuel supply apparatus through oxygen.

[0050] As mentioned above, in the oxygen-gaseous fuel supply apparatus shown in FIG. 10, one or more rows of baffle plates are arranged at intervals in a vertical mid portion of the hood arranged above the bed in the region supplied with the gaseous fuel, and the gaseous fuel supply pipes are arranged below the baffle plates to blow raw gaseous fuel at a high speed causing a blow-out phenomenon to thereby instantly dilute the gaseous fuel to not more than the lower flammable limit, while oxygen supply pipes are arranged above the baffle plates to supply oxygen toward the baffle plates. This apparatus is designed so that the direct contact between oxygen of high concentration and the gaseous fuel can be prevented since oxygen supplied from the oxygen supply pipes is uniformly diluted to a target concentration to be enriched while passing through the intervals between the baffle plates and joined with the gaseous fuel. Moreover, oxygen supplied from the pipes may not be pure oxygen.

[0051] Since gaseous fuel such as LNG or the like is lighter than air, the baffle plates arranged above the gaseous fuel supply pipes prevent the gaseous fuel from being leaked and lost above the hood. Moreover, oxygen is higher in the specific gravity as compared to the gaseous fuel, so that a fear of diffusing oxygen out of the hood is slight unless a strong wind blows.

[0052] In a worrying point of the oxygen enriching apparatus, however, a fire source is always existent because the sintering raw material is sintered by combustion heat generated in combustion of coke and gaseous fuel in the sintering machine. Therefore, when the oxygen supply pipe is made of, for example, a rolled steel material for general structure (SS steel) or the like usually used as city gas piping, even if non-oil treatment is applied, there is a fear that if an oxygen blowing port of the oxygen supplying pipe (nozzle or opening port) is ignited for some reason, the oxygen supply pipe is burnt out instantly up to a valve stand by reaction heat of iron and oxygen.

[0053] Since the gaseous fuel supplied from the gaseous fuel supply pipes is blown at a high speed causing a blow-out phenomenon, ignition can be prevented. Even if ignited, combustion is caused only at the ignited portion and hence the pipes themselves are never burnt out. Also, the amount of oxygen supplied is large as compared with the gaseous fuel, so that oxygen of high concentration is blown from a large blowing port at a high speed of not less than 10 m/s. However, as the oxygen concentration becomes higher and the flow rate becomes faster, the burnout through oxygen is easily caused as shown in FIG. 14, so that it is important to take measures for the burnout of the pipes.

[0054] In the invention, therefore, in order to prevent the burnout of the oxygen supply pipes as described above, at least a fire-source existing portion of the oxygen supply pipe arranged in the hood (header, branch pipe, nozzle or the like) is a piping made of copper alloy and/or Ni alloy. Since the copper alloy or Ni alloy is small in the ionization tendency as compared with iron, rust as an ignition source is hardly formed in the pipe, while these alloys form a dense oxide film hardly passing oxygen on their surfaces and hence further oxidation is suppressed and the burnout is hardly caused.

[0055] From the above viewpoints, the copper alloy is preferable to contain not less than 60 mass% of Cu and includes, for example, Cu-Zn alloy (brass) containing 60~70% of Cu, Cu-Ni alloy (white copper, cupronickel) containing 70~90% of Cu, Cu-Sn alloy (bronze) containing 65~98% of Cu, Cunife of Cu: 60 mass%-Ni: 20 mass%-Fe: 20 mass%, Be copper containing approximately 2 mass% of Be and so on. Also, the Ni alloy is preferable to contain not less than 60 mass% of Ni, and includes, for example, Inconel, Monel, nichrome and so on. Among them, copper and pure Ni are more preferable because they are excellent in the oxidation resistance. In Table 2 are shown oxidation resistances of various alloys in a high-temperature oxidizing atmosphere of not lower than 500°C for reference.

Table 2

Alloy	Chemical composition (mass %)				Evaluation of oxidation resistance*
	Cu	Ni	Fe	Others	
Pure Ni	-	100	-	-	◎
Pure Cu	100	-	-	"-"	◎
Monel	34	63	-	Fe, Mn and the like: 3	◎
Be copper	98	-	-	Be: 2	
Cupronickel (white copper)	70-90	10-30	-	-	◎
Cunife	60	20	20	-	○
Brass	60-70	-	-	Zn: 30-40	○
Inconel	-	72	13	Cr: 15	○
Nichrome	-	80	-	Cr: 20	○
Hastelloy B-2	-	69	1	Mo and the like: 30	○
Hastelloy C22	-	56	3	Cr, Mo and the like: 41	Δ
Bronze	65-98	-	-	Sn: 2-35	Δ
SUS304	-	8	74	Cr: 18	Δ
Carbon steel	-	-	99	Mn and the like: 1	×
Al alloy	-	-	-	Al and the like: 100	×
Mg alloy	-	-	-	Mg and the like: 100	×
* Evaluation of oxidation resistance; ◎ : Very stable ○: Stable (Usable) Δ: Oxidation depending on condition × : Ignition possible					

[0056] FIG. 15 is a schematic view illustrating the supply piping system of the gaseous fuel and oxygen in the gaseous fuel supply apparatus of FIG. 10. For example, when oxygen is referred, it is shown that oxygen is supplied to a header through an oxygen supply main pipe and further supplied to a plurality of branch pipes attached to the header and blown from plural nozzles attached to the branch pipe or plural opening ports arranged therein. In the invention, all the oxygen supply pipes are not necessarily made of copper alloy or Ni alloy, whereas it is necessary that at least a part of the pipe close to the fire source in the hood (branch pipe, nozzle or the like) is made of copper alloy or Ni alloy. In order to more enhance the safety, both the header and the oxygen supply main pipes are preferable to be made of copper alloy or Ni alloy.

[0057] Further, it is preferable that a flashback arrester (flame arrester) is arranged on the oxygen supply main pipe at a position outside of the hood but in the vicinity of the hood. It is thereby possible to further enhance the safety. The flashback arrester is not particularly limited, but a backfire valve, a dry type safety device or the like can be preferably used. In this case, it is preferable that the portion from the flashback arrester to the header is made of copper alloy or Ni alloy.

[0058] As the oxygen supply pipe located in the upstream side from the flashback arrester can be used an usual steel pipe, but it is preferable to use one made of SUS and subjected to the non-oil treatment

INDUSTRIAL APPLICABILITY

[0059] The technique of the invention is usable not only for steel-making, particularly a method of producing sintered ore used as a raw material for blast furnace, but also can be used as an agglomeration method of other ores.

DESCRIPTION OF REFERENCE SYMBOLS

[0060]

1 : hopper for raw material

2: drum mixer

3: rotary kiln

4,5: surge hopper

6: drum feeder

7: cutout chute

8: pallet

9: bed

10: ignition furnace

11: wind box

12: cut-off plate

Claims

1. An oxygen-gaseous fuel supply apparatus for a sintering machine by blowing oxygen into air inside a hood disposed above a raw material bed at a downstream side of an ignition furnace to enrich oxygen, and further sucking air supplied with a gaseous fuel diluted to not more than a lower flammable limit by wind boxes arranged below a pallet and introducing into the bed, and combusting the gaseous fuel and carbonaceous material in the bed to produce a sintered ore, **characterized in that** baffle plates each made of a chevron plate material are arranged in plural rows at intervals in the horizontal direction and in plural steps in the vertical direction so as to arrange the intervals in a zigzag form in a vertical mid position of the hood, and gaseous fuel supply pipes for supplying the gaseous fuel into air are arranged below the baffle plates, and oxygen supply pipes for blowing oxygen into air are arranged above the baffle plates.

2. The oxygen-gaseous supply apparatus according to claim 1, wherein the oxygen supply pipes are arranged so as to set the blowing direction of oxygen downwardly from the horizontal line.

3. The oxygen-gaseous supply apparatus according to claim 1 or 2, wherein each of the oxygen supply pipe is arranged above an interval between the baffle plates so as to direct the blowing direction of oxygen toward the interval between the baffle plates.

4. The oxygen-gaseous supply apparatus according to claim 1 or 2, wherein each of the oxygen supply pipe is arranged above a top of the baffle plate so as to direct the blowing direction toward the interval between the baffle plates.

5. The oxygen-gaseous supply apparatus according to any one of claims 1 to 4, wherein at least a portion of the oxygen supply pipes disposed in the hood is made of a copper alloy and/or Ni alloy.

6. The oxygen-gaseous supply apparatus according to any one of claims 1 to 4, wherein at least a portion of the oxygen supply pipe disposed in the hood is made of a copper alloy containing not less than 60 mass% of copper and/or Ni alloy containing not less than 60 mass% of Ni.

7. The oxygen-gaseous supply apparatus according to any one of claims 1 to 6, wherein the oxygen supply pipe is provided with a flashback arrester disposed outside of the hood and in the vicinity of the hood.

FIG. 1

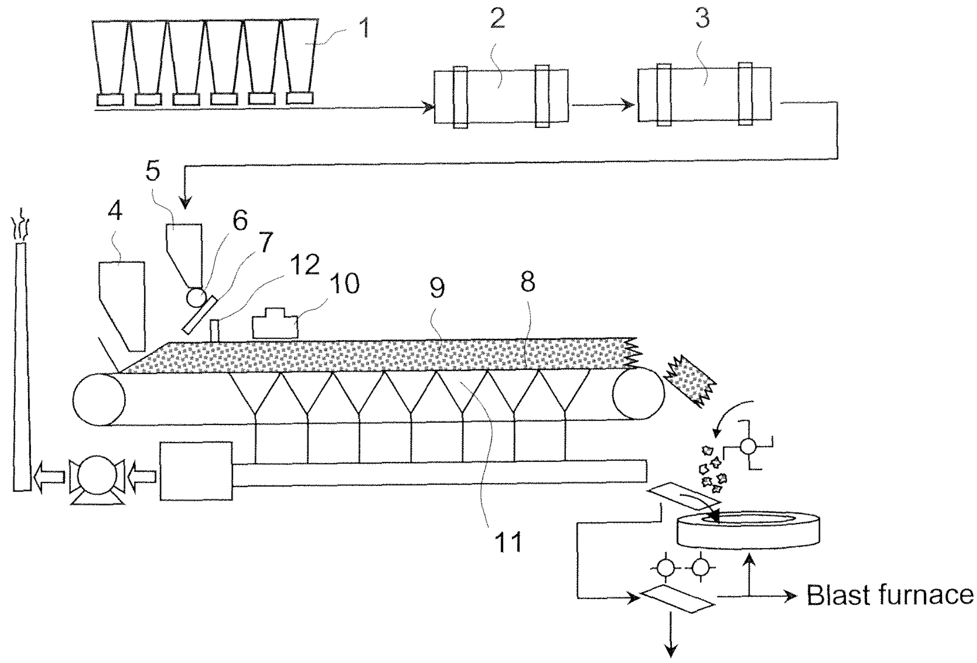

1
2
3
5
4
6
7
12
10
9
8
11
Blast furnace

FIG. 2

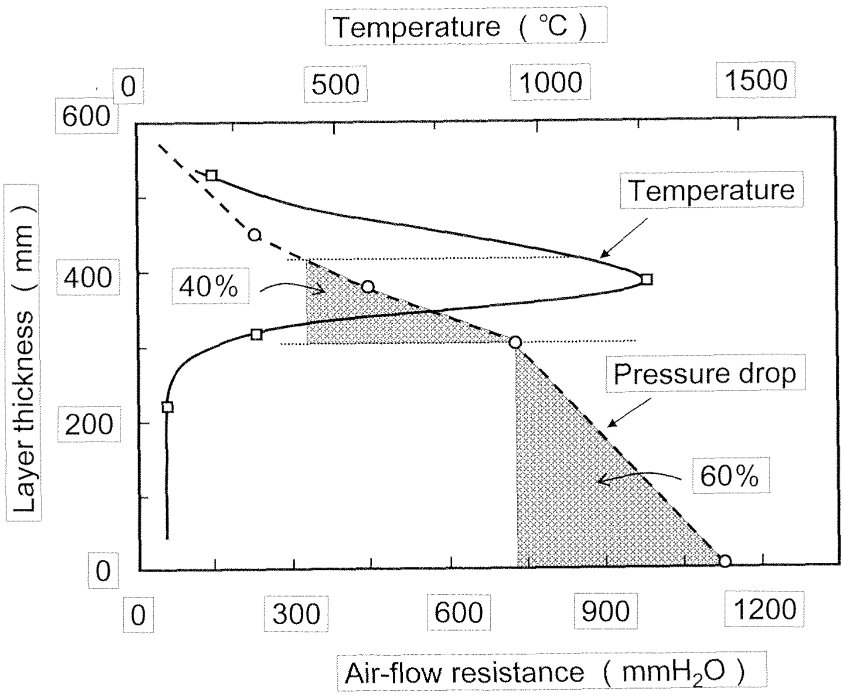

Temperature (℃)
0
500
1000
1500
600
400
200
0
Layer thickness (mm)
Temperature
40%
Pressure drop
60%
0
300
600
900
1200
Air-flow resistance (mmH2O)

FIG. 3

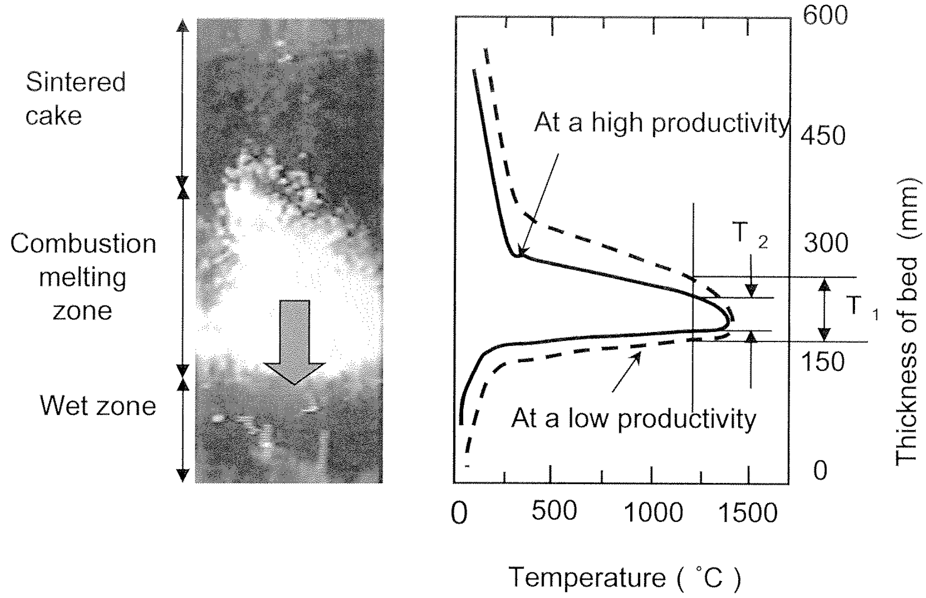

Sintered cake
Combustion melting zone
Wet zone
At a high productivity
At a low productivity
T 2
T 1
600
450
300
150
0
Thickness of bed (mm)
0
500
1000
1500
Temperature (˚C)

FIG. 4

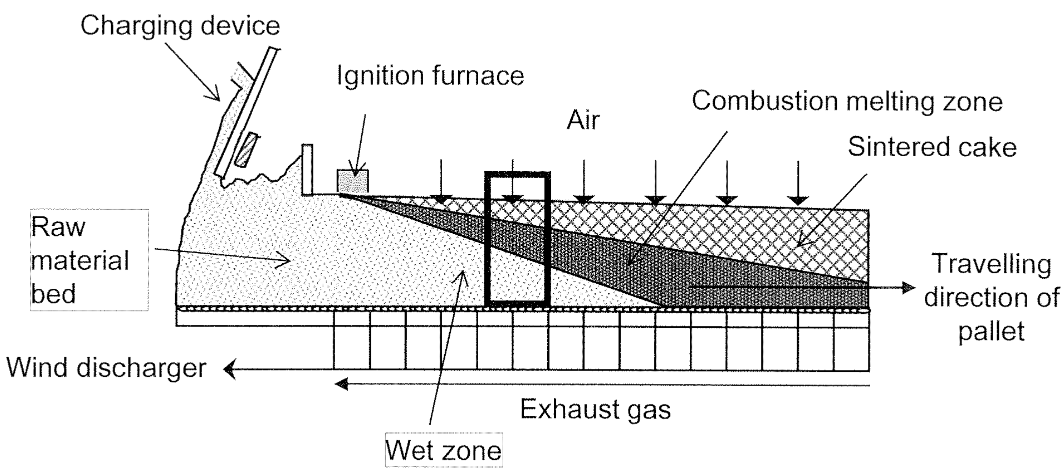

Charging device
Ignition furnace
Air
Combustion melting zone
Sintered cake
Raw material bed
Travelling direction of pallet
Wind discharger
Exhaust gas
Wet zone

FIG. 5

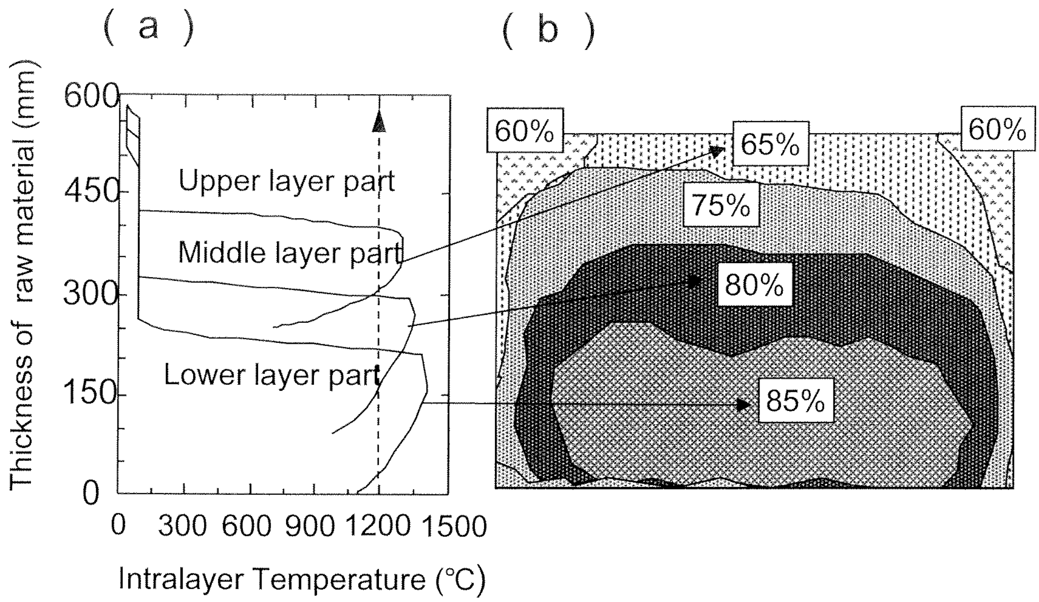

(a)
(b)
Thickness of raw material (mm)
600
450
300
150
0
Upper layer part
Middle layer part
Lower layer part
0 300 600 900 1200 1500
Intralayer Temperature (°C)
60%
65%
60%
75%
80%
85%

FIG. 6

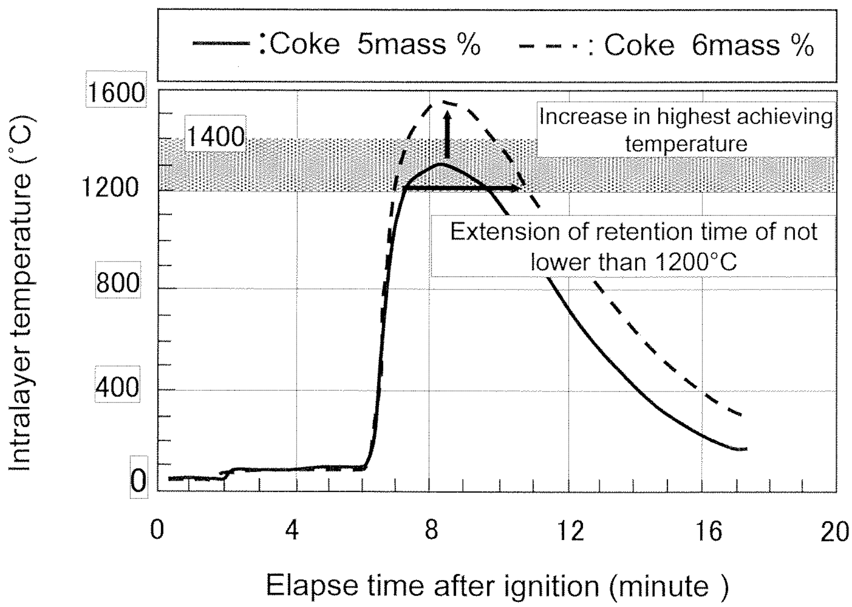

:Coke 5mass %
: Coke 6mass %
Intralayer temperature (°C)
1600
1400
1200
800
400
0
Increase in highest achieving temperature
Extension of retention time of not lower than 1200°C
0 4 8 12 16 20
Elapse time after ignition (minute)

FIG. 7

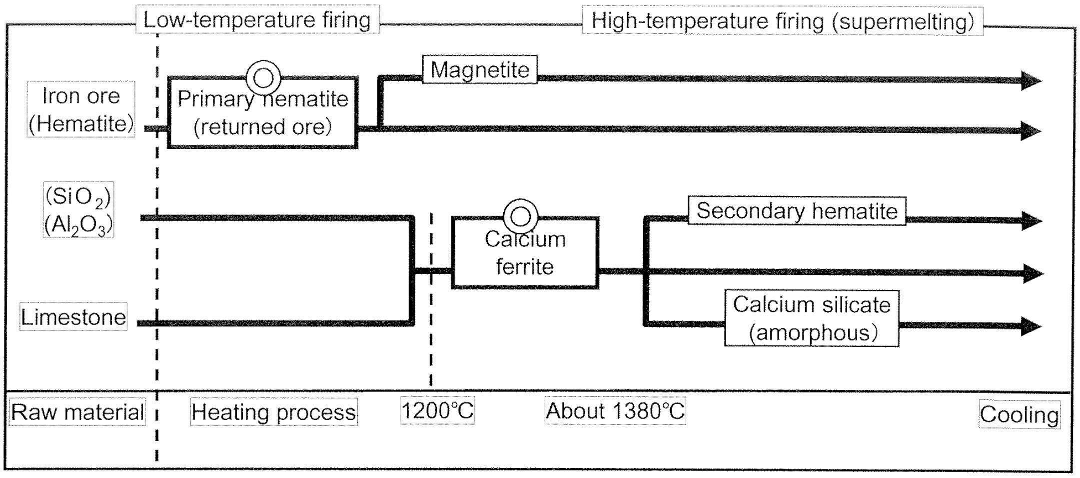

Low-temperature firing
High-temperature firing (supermelting)
Iron ore
(Hematite)
Primary hematite
(returned ore)
Magnetite
(SiO2)
(Al2O3)
Limestone
Calcium
ferrite
Secondary hematite
Calcium silicate
(amorphous)
Raw material
Heating process
1200°C
About 1380°C
Cooling

FIG. 8

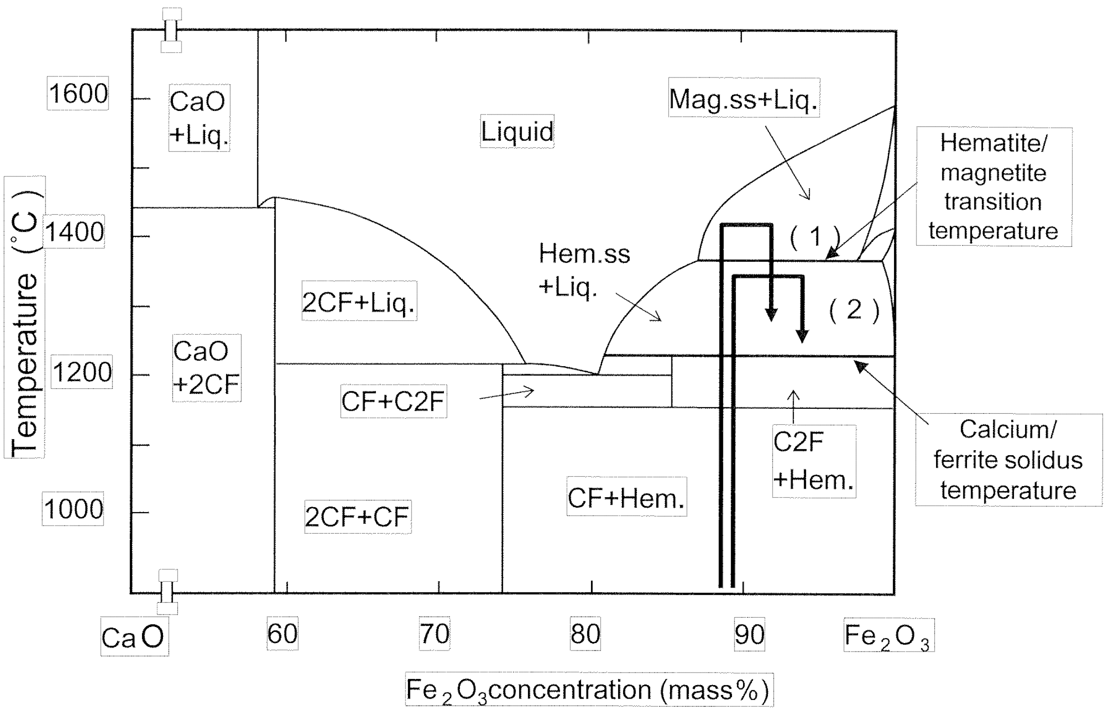

Temperature (°C)
1600
1400
1200
1000
CaO
+Liq.
Liquid
Mag.ss+Liq.
Hematite/
magnetite
transition
temperature
(1)
(2)
Hem.ss
+Liq.
2CF+Liq.
CaO
+2CF
CF+C2F
C2F
+Hem.
Calcium/
ferrite solidus
temperature
CF+Hem.
2CF+CF
CaO
60
70
80
90
Fe2O3
Fe2O3 concentration (mass%)

FIG. 9

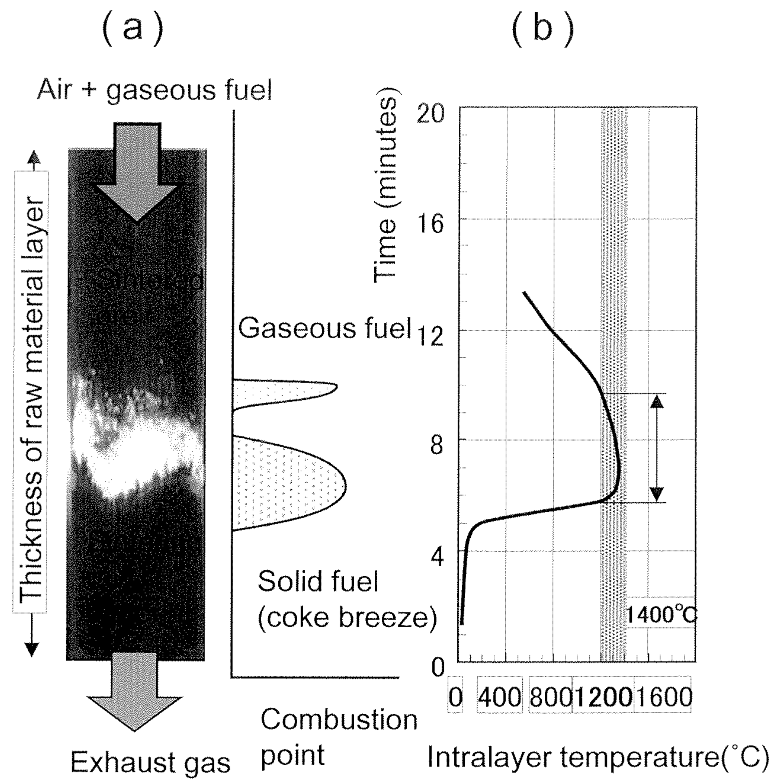

(a)
(b)
Air + gaseous fuel
Thickness of raw material layer
Gaseous fuel
Solid fuel
(coke breeze)
Exhaust gas
Combustion
point
Time (minutes)
20
16
12
8
4
0
0
400
800
1200
1600
1400°C
Intralayer temperature(˚C)

FIG. 10

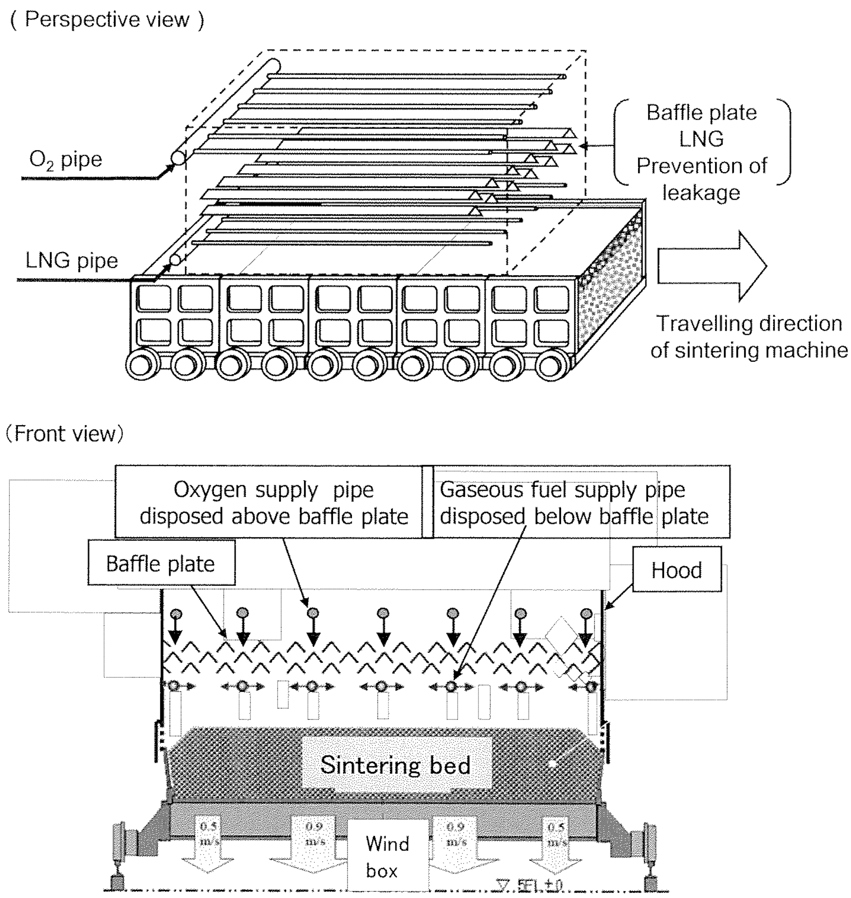

(Perspective view)
O_2 pipe
LNG pipe
Baffle plate
LNG
Prevention of
leakage
Travelling direction
of sintering machine
(Front view)
Oxygen supply pipe
disposed above baffle plate
Gaseous fuel supply pipe
disposed below baffle plate
Baffle plate
Hood
Sintering bed
Wind
box

FIG. 11

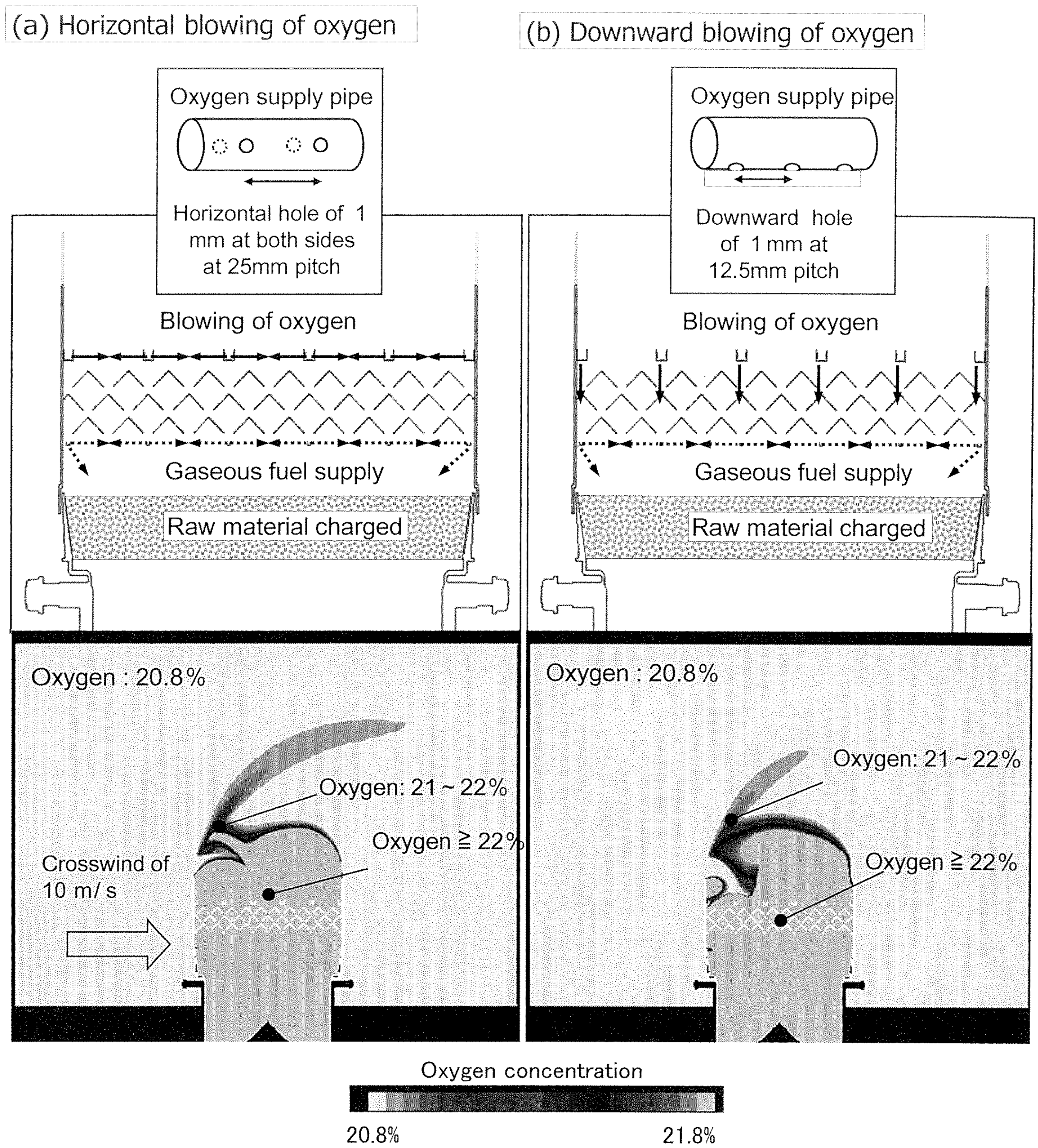

(a) Horizontal blowing of oxygen
(b) Downward blowing of oxygen
Oxygen supply pipe
Horizontal hole of 1 mm at both sides at 25mm pitch
Oxygen supply pipe
Downward hole of 1 mm at 12.5mm pitch
Blowing of oxygen
Blowing of oxygen
Gaseous fuel supply
Gaseous fuel supply
Raw material charged
Raw material charged
Oxygen : 20.8%
Oxygen: 21 ~ 22%
Oxygen ≧ 22%
Crosswind of 10 m/ s
Oxygen : 20.8%
Oxygen: 21 ~ 22%
Oxygen ≧ 22%
Oxygen concentration
20.8%
21.8%

FIG. 12

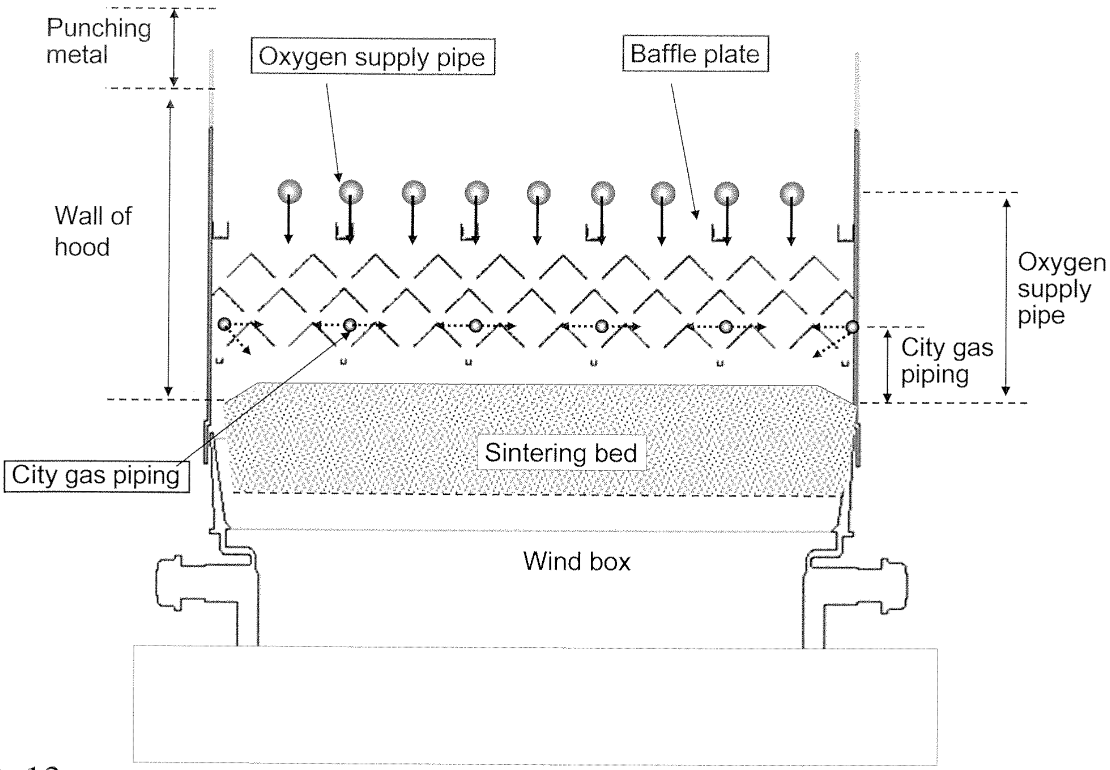

Punching metal
Oxygen supply pipe
Baffle plate
Wall of hood
Oxygen supply pipe
City gas piping
City gas piping
Sintering bed
Wind box

FIG. 13

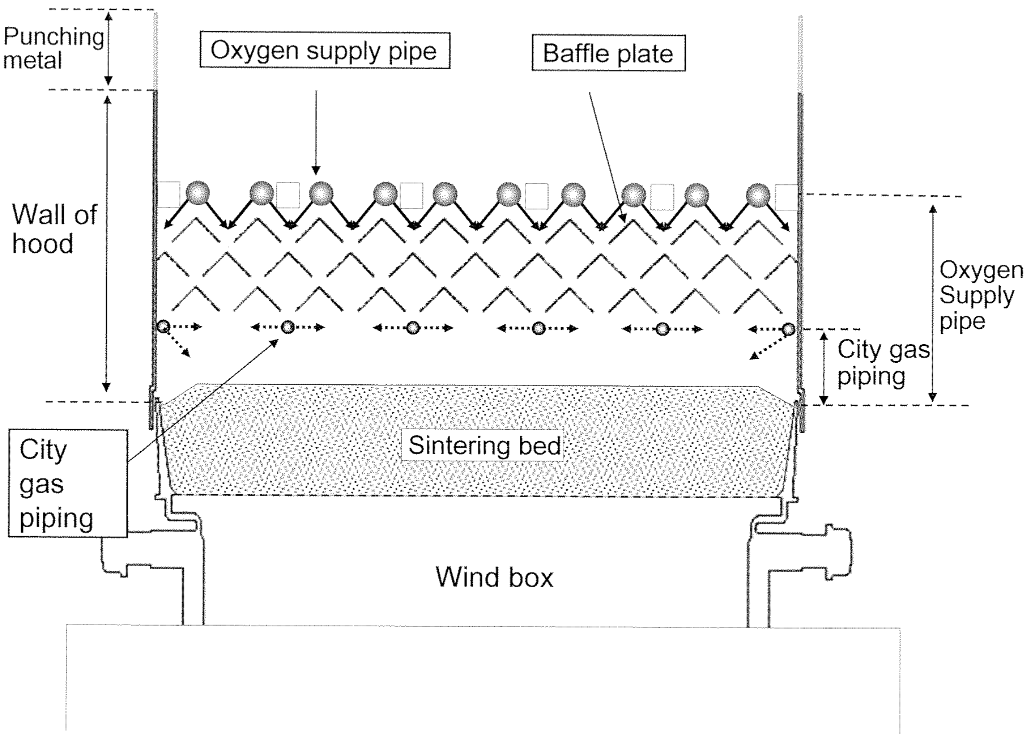

Punching metal
Oxygen supply pipe
Baffle plate
Wall of hood
Oxygen Supply pipe
City gas piping
City gas piping
Sintering bed
Wind box

FIG. 14

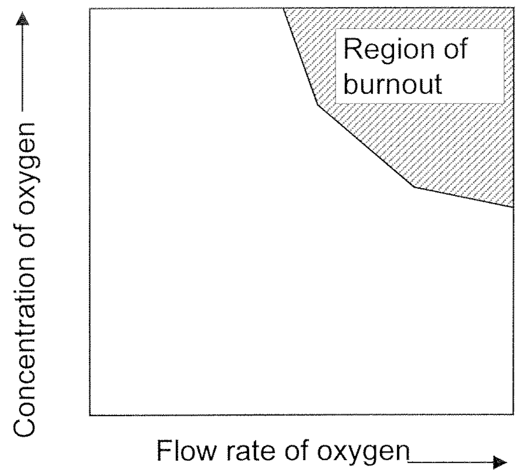
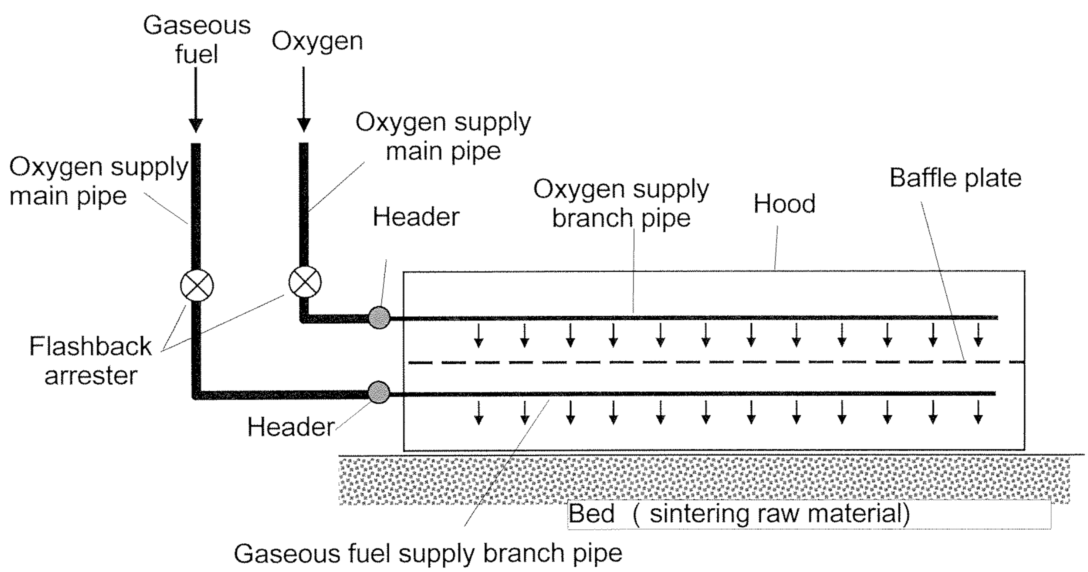

Region of burnout
Concentration of oxygen
Flow rate of oxygen

FIG. 15


Gaseous fuel
Oxygen
Oxygen supply main pipe
Oxygen supply main pipe
Header
Oxygen supply branch pipe
Hood
Baffle plate
Flashback arrester
Header
Bed (sintering raw material)
Gaseous fuel supply branch pipe

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/080037

A. CLASSIFICATION OF SUBJECT MATTER
C22B1/20(2006.01)i, *F27B21/08*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C22B1/20, F27B21/08

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2011/118822 A1 (JFE Steel Corp.), 29 September 2011 (29.09.2011), claims; paragraph [0076]; fig. 23 & JP 2012-207236 A & TW 201134946 A	1-4 5-7
Y	JP 2008-531852 A (L'Air Liquide, Societe Anonyme pour L'Etude et L'Exploitation des Procedes Georges Claude), 14 August 2008 (14.08.2008), claims; paragraphs [0002] to [0008] & JP 4838269 B & US 2009/0007967 A1 & EP 1859068 A & WO 2006/092516 A1 & FR 2882764 A & CA 2599857 A & KR 10-2007-0111505 A & CN 101133179 A	5-7

☒ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:
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"E" earlier application or patent 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	Date of mailing of the international search report
18 January, 2013 (18.01.13)	29 January, 2013 (29.01.13)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/080037

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2011-52860 A (JFE Steel Corp.), 17 March 2011 (17.03.2011), paragraphs [0031] to [0038]; fig. 3, 4 (Family: none)	7 1-6
Y	JP 2005-240840 A (Iwatani Industrial Gases Corp.), 08 September 2005 (08.09.2005), paragraphs [0001], [0002] (Family: none)	7
A	JP 2010-126775 A (JFE Steel Corp.), 10 June 2010 (10.06.2010), claims (Family: none)	1-7

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP S46027126 B **[0016]**
- WO 9807891 A **[0016]**
- JP H02073924 A **[0016]**
- JP 2008095170 A **[0016]**
- JP 2010047801 A **[0016]**
- JP 2008291354 A **[0016]**
- JP 2011058651 A **[0020] [0021] [0038]**

Non-patent literature cited in the description

- Mineral engineering. Asakura Publishing Co., Ltd, 1976, 175 **[0017]**