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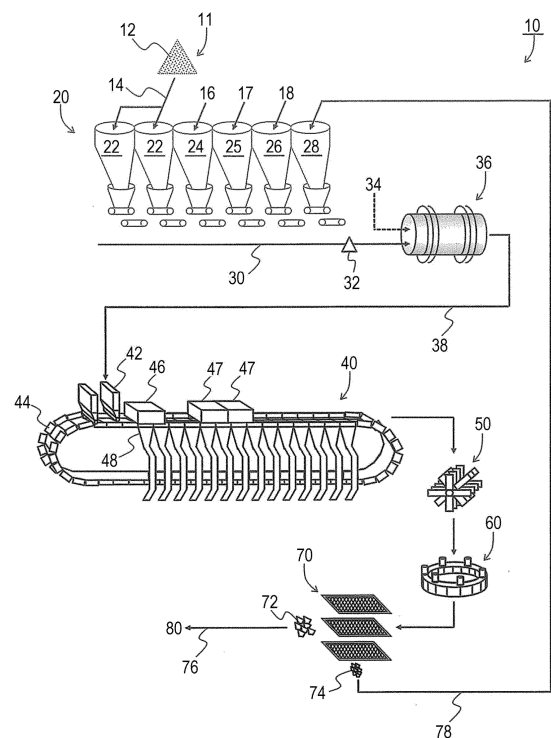
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(54) **METHOD FOR MANUFACTURING SINTERED ORE**

(57) Provided is a method for manufacturing sintered ore with which, even in the case where there is a variation in the component concentrations in iron ore and dust generated in a steel plant, it is possible to manufacture product sintered ore in which a deterioration in quality is inhibited by using a sintering raw material containing such iron ore and dust.

A method for manufacturing sintered ore, in which a sintering raw material containing at least an iron-containing raw material, a CaO-containing raw material, and a bonding agent is granulated, and the granulated sintering raw material is sintered in a sintering machine, the method including a measuring process of continuously measuring a component concentration in at least one of the iron-containing raw material, the sintering raw material, and the granulated sintering raw material, and an adjusting process of adjusting at least one of an amount of the CaO-containing raw material added, an amount of the bonding agent added, an amount of water added, and a moving speed of a pallet carriage of the sintering machine in accordance with the component concentration measured in the measuring process.

FIG. 1



Description

Technical Field

[0001] The present invention relates to a method for manufacturing sintered ore including controlling the amounts of, for example, CaO-containing raw materials added in a sintering raw material, and in particular, to a method for manufacturing sintered ore including continuously measuring component concentrations in the sintering raw material and controlling the amount of, for example, CaO-containing raw materials added in accordance with the measured component concentrations.

Background Art

[0002] In blast furnace ironmaking methods, nowadays, sintered ore, lump iron ore, pellets, and so forth are mainly used as iron sources for blast furnace feed materials. Here, sintered ore is a kind of agglomerated ore manufactured in such a manner that iron ore having a particle size of 10 mm or less, miscellaneous iron sources, such as various kinds of dust generated in a steel plant, CaO-containing raw materials, such as limestone, quick lime, and slag, auxiliary materials serving as SiO₂ sources or MgO sources, such as silica stone, serpentine, dolomite, and nickel refining slag, and solid fuels (carbonaceous materials) serving as bonding agents, such as coke breeze and anthracite, are mixed and granulated in a drum mixer while water is added, and then burned.

[0003] In recent years, the concentration of iron in iron ore contained in a sintering raw material, which is a raw material for sintered ore, has been decreasing, and, instead, the concentrations of gangue components, such as SiO₂ and Al₂O₃, have been increasing. In addition, the component concentrations in iron ore produced have become variable to such an extent that, even in the case of the same kind of iron ore, the component concentrations may vary from one ship to another when the iron ore is imported. Also, in the case of various kinds of dust generated in a steel plant, since there is a large variation in the amounts of the dust generated and in the component concentrations in the dust, it is very difficult to control the components of a sintering raw material.

[0004] A variation in the component concentrations in a sintering raw material causes a variation in the component concentrations in sintered ore, which is a product. For example, an increase in the amount of SiO₂ generally causes a deterioration in the reducibility of sintered ore, and an increase in the amount of Al₂O₃ generally causes a decrease in the strength of sintered ore. Therefore, in the case where the component concentrations in a sintering raw material deviate from target values, it is necessary to perform operational adjustment and composition adjustment to avoid a deterioration in product quality.

[0005] Generally, the component concentrations in sintered ore which is charged into a blast furnace are

constantly controlled for the purpose of, for example, controlling the quality of slag. For example, in the case where, regarding the components of product sintered ore, there is an increase in the basicity or the alumina content, since there is an increase in the viscosity of blast furnace slag, it is necessary to increase the temperature of molten iron to inhibit an increase in viscosity. Due to an increase in the viscosity of blast furnace slag, since there is a deterioration in the slag-discharging efficiency in the lower part of a blast furnace, gas flow is inhibited, which results in a deterioration in gas permeability. Therefore, it is necessary to increase the amount of coke added to increase the temperature of molten iron and to achieve satisfactory gas permeability in the lower part of a blast furnace. Like this, in the case where there is a variation in the component concentrations in product sintered ore such that the component concentrations in blast furnace feed materials significantly deviate from target component concentrations, the operation of a blast furnace becomes unstable. Therefore, various countermeasures are necessary.

[0006] In response to such problems, various efforts have been made to estimate the quality of a sintering raw material. For example, Patent Literature 1 discloses a technique focusing on clay minerals contained in iron ore in which the granulation capability of a sintering raw material is improved by controlling the content of a clay mineral (kaolin: Al₂Si₂O₅(OH)₄) in finely powdered ore contained in iron ore to be within an appropriate range.

[0007] Patent Literature 2 discloses a technique in which the FeO concentration in product sintered ore is measured and in which the bonding agents and granulation water content for a sintering raw material and an air-discharging rate are adjusted in accordance with the FeO concentration in the product sintered ore. Also, Patent Literature 3 discloses a technique in which the FeO concentration in product sintered ore is measured and in which the amount of city gas injected into a sintering machine is adjusted in accordance with the FeO concentration in the product sintered ore.

[0008] Patent Literature 4 discloses a technique in which the component concentrations in product sintered ore are estimated on the basis of the component concentrations in a surface layer of the burden layer of a sintering raw material, which has been charged onto a pallet, and determined by using a laser-type component measuring device disposed above a sintering machine and in which the composition of a sintering raw material is adjusted in accordance with the estimation results.

Citation List

Patent Literature

[0009]

PTL 1: Japanese Unexamined Patent Application Publication No. 2003-049227

PTL 2: Japanese Unexamined Patent Application

Publication No. 57-149433
 PTL 3: Japanese Unexamined Patent Application
 Publication No. 2011-038735
 PTL 4: Japanese Unexamined Patent Application
 Publication No. 60-262926

Summary of Invention

Technical Problem

[0010] In the case of the technique disclosed in Patent Literature 1, a certain amount of iron ore sample is weighed out, and the kaolin concentration is determined offline. Although it is possible to estimate the component concentrations in sintered ore by measuring the component concentrations in a sintering raw material offline as described above, it is difficult to address the heat quantity excess or deficiency caused by a variation in the component concentrations in a sintering raw material during manufacture of sintering ore.

[0011] In the case of the techniques disclosed in Patent Literature 2 and Patent Literature 3, although the FeO concentration in product sintered ore is continuously determined, since the time lag is too large to reflect the results of the component analysis of the product sintered ore in the composition adjustment of a sintering raw material, it is difficult to rapidly address a variation in the component concentrations in the sintering raw material during manufacture of sintered ore.

[0012] In the case of the technique disclosed in Patent Literature 4, although the component concentrations in product sintered ore are estimated on the basis of the component concentrations in the surface layer of a burden layer of a sintering raw material, since there is a variation in the conditions of the burden layer of the sintering raw material in accordance with a charging apparatus for the sintering raw material and the water content of the sintering raw material, there is a variation in the component concentrations in the surface layer of the burden layer of the sintering raw material. Therefore, there is no definite relationship between the component concentrations in the surface layer of the burden layer and the component concentrations in the product sintered ore, which makes it difficult to practically estimate the component concentrations in the product sintered ore on the basis of the component concentrations in the surface layer of the burden layer.

[0013] The present invention has been completed in view of such problems of the conventional techniques, and an object of the present invention is to provide a method for manufacturing sintered ore with which, even in the case where there is a variation in the component concentrations in iron ore and dust generated in a steel plant, it is possible to manufacture product sintered ore with only a small variation in component concentrations by using a sintering raw material containing such iron ore and dust.

Solution to Problem

[0014] The features of the present invention for solving such problems are as follows.

(1) A method for manufacturing sintered ore, in which a sintering raw material containing at least an iron-containing raw material, a CaO-containing raw material, and a bonding agent is granulated, and the granulated sintering raw material is sintered in a sintering machine, the method including a measuring process of continuously measuring a component concentration in at least one of the iron-containing raw material, the sintering raw material, and the granulated sintering raw material, and an adjusting process of adjusting at least one of an amount of the CaO-containing raw material added, an amount of the bonding agent added, an amount of water added, and a moving speed of a pallet carriage of the sintering machine in accordance with the component concentration measured in the measuring process.

(2) The method for manufacturing sintered ore according to item (1), in which the sintering raw material further contains a MgO-containing raw material and in which at least one of the amount of the CaO-containing raw material added, an amount of the MgO-containing raw material added, the amount of the bonding agent added, the amount of the water added, and the moving speed of the pallet carriage of the sintering machine is adjusted in the adjusting process in accordance with the component concentration measured in the measuring process.

(3) A method for manufacturing sintered ore, in which a sintering raw material containing at least an iron-containing raw material, a CaO-containing raw material, and a bonding agent is granulated, and the granulated sintering raw material is sintered in a sintering machine while a gas fuel and oxygen are fed, the method including a measuring process of continuously measuring a component concentration in at least one of the iron-containing raw material, the sintering raw material, and the granulated sintering raw material, and an adjusting process of adjusting at least one of an amount of the CaO-containing raw material added, an amount of the bonding agent added, an amount of water added, a moving speed of a pallet carriage of the sintering machine, an amount of the gas fuel fed, and an amount of the oxygen fed in accordance with the component concentration measured in the measuring process.

(4) The method for manufacturing sintered ore according to item (3), in which the sintering raw material further contains a MgO-containing raw material and in which at least one of the amount of the CaO-containing raw material added, an amount of the MgO-containing raw material added, the amount of the bonding agent added, the amount of the water added, the moving speed of the pallet carriage of the

sintering machine, the amount of the gas fuel fed, and the amount of the oxygen fed is adjusted in the adjusting process in accordance with the component concentration measured in the measuring process. (5) The method for manufacturing sintered ore according to any one of items (1) to (4), in which a concentration of at least one of total-CaO, SiO₂, MgO, Al₂O₃, FeO, C, and water is measured in the measuring process.

Advantageous Effects of Invention

[0015] By implementing the method for manufacturing sintered ore according to the present invention, it is possible to manufacture product sintered ore in which there is only a small variation in component concentrations and in which a deterioration in quality is inhibited by using a sintering raw material containing iron ore and dust generated in a steel plant in which there is a large variation in component concentrations.

Brief Description of Drawings

[0016]

Fig. 1 is a schematic diagram illustrating an example of sintered ore manufacturing equipment 10 with which the method for manufacturing sintered ore according to the present embodiment is implemented. Fig. 2 includes graphs illustrating the variations of the basicity of a sintering raw material and the drop strength of product sintered ore 72 in the case of example 1 of the present invention.

Fig. 3 includes graphs illustrating the variations of the basicity of a sintering raw material and the drop strength of product sintered ore 72 in the case of comparative example 1.

Fig. 4 includes graphs illustrating the variations of the production rate of the sintering machine, the carbon concentration in a sintering raw material, and the moving speed of a pallet carriage in the case of example 2 of the present invention.

Fig. 5 includes graphs illustrating the variations of the production rate of the sintering machine, the carbon concentration in a sintering raw material, and the moving speed of a pallet carriage in the case of comparative example 2.

Description of Embodiments

[0017] Hereafter, the present invention will be described in accordance with the embodiment of the present invention. Fig. 1 is a schematic diagram illustrating an example of sintered ore manufacturing equipment 10 with which the method for manufacturing sintered ore according to the present embodiment is implemented. An iron-containing raw material 12 which is stored in a yard 11 is transported to a blending tank 22 via a trans-

porting conveyer 14. The iron-containing raw material 12 contains various brands of iron ore and dust generated in a steel plant.

[0018] A raw material feeding apparatus 20 has plural blending tanks 22, 24, 25, 26, and 28. The blending tank 22 contains the iron-containing raw material 12. The blending tank 24 contains a CaO-containing raw material 16 including limestone, quicklime, and so forth. The blending tank 25 contains a MgO-containing raw material 17 including dolomite, nickel refining slag, and so forth. The blending tank 26 contains a bonding agent 18 including coke breeze, which is prepared by crushing in a rod mill so that the particle diameter is 1 mm or less, and anthracite. The blending tank 28 contains return ore having a particle diameter of 5 mm or less, which is the portion of sintered ore passing through sieves for sintered ore (powder under the sieves for sintered ore). Predetermined amounts of the raw materials are discharged from each of the blending tanks 22 through 28 of the raw material feeding apparatus 20, and a mixture of the discharged raw materials is used as a sintering raw material. The sintering raw material is transported to a drum mixer 36 via a transporting conveyer 30. Since the MgO-containing raw material 17 is an optional blending material, it may be contained or not in the sintering raw material.

[0019] In a transporting conveyer 30 placed between the blending tank 28 and the drum mixer 36, an infrared analyzer 32 is installed. By using the infrared analyzer 32, a measuring process is performed. In the measuring process, the concentration of at least one of total-CaO, SiO₂, MgO, Al₂O₃, FeO, C, and water which are contained in the sintering raw material is measured. Here, the term "water" refers to a combination of adhered water, which adheres to the sintering raw material, and inherent water, which is held within the raw materials at constant temperature and removed from the raw materials by heating.

[0020] The infrared analyzer 32 radiates infrared light having a wavelength of 0.5 μm to 50.0 μm onto the sintering raw material and receives reflected light from the sintering raw material. Since total-CaO, SiO₂, MgO, Al₂O₃, FeO, and water which are contained in the sintering raw material each have respective molecular vibrations and each absorb respective specific-wavelength components of the radiated infrared light, these components each impart respective specific-wavelength components to the reflected infrared light. Also, the crystal structure of a single-atom molecule, such as carbon (C), starts to vibrate at the time of radiating the infrared light and thereby imparts the specific-wavelength component to the reflected infrared light. Therefore, it is possible to determine the concentrations of total-CaO, SiO₂, MgO, Al₂O₃, FeO, C, and water in the sintering raw material by analyzing the radiated infrared light and the reflected infrared light. The term "total-CaO" refers to the total amount of Ca in terms of CaO in all the compounds including Ca and O, such as CaO, CaCO₃, Ca(OH)₂, and Fe₂CaO₄.

[0021] For example, the infrared analyzer 32 radiates infrared light having 20 or more wavelengths and receives reflected light reflected from the sintering raw material at a frequency of 128 times per minute. Since it is possible to radiate infrared light in such a short time by using the infrared analyzer 32, it is possible to continuously measure the component concentrations in the sintering raw material, which is transported on the transporting conveyer 30, online by using the infrared analyzer 32. Since the infrared analyzer 32 is an example of an analyzing device which is used to measure the component concentrations in the sintering raw material, a laser analyzer which radiates laser beams onto an object to be measured, a neutron analyzer which radiates neutrons onto an object to be measured, or a microwave analyzer which radiates microwaves onto an object to be measured may be used instead of the infrared analyzer 32.

[0022] The sintering raw material, which has been transported to the drum mixer 36, is charged into the drum mixer 36 with an appropriate amount of water 34 being added and granulated to form quasi-particles having an average particle diameter of, for example, 3.0 mm to 6.0 mm. The granulated sintering raw material is transported via a transporting conveyer 38 to a sintering raw material feeder of a sintering machine 40. Since the drum mixer 36 is an example of a granulating apparatus which is used to granulate the sintering raw material, plural drum mixers 36 may be used, and a pelletizer may be used as a granulating apparatus instead of the drum mixer 36. Both the drum mixer 36 and the pelletizer may be used, and a high-speed stirring apparatus may be placed upstream of the drum mixer 36 to stir the sintering raw material. In the present embodiment, the term "average particle diameter" refers to an arithmetic average particle diameter defined by the formula $\sum(V_i \times d_i)$, where V_i denotes the abundance ratio of particles having a particle diameter within the i -th range defined in terms of particle diameter and d_i denotes the representative particle diameter of the i -th range).

[0023] An adjusting process is performed in such a manner that at least one of the amount of the CaO-containing raw material 16 added, the amount of the bonding agent 18 added, and the amount of water 34 added in the drum mixer 36 is adjusted in accordance with the component concentrations in the sintering raw material measured in the measuring process so that a predetermined target value is achieved. The meaning of the term "predetermined target value" includes, for example, the basicity (CaO/SiO_2) of the sintering raw material, the carbon concentration in the sintering raw material, the MgO concentration in the sintering raw material, the water concentration in the sintering raw material, the Al_2O_3 concentration in the sintering raw material, and the heat quantity when sintering is performed, and such target values are determined in advance on the basis of, for example, values recorded in past operations for manufacturing sintered ore. In the case where the MgO-con-

taining raw material 17 is added, the amount of the MgO-containing raw material 17 added may be adjusted in the adjusting process in accordance with the component concentrations in the sintering raw material measured in the measuring process.

[0024] In the present embodiment, since the frequency of measurement of the component concentrations utilizing the infrared analyzer 32 is 128 times per minute, the average component concentrations for the 128 times is calculated every one minute, and the amounts of the blast furnace feed materials added are adjusted in accordance with the calculated average component concentrations every one minute.

[0025] Even in the case where there is a variation in the concentrations of gangue components in iron ore, by performing this adjusting process, that is, for example, by adjusting the amount of the CaO-containing raw material 16 added through feedback control in accordance with the component concentrations in the sintering raw material measured in the measuring process so that the predetermined target value of the basicity (CaO/SiO_2) of the sintering raw material is achieved, there is a decreased variation in the basicity (CaO/SiO_2) of the sintering raw material.

[0026] Even in the case where there is a variation in the carbon concentration in dust generated in a steel plant, by adjusting the amount of the bonding agent 18 added through feedback control in accordance with the carbon concentration in the sintering raw material measured in the measuring process so that the predetermined target value of the carbon concentration in the sintering raw material is achieved, there is a decreased variation in the carbon concentration in the sintering raw material.

[0027] Even in the case where there is a variation in the water concentration in iron ore and dust generated in a steel plant, it is possible to perform feedforward control in which the amount of water 34 added in the drum mixer 36 is determined in accordance with the water concentration in the sintering raw material measured in the measuring process and a predetermined target water concentration. Then, by adjusting the amount of water 34 added in the drum mixer 36 through such feedforward control, it is possible to achieve the target water concentration in the sintering raw material.

[0028] The sintering machine 40 is, for example, a downward suction-type Dwight-Lloyd sintering machine. The sintering machine 40 has a sintering raw material feeding device 42, an endless mobile pallet carriage 44, an ignition furnace 46, gas fuel feeding devices 47, and wind boxes 48. The sintering raw material is charged into the pallet carriage 44 through the sintering raw material feeding device 42 to form a burden layer of the sintering raw material. The burden layer is ignited by using the ignition furnace 46. By suctioning air downwardly through the wind boxes 48, a gas fuel and oxygen fed through the gas fuel feeding device 47 disposed above the burden layer is taken into the burden layer to burn the gas fuel and the bonding agent 18 in the burden layer while a

combustion-melting zone in the burden layer moves toward the lower portion of the burden layer. With this, the burden layer is sintered to form a sintered cake. In the present embodiment, the gas fuel is a combustible gas selected from among blast furnace gas, coke oven gas, a mixture of blast furnace gas and coke oven gas, converter gas, city gas, natural gas, methane gas, ethane gas, propane gas, and shale gas, and a mixture thereof.

[0029] Adjustment may be performed in accordance with the component concentrations of the sintering raw material measured in the measuring process on at least one of a moving speed of a pallet carriage 44 in the sintering machine 40, the amount of the gas fuel fed in the sintering machine, and the amount of the oxygen fed in the sintering machine.

[0030] The sintered cake is crushed by using a crushing machine 50 to form sintered ore. The sintered ore, which has been crushed by using the crushing machine 50, is cooled by using a cooling machine 60. The sintered ore, which has been cooled by using the cooling machine 60, is subjected to screening utilizing a sieving apparatus 70 having plural sieves to separate the sintered ore into product sintered ore 72 having a particle diameter of more than 5 mm and return ore 74 having a particle diameter of 5 mm or less. The product sintered ore 72 is transported to a blast furnace 80 via a transporting conveyer 76 and charged into the blast furnace as a blast furnace feed material. On the other hand, the return ore 74 is transported to the blending tank 28 in the raw material feeding apparatus 20 via a transporting conveyer 78. Since the product sintered ore 72 is sintered ore which has been subjected to crushing by using the crushing machine 50 followed by cooling and screening, the product sintered ore 72 and the sintered ore which has been crushed by using the crushing machine 50 have the same component concentrations. In the present embodiment, the term "particle diameter" of the product sintered ore 72 or the return ore 74 refers to a particle diameter determined by performing screening utilizing a sieve, and, for example, the expression "a particle diameter of more than 5 mm" refers to the particle diameter of particles which remain on a sieve having a sieve mesh of 5 mm, and the expression "a particle diameter of 5 mm or less" refers to the particle diameter of particles which pass through a sieve having a sieve mesh of 5 mm. The value expressing the particle diameter of the product sintered ore 72 or the return ore 74 is definitely used as an example, and the particle diameter of the product sintered ore 72 or the return ore 74 is not limited to this example.

[0031] As described above, in the method for manufacturing sintered ore according to the present embodiment, the adjusting process is performed in such a manner that at least one of the amount of the CaO-containing raw material 16 added, the amount of the bonding agent 18 added, and the amount of water 34 added in the drum mixer 36 is adjusted in accordance with the component concentrations measured by using the infrared analyzer 32 in the measuring process so that a predetermined

target value is achieved. With this, since there is a decreased variation in the component concentrations in the sintering raw material, there is a decreased variation in the component concentrations in the product sintered ore 72 manufactured by using such a sintering raw material, which results in the quality of the product sintered ore 72 being inhibited from deteriorating.

[0032] For example, in the adjusting process, the amount of the CaO-containing raw material 16 added may be adjusted in accordance with the concentrations of CaO and SiO₂ measured in the measuring process so that the predetermined target value of the basicity (CaO/SiO₂) of the sintering raw material is achieved. With this, even in the case where iron ore in which there is a significant variation in the concentrations of gangue components is used, since there is a decreased variation in the basicity (CaO/SiO₂) of the sintering raw material, there is a decreased variation in the basicity of the product sintered ore 72 manufactured by using such a sintering raw material, which makes it possible to manufacture product sintered ore 72 having stable strength. By using the product sintered ore 72 in which there is a decreased variation in basicity as a blast furnace feed material, it is possible to make a contribution to the stable operation of the blast furnace.

[0033] In the case where there is a significant variation in the carbon concentration in the sintering raw material, there is a significant variation in the heat quantity when sintering is performed, which results in a significant variation in the FeO concentration in the product sintered ore 72. In the case where there is a significant variation in the FeO concentration as described above, at least one of the amount of the bonding agent 18 added, the amount of the gas fuel fed in the sintering machine, and the amount of oxygen fed in the sintering machine may be adjusted in the adjusting process so that the predetermined target value of the heat quantity is achieved when sintering is performed. With this, since there is a decreased variation in heat quantity when sintering is performed, there is a decreased variation in the FeO concentration in the product sintered ore 72.

[0034] In the method for manufacturing sintered ore according to the present embodiment, the amount of water 34 added in the drum mixer 36 may be adjusted. By adjusting the amount of water 34 added so that the predetermined target value of the water concentration is achieved, since there is a decreased variation in the water concentration in the sintering raw material, there is a further decreased variation in heat quantity when sintering is performed. With this, there is a further decreased variation in the FeO concentration in the product sintered ore 72.

[0035] In the case where there is an increase in the FeO concentration due to a variation in the FeO concentration in the product sintered ore 72, there is a deterioration in the reducibility of the blast furnace feed materials. In the case where there is a deterioration in the reducibility of the blast furnace feed materials, since there

is a decrease in the likelihood of an indirect reduction reaction, which is an exothermic reaction, and since there is an increase in the likelihood of direct reduction reaction, which is an endothermic reaction, there is a deficiency of heat quantity in the blast furnace. To compensate for such a deficiency of heat quantity, there is an increase in the amount of a reducing agent charged into the blast furnace, which results in an increase in coke ratio in the operation of the blast furnace. Therefore, by controlling the FeO concentration in the product sintered ore 72 to be equal to a predetermined target value, it is possible to inhibit the coke ratio in the operation of a blast furnace from increasing.

[0036] In the case where there is an increase in the temperature of a sintered cake due to an increase in the heat quantity when sintering is performed, an excessive load is placed on the cooling machine 60. Therefore, in the case where an increase in the carbon concentration in the sintering raw material is recognized in the measuring process, the moving speed of the pallet carriage 44 in the sintering machine may be decreased when such a sintering raw material is sintered in the sintering machine 40. With this, it is possible to decrease a load placed on the cooling machine 60. In the measuring process according to the present embodiment, since the component concentrations in the sintering raw material is continuously measured online, it is possible to recognize a sudden increase in the carbon concentration. By decreasing the moving speed of the pallet carriage 44 in the sintering machine in accordance with such an increase in the carbon concentration, it is possible to prevent the equipment from being damaged due to an increase in the temperature of the sintered cake.

[0037] In the case where the MgO-containing raw material 17 is added in the sintering raw material, the amount of MgO-containing raw material 17 added may be adjusted in accordance with the MgO concentration measured by using the infrared analyzer 32 in the measuring process so that a predetermined target value of the MgO concentration is achieved. With this, there is a decreased variation in the concentration of MgO in the product sintered ore 72. MgO in the product sintered ore 72 is effective for improving softening and melting property by increasing the melting point. Therefore, by decreasing a variation in the MgO concentration in the product sintered ore 72, since it is possible to realize the effect of improving softening and melting property, it is possible to make a contribution to the stable operation of the blast furnace.

[0038] Although an example, in which sintered ore is manufactured by using the sintering machine 40 having the gas fuel feeding device 47, is described in the present embodiment, sintered ore manufacturing equipment having a sintering machine not having the gas fuel feeding device 47 may be used instead of the sintered ore manufacturing equipment 10 having the sintering machine 40 having the gas fuel feeding device 47. In the case where a sintering machine not having the gas fuel feeding device 47 is used, at least one of the amount of the CaO-

containing raw material 16 added, the amount of the bonding agent 18 added, the amount of water 34 added, and the moving speed of the pallet carriage 44 in the sintering machine is adjusted in accordance with the component concentrations measured in the measuring process. That is, in the present embodiment, it is sufficient that the gas fuel and oxygen be added as needed in the sintering machine 40 and that the amount of the gas fuel fed and/or the amount of oxygen fed be adjusted as needed in the adjusting process.

[0039] Although an example, in which the infrared analyzer 32 is installed in the transporting conveyer 30 placed between the blending tank 28 and the drum mixer 36 to measure the component concentrations in the sintering raw material, is described in the present embodiment, the embodiment of the present invention is not limited to this example. The infrared analyzer 32 may be installed in the transporting conveyer 14 to measure the concentration of at least one of total-CaO, SiO₂, MgO, Al₂O₃, FeO, C, and water contained in the iron-containing raw material 12, which is transported to the blending tank 22, and the infrared analyzer 32 may be installed in the transporting conveyer 30 between the blending tank 22 and the blending tank 24 to measure the concentration of at least one of total-CaO, SiO₂, MgO, Al₂O₃, FeO, C, and water contained in the iron-containing raw material 12, which has been transported from the blending tank 22. A factor having a large effect on a variation in the component concentrations in the sintering raw material is a variation in the component concentrations in various brands of iron ore and the dust generated in a steel plant contained in the iron-containing raw material 12 stored in the yard 11. Therefore, by installing the infrared analyzer 32 in the transporting conveyer 14 to measure the component concentrations in the iron-containing raw material 12, since it is possible to perform feedforward control in which at least one of the amount of the CaO-containing raw material 16 added, the amount of the bonding agent 18 added, and the amount of water 34 added is determined in accordance with such measured values and target component concentrations in the sintering raw material, it is possible to decrease a variation in the component concentrations in the sintering raw material. Also, by installing the infrared analyzer 32 in the transporting conveyer 14 to measure the component concentrations in the iron-containing raw material 12, and by adjusting the moving speed of the pallet carriage 44 in the sintering machine, the amounts of the gas fuel and/or oxygen fed in the sintering machine in accordance with such measured values, it is possible to decrease negative effects due to a variation in the heat quantity when sintering is performed.

[0040] The infrared analyzer 32 may be installed in the transporting conveyer 38 to measure the concentration of at least one of total-CaO, SiO₂, MgO, Al₂O₃, FeO, C, and water contained in the granulated sintering raw material which is transported to the sintering machine 40. Since the various raw materials contained in the granu-

lated sintering raw material are homogeneously mixed in the drum mixer 36 so that there is no segregation, it is possible to measure the component concentrations in the sintering raw material with high accuracy. In addition, by adjusting at least one of the amount of the CaO-containing raw material 16 added, the amount of the bonding agent 18 added, and the amount of water 34 added through feedback control in accordance with the component concentrations, it is possible to decrease a variation in the component concentrations in the sintering raw material. Moreover, the moving speed of the pallet carriage 44 in the sintering machine, the amount of the gas fuel and/or oxygen added may be adjusted in accordance with such measured values, which makes it possible to decrease negative effects due to a variation in the heat quantity when sintering is performed.

[0041] Although an example, in which raw materials are discharged from each of the blending tanks 22 through 28 in the raw material feeding apparatus 20, made into the sintering raw material in the transporting conveyer 30, and granulated in the drum mixer 36, is described in the present embodiment, the embodiment of the present invention is not limited to this example. For example, carbonaceous material-coated particles, which are manufactured by charging a sintering raw material containing the iron-containing raw material 12, the CaO-containing raw material 16, and the return ore 74 to the drum mixer 36, by adding water to the sintering raw material to granulate the sintering raw material, and by charging the bonding agent 18 in the posterior part of the sintering time to coat the granulated particles with the bonding agent 18, may be used as a granulated sintering raw material. In this case, the component concentration in at least one of the iron-containing raw material 12 and the sintering raw material described above is measured by using the infrared analyzer 32, and at least one of the amount of the CaO-containing raw material 16 added, the amount of the bonding agent 18 added, the amount of the water 34 added, the moving speed of the pallet carriage 44 in the sintering machine, the amount of the gas fuel fed, and the amount of oxygen fed is adjusted in accordance with such measured values.

[0042] Carbonaceous material-coated particles, which are manufactured by charging a sintering raw material containing the iron-containing raw material 12, the CaO-containing raw material 16, the return ore 74, and part of the bonding agent 18 to the drum mixer 36, by adding water to the sintering raw material to granulate the sintering raw material, and by charging the remaining bonding agent 18 in the posterior part of the sintering time to coat the granulated sintering raw material with the bonding agent 18, may be used as a granulated sintering raw material. Examples of the bonding agent which is added in the posterior part of the sintering time after water is added to the sintering raw material include coke breeze and anthracite.

[0043] In the case where plural drum mixers 36 are used and the carbonaceous material-coated particles

which are coated with the bonding agent 18 are used, the carbonaceous material-coated particles, which are coated with the bonding agent 18, may be manufactured by charging all or part of the bonding agent 18 into the posterior part of the last drum mixer 36 and by charging the sintering raw material into the drum mixers 36 by using the method described above. Moreover, regarding water which is added to the sintering raw material in the case where plural drum mixers 36 are used, all of the water may be added in the first drum mixer 36, or part of the water may be added in the first drum mixer 36 with the remaining water being added in the other drum mixers 36.

[0044] Although an example, in which raw materials are discharged from each of the blending tanks 22 through 28 in the raw material feeding apparatus 20, made into the sintering raw material in the transporting conveyer 30, and granulated in the drum mixer 36, is described in the present embodiment, the embodiment of the present invention is not limited to this example. For example, granulated particles, which are manufactured by charging a sintering raw material containing the iron-containing raw material 12 and the return ore 74 to the drum mixer 36, by adding water to the sintering raw material to granulate the sintering raw material, and by charging the CaO-containing raw material 16 or the CaO-containing raw material 16 and the bonding agent 18 in the posterior part of the sintering time to coat the granulated particles with the CaO-containing raw material 16 or the CaO-containing raw material 16 and the bonding agent 18, may be used as a granulated sintering raw material. In this case, the component concentration in at least one of the iron-containing raw material 12 and the sintering raw material described above is measured by using the infrared analyzer 32, and at least one of the amount of the CaO-containing raw material 16 added, the amount of the bonding agent 18 added, the amount of the water 34 added, the moving speed of the pallet carriage 44 in the sintering machine, the amount of the gas fuel fed in the sintering machine, and the amount of oxygen fed in the sintering machine is adjusted in accordance with such measured values.

[0045] Granulated particles, which are manufactured by charging a sintering raw material containing the iron-containing raw material 12, the return ore 74, and part of the CaO-containing raw material 16 or part of the CaO-containing raw material 16 and part of the bonding agent 18 to the drum mixer 36, by adding water to the sintering raw material to granulate the sintering raw material, and by adding the remaining CaO-containing raw material 16 and the remaining bonding agent 18 in the posterior part of the sintering time to coat the granulated sintering raw material with the CaO-containing raw material 16 and the bonding agent 18, may be used as a granulated sintering raw material.

[0046] In the case where plural drum mixers 36 are used and the granulated particles which are coated with the CaO-containing raw material 16 or the CaO-contain-

ing raw material 16 and the bonding agent 18 are used, the granulated particles, which are coated with the CaO-containing raw material 16 and the bonding agent 18, may be manufactured by charging all or part of the CaO-containing raw material 16 and the bonding agent 18 into the posterior part of the last drum mixer 36 and by charging the sintering raw material into the drum mixers 36 by using the method described above.

[0047] Although an example, in which raw materials are discharged from each of the blending tanks 22 through 28 in the raw material feeding apparatus 20 and made into the sintering raw material in the transporting conveyer 30, is described in the present embodiment, the embodiment of the present invention is not limited to this example. For example, parts of the respective raw materials discharged from each of the blending tanks 22 through 28 in the raw material feeding apparatus 20 are directly transported to the drum mixer 36 via the transporting conveyer 30, and the remaining parts of the respective raw materials are transported to a high-speed stirring apparatus via a transporting conveyer, which is different from the transporting conveyer 30, so as to be subjected to a stirring treatment. Subsequently, such remaining parts may be charged into the transporting conveyer 30 or the transporting conveyer 38 after having been subjected to granulation utilizing a granulating machine, such as a drum mixer or a pelletizer, optionally followed by drying utilizing a drying machine as needed. Also, such remaining parts may be directly charged into the transporting conveyer 30 after having been subjected to a stirring treatment without being subjected to granulation utilizing the granulating machine, such as a drum mixer or a pelletizer. Moreover, a crushing process and/or a sieving process may be performed before a stirring treatment is performed by using the high-speed stirring apparatus. In the case where plural drum mixers 36 are used, such remaining parts may be charged into any one of transporting conveyers placed between the drum mixers.

[0048] Although an example, in which the infrared analyzer 32 in the measuring process is installed in the transporting conveyer 30 placed between the blending tank 28 and the drum mixer 36, is described in the present embodiment, the embodiment of the present invention is not limited to this example. For example, the infrared analyzer 32 may be installed in the transporting conveyer 14 placed between the yard 11 and the blending tank 22, which is closest to the entrance among the blending tanks, in the transporting conveyer 30 placed between the blending tank 22 and the blending tank 24, or in the transporting conveyer 38 placed between the drum mixer 36 and the sintering machine 40. However, in the case where the granulated particles coated with the bonding agent 18 or the CaO-containing raw material 16 and the bonding agent 18 are used, since the components in the surface layer may have an effect on the measurement of the component concentrations, it is preferable that the infrared analyzer 32 be installed in the transporting con-

veyer 14, in the transporting conveyer 30 placed between the blending tank 22 and the blending tank 24, or in the transporting conveyer 30 placed between the blending tank 28 and the drum mixer 36.

[0049] In the measuring process, not only one but plural infrared analyzers 32 may be installed. Two or more infrared analyzers 32 may be installed in the transporting conveyer 14, in the transporting conveyer 30 placed between the blending tank 22 and the blending tank 24, in the transporting conveyer 30 placed between the blending tank 28 and the drum mixer 36, and in the transporting conveyer 38. The component concentrations in two or all of the sintering raw material, the iron-containing raw material 12, and granulated sintering raw material may be measured by using plural infrared analyzers, and at least one of the amount of CaO-containing raw material 16 added, the amount of the bonding agent 18 added, the amount of the water 34 added, the moving speed of the pallet carriage 44 in the sintering machine, the amount of the gas fuel fed in the sintering machine, and the amount of oxygen fed in the sintering machine may be adjusted in accordance with such measured values.

EXAMPLES

(Example 1)

[0050] In the case of both of example 1 of the present invention and comparative example 1, product sintered ore was manufactured by using the sintered ore manufacturing equipment 10 illustrated in Fig. 1. In the case of example 1 of the present invention, the product sintered ore was manufactured for 36 hours while the component concentrations in the sintering raw material were continuously measured by using the infrared analyzer 32 installed in the transporting conveyer 30 and the amount of the CaO-containing raw material 16 added was adjusted in accordance with the measured component concentrations so that the target value of the basicity (CaO/SiO_2) of the sintering raw material was achieved. On the other hand, in the case of comparative example 1, the product sintered ore was manufactured for 36 hours while the component concentrations in the sintering raw material were not continuously measured but measured offline every 2 hours, and the amount of the CaO-containing raw material 16 added was adjusted in accordance with the measured component concentrations so that the target value of the basicity (CaO/SiO_2) of the sintering raw material was achieved.

[0051] Fig. 2 includes graphs illustrating the variations of the basicity of a sintering raw material and the drop strength of product sintered ore in the case of example 1 of the present invention. Fig. 3 includes graphs illustrating the variations of the basicity of a sintering raw material and the drop strength of product sintered ore in the case of comparative example 1. The term "basicity" in Fig. 2(a) and Fig. 3(a) refers to the total-CaO concentration divided by the SiO_2 concentration in the sintering

raw material. The term "drop strength" in Fig. 2(b) and Fig. 3(b) refers to the strength measured by using the testing method for drop strength prescribed in JIS M 8711.

[0052] As indicated in Fig. 2(a) and Fig. 2(b), in the case of example 1 of the present invention, there was a decreased deviation from the target basicity of the sintering raw material, and there was a decreased variation in the drop strength of the product sintered ore. In the case of example 1 of the present invention, the component concentrations in the sintering raw material were continuously measured. Therefore, even in the case where there was a sudden variation in the component concentrations, it was possible to promptly detect such a variation in the component concentrations and to promptly adjust the amount of the CaO-containing raw material 16 added so that the target values of the component concentrations were achieved. With this, in the case of example 1 of the present invention, it was possible to decrease the deviation from the target basicity of the sintering raw material and a variation in the basicity and also to decrease a variation in the drop strength of the product sintered ore.

[0053] On the other hand, as indicated in Fig. 3(a) and Fig. 3(b), in the case of comparative example 1, there was a significant deviation from the target basicity of the sintering raw material, there was a significant variation in the drop strength of the product sintered ore, and product sintered ore having low drop strength was manufactured. In the case where there is a decrease in the drop strength of the product sintered ore, since the product sintered ore is easily crushed due to impact when the product sintered ore is transported to or charged into a blast furnace, there is a variation in the particle size of the product sintered ore. It is not preferable that there be a variation in the particle size of the product sintered ore, because this causes a disturbed burden distribution in a blast furnace.

[0054] From these results, it is clarified that, by using the manufacturing method according to example 1 of the present invention, it is possible to manufacture product sintered ore in which there is a decreased variation in the component concentrations and in the drop strength.

(Example 2)

[0055] In the case of both of example 2 of the present invention and comparative example 2, product sintered ore was manufactured by using the sintered ore manufacturing equipment 10 illustrated in Fig. 1. In the case of example 2 of the present invention, the product sintered ore was manufactured for 36 hours while the carbon concentration in the sintering raw material was continuously measured by using the infrared analyzer 32 installed in the transporting conveyer 30 and the amount of the bonding agent 18 added was adjusted in accordance with the measured carbon concentration so that the target value of the carbon concentration in the sintering

raw material was achieved. On the other hand, in the case of comparative example 2, the product sintered ore was manufactured for 36 hours while the carbon concentration in the sintering raw material was not continuously measured but measured offline every 4 hours, and the amount of the bonding agent 18 added was adjusted in accordance with the measured carbon concentration so that the target value of the carbon concentration in the sintering raw material was achieved. The target value of the carbon concentration in the sintering raw material was determined on the basis of the necessary amount of carbon derived by calculating a sintering temperature in accordance with the component concentrations in the sintering raw material so that the liquid phase rate of the sintering raw material when sintering was performed was within a preferable range and by calculating the amount of carbon necessary for generating combustion heat to achieve the calculated sintering temperature. In the case of both of example 2 of the present invention and comparative example 2, the sintering raw material was changed to one having a higher carbon concentration during a specific period of time in the middle of the manufacturing time for the product sintered ore, and, thereafter, the sintering raw material was changed back to the original one to continue to produce the product sintered ore.

[0056] Fig. 4 includes graphs illustrating the variations of the production rate of the sintering machine, the carbon concentration in a sintering raw material, and the moving speed of a pallet carriage in the case of example 2 of the present invention. Fig. 5 includes graphs illustrating the variations of the production rate of the sintering machine, the carbon concentration in a sintering raw material, and the moving speed of a pallet carriage in the case of comparative example 2. Fig. 4(a) and Fig. 5(a) illustrate the variation of the production rate ($t/(h \times m^2)$) of the sintering machine. The expression "the production rate ($t/(h \times m^2)$) of a sintering machine" refers to the mass (t) of a sintered cake produced by a sintering machine per one hour divided by the area (m^2) of a pallet carriage. Fig. 4(b) and Fig. 5(b) illustrate the variation of the carbon concentration (mass%) in the sintering raw material. Fig. 4(c) and Fig. 5(c) illustrate the variation of the moving speed (m/min) of the pallet carriage. In both of Fig. 4 and Fig. 5, the portions defined by the dashed lines indicate a "period of raw material change", during which the sintering raw material having a higher carbon concentration was used.

[0057] In the case of example 2 of the present invention, the carbon concentration in the sintering raw material was continuously measured, and the amount of the bonding agent 18 added was adjusted so that the target value of the carbon concentration was achieved. By continuously measuring the component concentrations in the sintering raw material like this, since it was possible to detect an increase in the carbon concentration in the early stage of the period of raw material change, the amount of the bonding agent 18 added was promptly

adjusted in accordance with the measured concentration so that the target value of the carbon concentration in the sintering raw material was achieved. With this, since an increase in the carbon concentration in the sintering raw material was inhibited as illustrated in Fig. 4(b), it was possible to manufacture sintered ore without decreasing the moving speed of the pallet carriage as illustrated in Fig. 4(c), which resulted in no significant decrease in the production rate of the sintering machine 40 as illustrated in Fig. 4(a).

[0058] On the other hand, in the case of comparative example 2, since the carbon concentration in the sintering raw material was not continuously measured, the detection of an increase in the carbon concentration in the sintering raw material was delayed. Therefore, as illustrated in Fig. 5(b), there was a significant increase in the carbon concentration in the sintering raw material. In the case where there is an excessive increase in the temperature of a sintered cake due to an increase in the carbon concentration, since an excessive load is placed on the cooling machine 60, it is necessary to decrease the moving speed of the pallet carriage to decrease a load placed on the cooling machine 60. Therefore, the moving speed of the pallet carriage was decreased as illustrated in Fig. 5(c), which resulted in a significant decrease in the production rate of the sintering machine 40 as illustrated in Fig. 5(a).

[0059] As described above, by using the manufacturing method according to example 2 of the present invention, even in the case where there is a variation in the carbon concentration in the sintering raw material, since it is possible to promptly detect such a variation in the carbon concentration, it is possible to promptly adjust the amount of the bonding agent 18 added in response to such a variation in the carbon concentration. It is clarified that, with this, since there is a decreased variation in heat quantity when sintered ore is manufactured due to a decreased variation in the carbon concentration in the sintering raw material, an increase in the temperature of product sintered ore is inhibited, which results in a decrease in the production rate of the sintering machine 40 being inhibited.

Reference Signs List

[0060]

10 sintered ore manufacturing equipment
 11 yard
 12 iron-containing raw material
 14 transporting conveyer
 16 CaO-containing raw material
 17 MgO-containing raw material
 18 bonding agent
 20 raw material feeding apparatus
 22 blending tank
 24 blending tank
 25 blending tank

26 blending tank
 28 blending tank
 30 transporting conveyer
 32 infrared analyzer
 5 34 water
 36 drum mixer
 38 transporting conveyer
 40 sintering machine
 42 sintering raw material feeding device
 10 44 pallet carriage
 46 ignition furnace
 47 gas fuel feeding device
 48 wind box
 50 crushing machine
 15 60 cooling machine
 70 sieving apparatus
 72 product sintered ore
 74 return ore
 76 transporting conveyer
 20 78 transporting conveyer
 80 blast furnace

Claims

- 25
1. A method for manufacturing sintered ore, in which a sintering raw material containing at least an iron-containing raw material, a CaO-containing raw material, and a bonding agent is granulated while water is added to the sintering raw material, and the granulated sintering raw material is sintered in a sintering machine, the method comprising
 30 a measuring process of continuously measuring a component concentration in at least one of the iron-containing raw material, the sintering raw material, and the granulated sintering raw material, and
 35 an adjusting process of adjusting at least one of an amount of the CaO-containing raw material added, an amount of the bonding agent added, an amount of the water added, and a moving speed of a pallet carriage of the sintering machine in accordance with the component concentration measured in the measuring process.
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 - 45 2. The method for manufacturing sintered ore according to Claim 1, wherein
 the sintering raw material further contains a MgO-containing raw material, and
 50 at least one of the amount of the CaO-containing raw material added, an amount of the MgO-containing raw material added, the amount of the bonding agent added, the amount of the water added, and the moving speed of the pallet carriage of the sintering machine is adjusted in the adjusting process in accordance with the component concentration measured in the measuring process.
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 3. A method for manufacturing sintered ore, in which a

sintering raw material containing at least an iron-containing raw material, a CaO-containing raw material, and a bonding agent is granulated while water is added to the sintering raw material, and the granulated sintering raw material is sintered in a sintering machine while a gas fuel and oxygen are fed, the method comprising

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a measuring process of continuously measuring a component concentration in at least one of the iron-containing raw material, the sintering raw material, and the granulated sintering raw material, and an adjusting process of adjusting at least one of an amount of the CaO-containing raw material added, an amount of the bonding agent added, an amount of the water added, a moving speed of a pallet carriage of the sintering machine, an amount of the gas fuel fed, and an amount of the oxygen fed in accordance with the component concentration measured in the measuring process.

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- 4. The method for manufacturing sintered ore according to Claim 3, wherein the sintering raw material further contains a MgO-containing raw material, and at least one of the amount of the CaO-containing raw material added, an amount of the MgO-containing raw material added, the amount of the bonding agent added, the amount of the water added, the moving speed of the pallet carriage of the sintering machine, the amount of the gas fuel fed, and the amount of the oxygen fed is adjusted in the adjusting process in accordance with the component concentration measured in the measuring process.

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- 5. The method for manufacturing sintered ore according to any one of Claims 1 to 4, wherein a concentration of at least one of total-CaO, SiO₂, MgO, Al₂O₃, FeO, C, and water is measured in the measuring process.

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FIG. 1

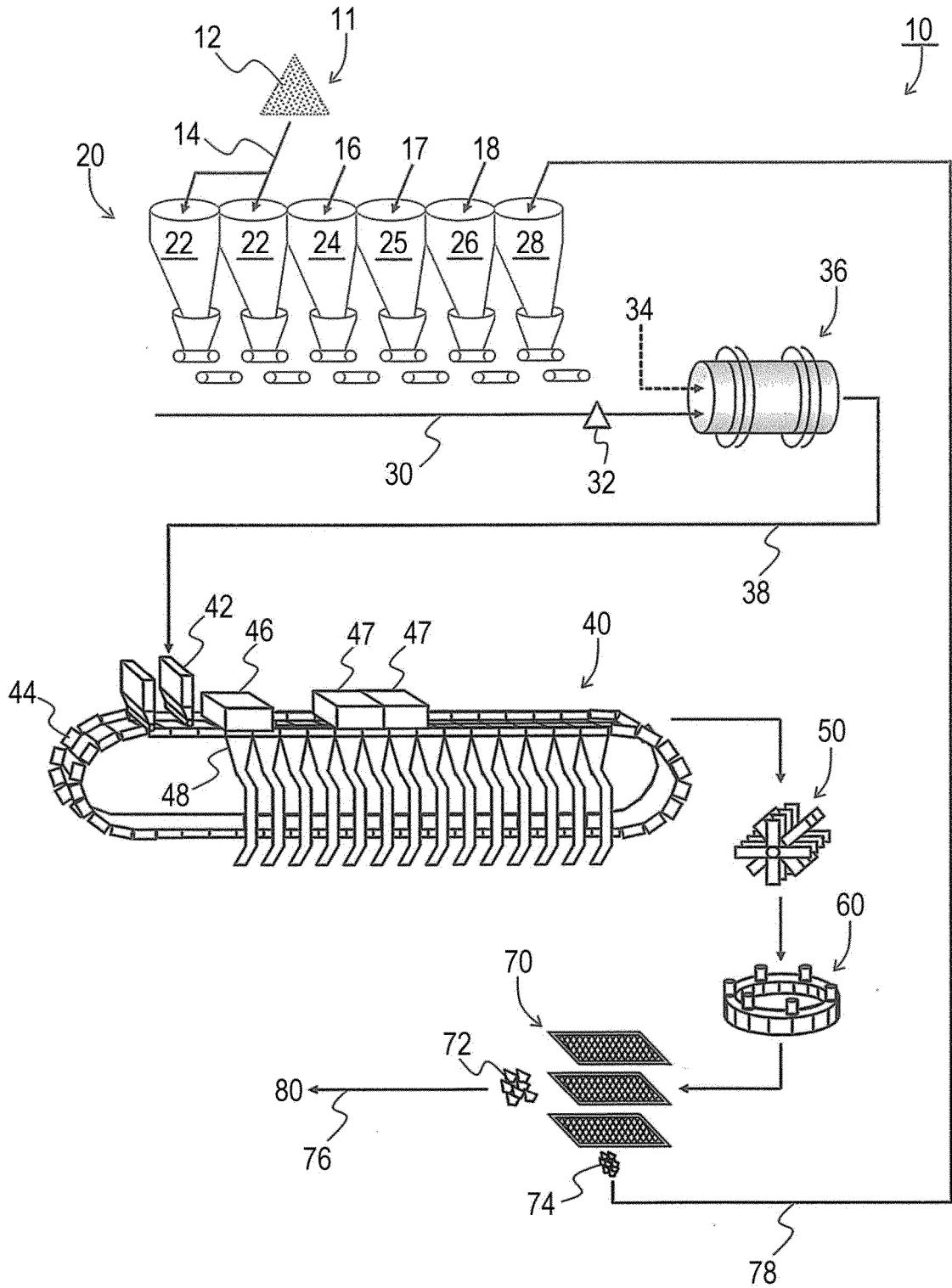


FIG. 2

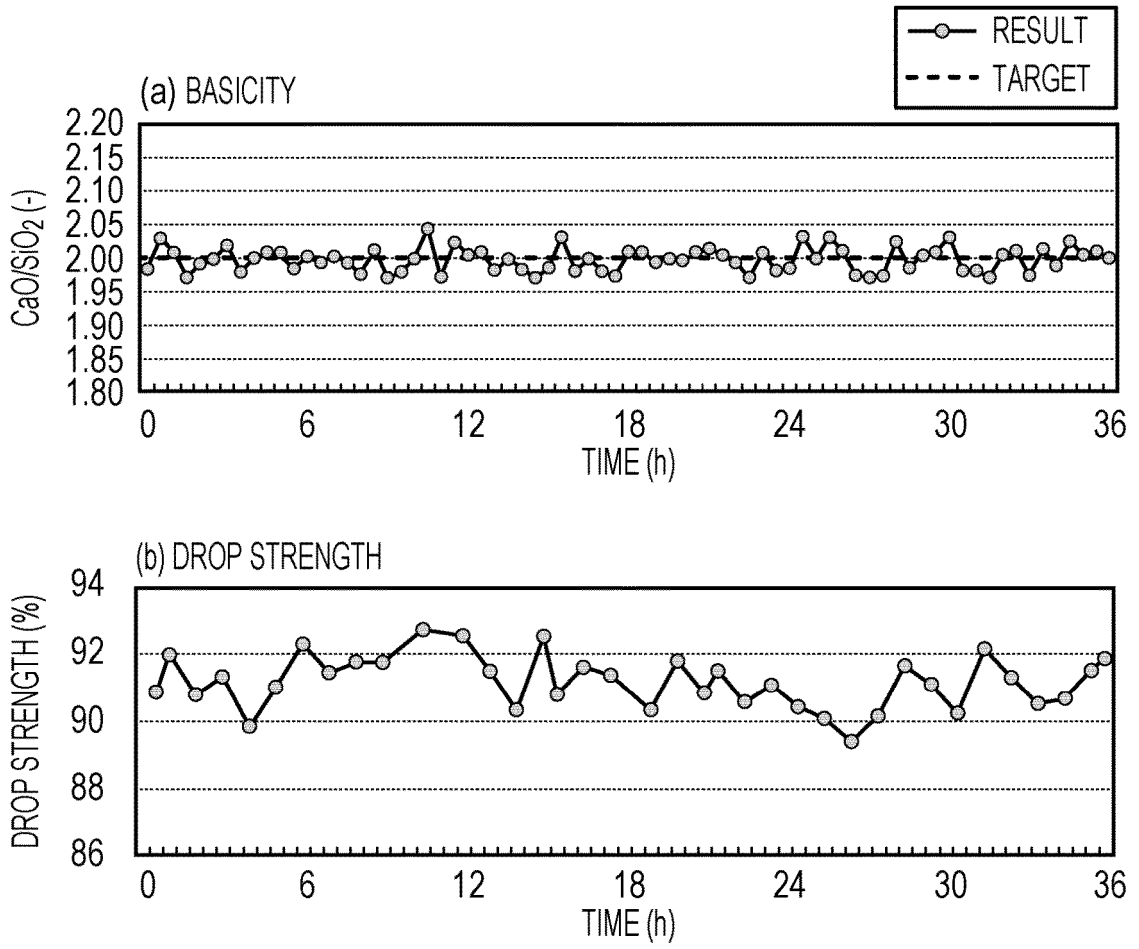


FIG. 3

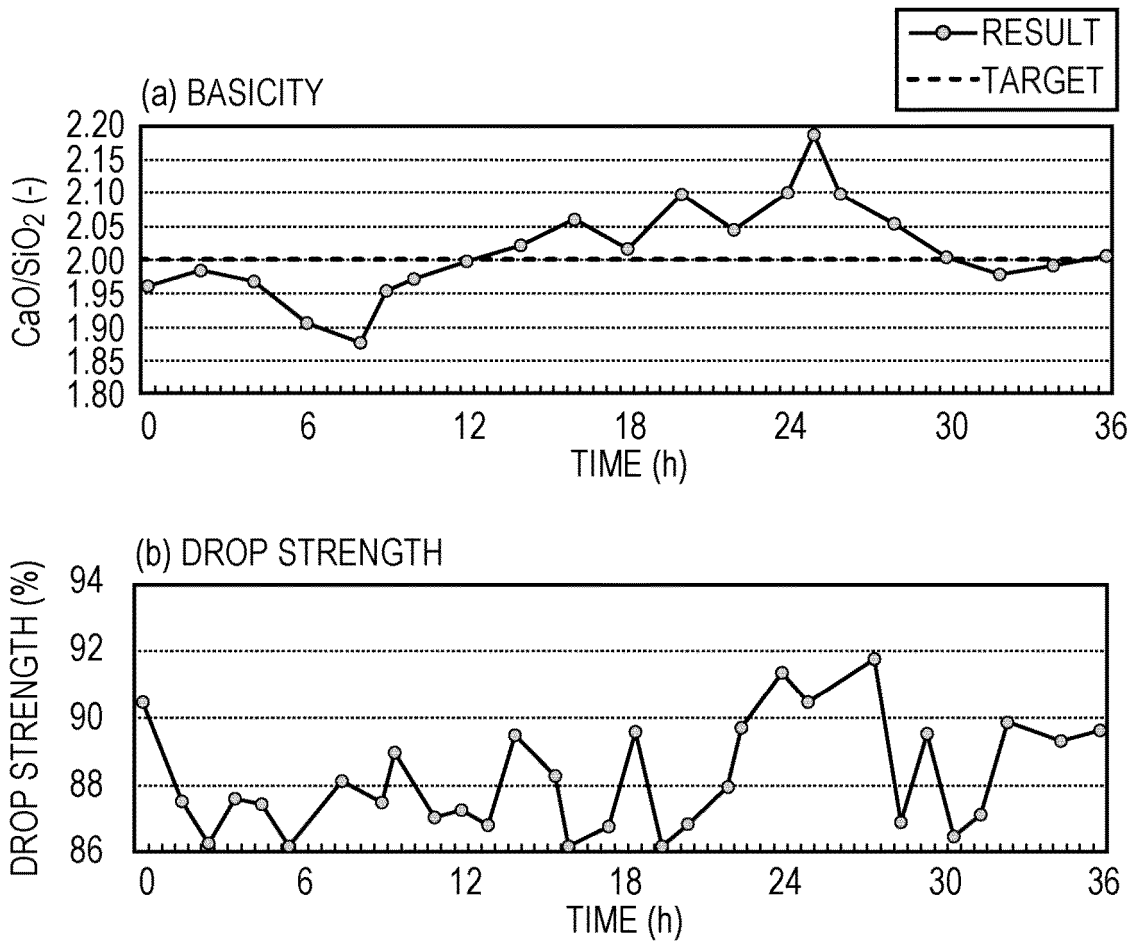


FIG. 4

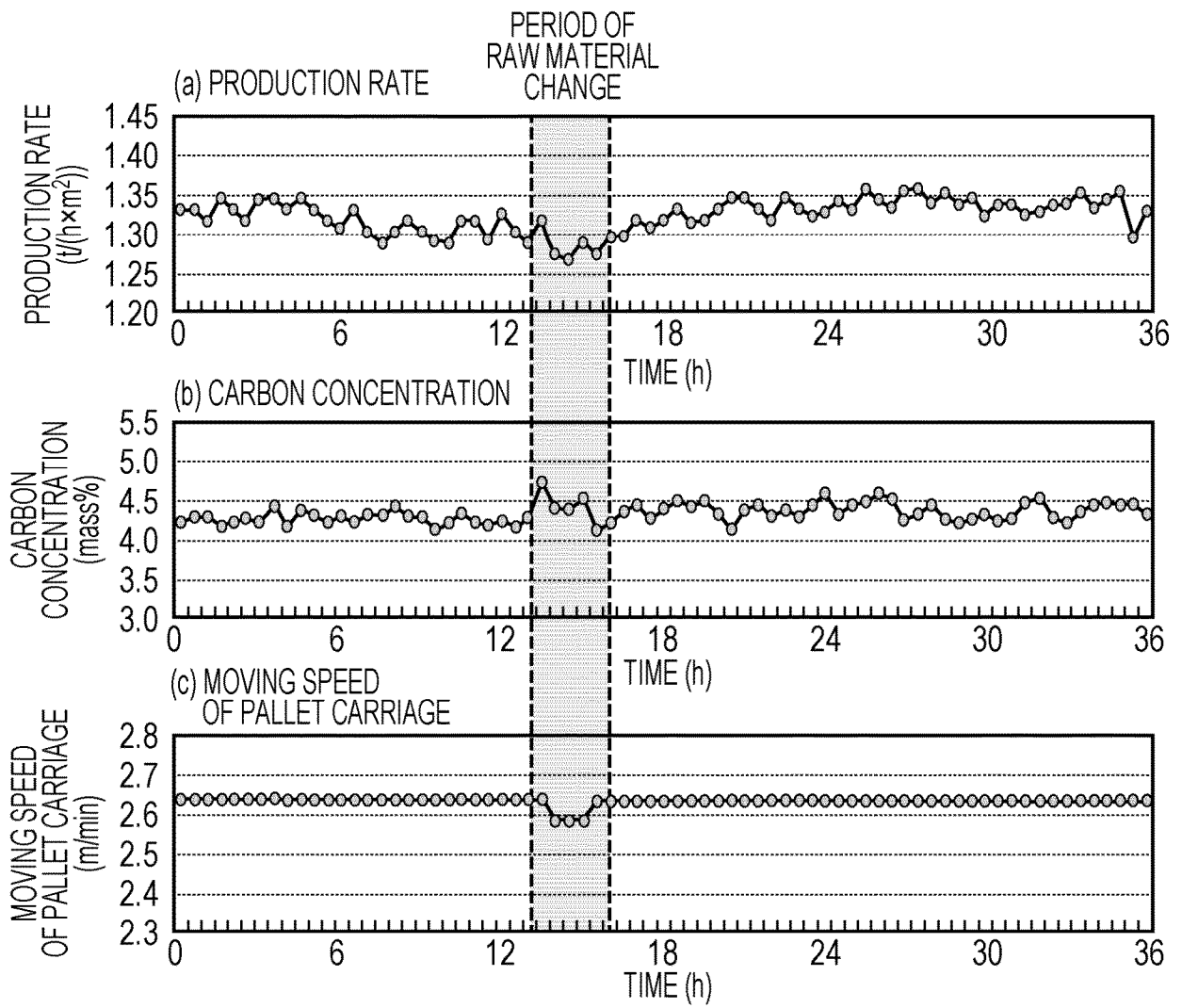
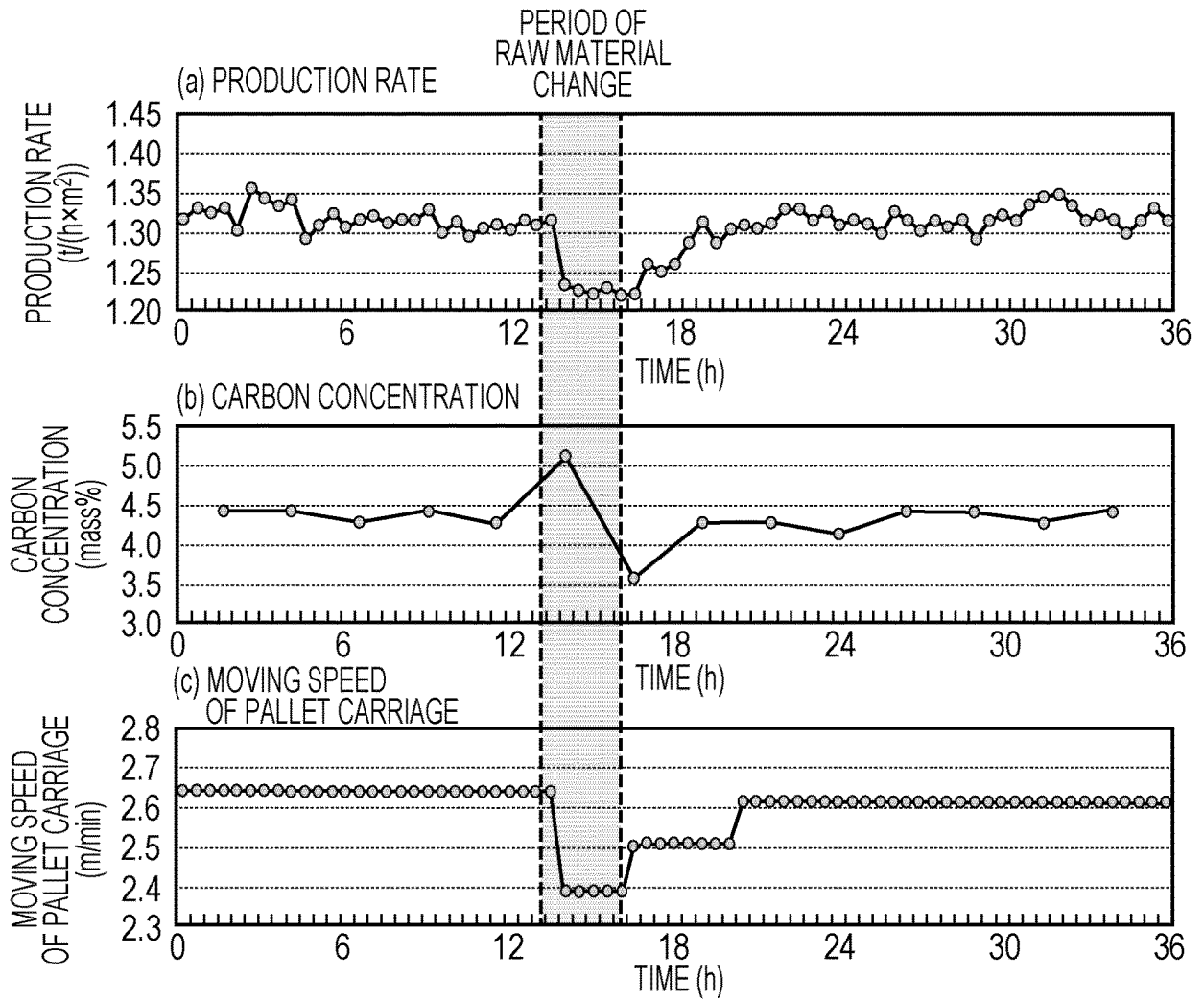


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/004516

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. C22B1/16 (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)

Int. Cl. C22B1/16

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

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

JSTPlus/JST7580/JSTChina (JDreamIII), CiNii

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X <u>Y</u>	JP 2007-138246 A (NIPPON STEEL CORP.) 07 June 2007, claims, paragraphs [0017]-[0098], fig. 1-6, (Family: none)	1-2, 5 <u>1-5</u>
Y	JP 2014-031580 A (JFE STEEL CORP.) 20 February 2014, claims, paragraphs [0002]-[0045], fig. 1, (Family: none)	3-5
Y	JP 10-017946 A (NKK CORP.) 20 January 1998, claims, paragraphs [0008]-[0016], fig. 1, (Family: none)	1-5
A	JP 2011-162814 A (JFE STEEL CORP.) 25 August 2011, entire text, all drawings, (Family: none)	1-5
A	JP 57-149433 A (NISSHIN STEEL CO., LTD.) 16 September 1982, entire text, all drawings, (Family: none)	1-5

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

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"I" 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
27.02.2018Date of mailing of the international search report
06.03.2018Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/004516

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 46-031641 B1 (NIPPON STEEL CORP.) 14 September 1971, entire text, all drawings, (Family: none)	1-5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003049227 A [0009]
- JP 57149433 A [0009]
- JP 2011038735 A [0009]
- JP 60262926 A [0009]