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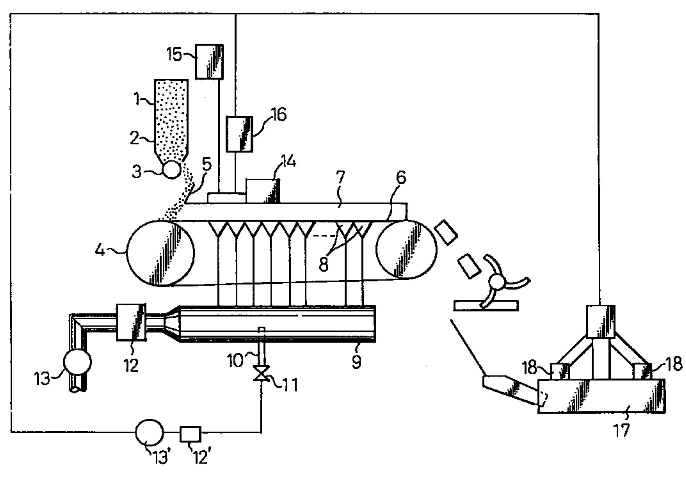
(54) SINTERED STEEL MANUFACTURING PROCESS

(57) According to the present invention, there is provided a microwave generator between the raw material feeding device and the ignition furnace of the Dwight Lloyd type sintering machine. (1) Microwaves alone heat a surface layer of raw material to 120 to 600°C. (2) After the microwaves have heated the surface layer of raw material to 50 to 200°C, a hot blast is sucked and the surface layer of raw material is heated to 150 to 600°C. (3) Microwaves and the hot blast are simultaneously utilized so as to heat the upper layer of raw material to 150 to 600°C. After the heating described in items (1), (2) and (3), the raw material is sintered. Due to the foregoing, the raw material is quickly dried, heated and sintered at high temperatures in a short period of time without the collapse of pseudo particles on the surface layer of raw material to be sintered, and sintered ore of high quality can be obtained.

Fig.1



EP 0 767 242 A1

Description

TECHNICAL FIELD

The present invention relates to a method of producing sintered ore to be used as raw material of iron-making in which sintered ore of high quality can be provided when iron ore is quickly dried and heated to high temperatures in a short period of time by a Dwight Lloyd type sintering machine.

BACKGROUND OF THE INVENTION

In the iron and steel industry, Dwight Lloyd type sintering machines have come into wide use. In this type sintering machine, a surface layer of blended raw material is ignited in an ignition furnace, and the generated combustion gas is sucked downward, so that the combustion zone is gradually moved from an upper layer to an intermediate and to a lower layer. In this way, the entire sintering process is generally completed in 25 to 35 minutes.

In the production process of sintered ore, the most important thing is to adopt a production method by which the productivity can be maximized while the quality of the sintered ore is maintained high, and the fuel consumption and the ignition fuel consumption can be minimized. Accordingly, in the actual operation of the sintering machine, it is desired that quantities of coke breeze and anthracite added to iron ore as fuel are reduced to as small an amount as possible, and also it is desired that quantities of coke oven gas and puevlrized coal are reduced to as small an amount as possible while the quality of the sintered ore is maintained high. However, when a blending proportion of fuel added to raw material to be sintered is simply decreased, or alternatively when a quantity of fuel used in the ignition furnace is simply decreased, it is impossible to provide good effects. When the quantity of fuel is greatly reduced, the quality of the sintered ore is deteriorated and the quantity of returned ore is increased. As a result, the fuel consumption and the ignition fuel consumption are deteriorated.

In order to solve the above problems, for example, Japanese Examined Patent Publication No. 54-24682 discloses the following method of producing sintered ore. In a Dwight Lloyd type sintering machine, there is provided a hot blast feeding device between an ore feeding device for feeding raw material to pallets, and an ignition furnace. A blast of hot air is blown onto an upper surface of raw material so that only the temperature of an upper layer of raw material is raised, and the upper layer of raw material, the temperature of which has been raised, is successively ignited in the ignition furnace. In this way, raw material is sintered while the thermal shock caused in the process of ignition is reduced. According to the description of the above patent publication, the following effects can be provided by this method of producing sintered ore. According to this method, while the shatter test strength is maintained to be constant, the productivity can be enhanced and the unit requirement of coke breeze can be reduced, however, the product yield is a little lowered.

According to Japanese Examined Patent Publication No. 57-45296, the following method of producing sintered ore is disclosed. In a sintering machine in which raw material is formed into layers and an upper surface of the upper layer is ignited, there is provided a hot blast feeding device between an ore feeding device and an ignition furnace. A blast of hot air is blown onto an upper surface of raw material and sucked downward, so that only an upper layer of raw material is dried and then ignited in an ignition furnace. After the ignition furnace, there is provided a hot blast feeding device, and a blast of hot air is fed from the hot blast feeding device and sucked downward so that a sintering reaction can be conducted. The following are described in the above patent publication. According to the above method, it is possible to improve various factors, which are incompatible with each other, such as an improvement of the productivity, reduction of the coke breeze consumption, improvement of the quality of sintered ore, and suppression of the generation of NO_x gas. However, when only a blast of hot air is blown onto the upper surface of raw material, it is difficult to enhance the product yield greatly.

SUMMARY OF THE INVENTION

According to the above preheating sintering method, when a thermal shock given to the surface layer of raw material in the ignition surface is reduced and the dried zone is extended, a moisture condensing zone is relatively reduced. Accordingly, a quantity of combustion air to be sucked after the ignition is increased, so that the sintering time can be reduced. Since the maximum temperature in the heat pattern of the preheated upper layer of raw material is raised higher than that of the upper layer of raw material which has not been preheated, the productivity, product yield and sintered ore quality can be enhanced, and further the fuel consumption and the ignition fuel consumption can be reduced. However, according to the above method, it is difficult to dry and heat the raw material to be sintered provided on the pallets without collapsing a portion of the pseudo particles in the blended raw material on the surface layer, the thickness of which is 5 to 50 mm. Therefore, in the process of drying and heating the surface layer of raw material, a portion of the pseudo particles are collapsed, and the nonuniformity of drying and heating is caused on the surface layer of raw material in the width direction of the pallets. Due to the above nonuniformity of drying and heating, the sintering speed fluctuates after the raw material has been ignited. As a result, it is difficult to greatly enhance the product yield, fuel consumption and ignition fuel consumption. According to the drying and heating method conducted only by sucking a hot blast downward, the space and time before the ignition furnace are limited, so that it is difficult to dry and heat the raw material to be sintered in a short period of time. Consequently, it is impossible to enhance the productivity greatly. Also, it is difficult to greatly raise the preheating temperature of raw material by sucking a hot blast. Accordingly, there is a limitation to the enhancement of the product yield. In view of the above circumstances, it is an object of the present invention to quickly dry and heat raw material to be sintered to high temperatures in a short period of time without collapsing pseudo particles on the surface layer of raw material to be sintered.

In this case, the pseudo particles are composed as follows. Raw materials of sintered ore such as iron ore, coke breeze, lime stone and so forth are previously mixing in a mixer while water is added to the mixture. Due to the foregoing, fine particles adhere onto the periphery of a core particle which is a raw material grain formed by the mixer. In this way, one pseudo particles are composed.

In the case of sintered ore, sintering is conducted when the fines, which adhere to the pseudo particles, and the core particles are melted with each other in a very short period of time. Therefore, it is important that the pseudo particles are held as they are without collapsing in the sintering process, especially in the drying zone.

As described before, the pseudo particles are made by pelletizing raw material and water, wherein a binder is added to the raw material and water when necessary. The particle diameter is increased when fines adhere to each other or alternatively fines adhere to rough grains. Raw material to be sintered, the particle diameter of which has been increased, is charged into the sintering machine so that a layer of raw material of a predetermined height can be formed. After a sintering bed has been formed in this way, sintering is conducted. However, when the pseudo particles collapse in the process of drying and heating the surface layer of raw material, clearances formed in the raw material to be sintered are filled with fines of the raw material. Therefore, a uniform flow of hot blast is blocked.

In other words, according to the method of producing sintered ore in which a hot blast is sucked, a hot blast flows smoothly in some portions and does not flow smoothly in other portions. Accordingly, the surface layer of raw material is not heated uniformly in the pallet width direction. Due to the foregoing, the sintering speed fluctuates after the ignition, so that the raw material can not be sintered uniformly, which deteriorates the product yield. Unless the pseudo particles collapse, sintering is conducted uniformly, so that the yield can be enhanced.

The present inventors made investigation in earnest into a means for drying and heating the surface layer of raw material to be sintered, in a short period of time without collapsing the pseudo particles. As a result of the investigation, they found that sintered ore of high quality can be produced at a high yield when high-frequency heating is conducted on the raw material, especially when microwaves are irradiated alone, or alternatively when microwaves and a hot blast are combined and given to the raw material to be sintered.

The reason why microwaves are used in the present invention is described as follows. It was found that the problem of collapse of pseudo particles cannot be solved as long as heating is conducted from the outside of raw material. Accordingly, from the idea of utilizing the surface layer of raw material as a heating unit, when the phenomenon of polarization, which is peculiar to microwaves, is used, it becomes possible to heat the raw material from the inside. Further, when microwaves are used, the thermal efficiency is high in principle, and it is possible to heat the raw material to be sintered in a short period of time even if the input of electric power to be given is small. Utilizing the above knowledge, the inventors succeeded in solving the above conventional problems by one effort.

The present invention is to provide a method of producing sintered ore comprising the steps of: charging raw material of sintered ore in the form of a layer; heating an upper surface of the layer of raw material to 120 to 600°C by microwaves generated by a microwave generator arranged between a raw material feeding device and an ignition furnace; igniting the upper surface of the layer of raw material in the ignition furnace; and sintering the raw material.

The present invention is also to provide a method of producing sintered ore comprising the steps of: charging raw material of sintered ore in the form of a layer; heating an upper surface of the layer of raw material to 50 to 200°C by microwaves generated by a microwave generator arranged between a raw material feeding device and an ignition furnace; heating the upper surface of the layer of raw material to 150 to 600°C by a hot blast fed by a hot blast feeding device arranged also between the raw material feeding device and the ignition furnace; igniting the upper surface of the layer or raw material in the ignition furnace; and sintering the raw material.

The present invention is also to provide a method of producing sintered ore comprising the steps of: charging raw material of sintered ore in the form of a layer; heating an upper surface of the layer of raw material to 150 to 600°C by microwaves generated by a microwave generator arranged between a raw material feeding device and an ignition furnace and simultaneously heating the upper surface of the layer of raw material to 150 to 600°C by a hot blast fed by a hot blast feeding device also arranged between the raw material feeding device and the ignition furnace; igniting the upper surface of the layer or raw material in the ignition furnace; and sintering the raw material.

According to the microwave heating method, it is possible to quickıy remove the moisture of 6 to 7 wt% contained in the blended raw material, without the collapse of the pseudo particles after pelletization. Therefore, nonuniformity of drying and heating the surface layer of raw material in the pallet width direction can be reduced. Further, it is possible to quickly preheat the blended raw material provided on the pallets to a high temperature.

According to the conventional method in which a hot blast is sucked downward, a hot blast flows smoothly in some portions and does not flow smoothly in other portions, that is, the sintering speed fluctuates. Due to the foregoing, sintering can not be conducted uniformly in the pallet width direction. However, as described before, according to the present invention, nonuniformity of sintering in the pallet width direction can be remarkably reduced. When the microwave heating is combined with the suction of a hot blast, it is possible to quickly remove the moisture which has flowed onto the surface of the iron ore. Accordingly, while the collapse of pseudo particles is perfectly prevented, the blended raw material on the surface layer on the pallets can be more quickly heated to a high temperature. As a result, the maximum temperature of the sintered ore layer after the ignition can be raised, and the nonuniformity of sintering speed in the pallet width direction can be reduced. Therefore, the following effects can be simultaneously provided by this method. The productivity is enhanced and the unit requirement of fuel is reduced, and further the generation of NO_x gas is reduced.

In this connection, the surface layer of raw material is defined as a region of the raw material layer formed in the thickness direction, wherein the thickness of the raw material layer is usually in a range from 350 to 500 mm, and the thickness of the surface layer is in a range within 1/10 of the thickness of the raw material layer. The reason why the microwave heating is conducted only on the surface layer of raw material is described as follows.

In the iron ore sintering process, a blast of air or waste gas is sucked so as to cause a sintering reaction. Accordingly, on the surface layer of raw material onto which cooling air or cooling waste gas is immediately sucked, the temperature is not sufficiently raised, that is, a sufficiently large quantity of heat is not fed. When the maximum temperature of the surface layer, the thickness of which is approximately 1/10 of the raw material layer, is raised when the surface layer is heated by microwaves, the product yield of this portion can be enhanced. Further, the heat given onto the surface layer by the microwaves in this way is successively transferred to the lower layers. Accordingly, the maximum temperature, heat level and product yield of the upper and the intermediate layer can be enhanced by this transferred heat. In this case, the lower layer is fed with a sufficiently large quantity of heat even when the conventional method is adopted. Accordingly, it is impossible to expect a high effect on the lower layer. Since the heat inputted onto the surface layer is successively transferred onto the layer located immediately below the surface layer, the microwave heating may be conducted only on the surface layer.

Concerning the wavelength of microwaves used for drying and heating the surface layer of raw material on the pallets, it is allowed to use the ISN bands of 2450 MHz and 915 MHz. Either of them may be selected. In order to ensure a necessary intensity of energy, for example, a plurality of microwave generators, The capacity of each microwave generator is 5 kW or 25 kW, may be provided, and the microwaves generated by each microwave generator are collected by a wave guide and irradiated. The optimum range of irradiation of microwaves onto the surface layer of raw material on the pallets is from 10 to 200 kW/m^2. The reason why the above optimum range of irradiation of microwaves is determined is described as follows. When the range of irradiation of microwaves is lower than 10 kW/m^2, it is impossible to provide a sufficiently high effect of heating by microwaves. When the range of irradiation of microwaves is higher than 200 kW/m^2, the effect of heating by microwaves reaches the upper limit. The optimum temperature of a hot blast blown to the raw material on the pallets is 150 to 600°C, and the blowing speed (sucking speed) of a hot blast is 0.3 to 3.0 m/sec. When the hot blast temperature is lower than 150°C, it is impossible to provide a sufficiently high effect of drying and heating. When the hot blast temperature is higher than 600°C, the effect of heating reaches the upper limit. When the hot blast blowing speed is lower than 0.3 m/sec, it is impossible to provide a sufficiently high effect of drying and heating. When the hot blast blowing speed is higher than 3.0 m/sec, the pressure of a blast of air is increased, and the raw material on the pallets contracts, which exerts a harmful influence on the sintering process.

The reason why microwaves are irradiated before a hot blast is blown onto the surface layer of raw material on the pallets is described as follows. When microwaves are irradiated onto the surface layer of raw material on the pallets, the moisture in the pseudo particles of blended raw material containing iron ore, limestone and coke breeze can be made to flow quickly onto the surfaces of pseudo particles without the collapse of the pseudo particles. Even when the microwave heating and the hot blast blowing are simultaneously conducted, the moisture in the blended raw material flows quickly by the action of microwave heating. Therefore, the collapse of pseudo particles caused by the hot blast heating can be prevented. The above method in which the microwave heating and the hot blast blowing are simultaneously conducted is very effective for preventing the collapse of pseudo particles, because the moisture flowing onto the surfaces of pseudo particles of blended raw material can be quickly evaporated.

In this connection, a method in which microwaves are irradiated after a hot blast has been blown onto the surface layer of raw material on the pallets is disadvantageous in that a portion of pseudo particles of blended raw material are collapsed in the process of heating conducted by blowing a hot blast. To explain in detail, the moisture in the pseudo particles is dried from the outside to the inside by the hot blast heating method. Therefore, when the moisture inside the pseudo particles flows onto their surfaces, a portion of raw material, which has already been dried, is collapsed by the moisture. Due to the collapse of raw material, the gas permeability of the sintering bed is deteriorated and the sintering time is extended. As a result, the productivity is lowered. However, according to the method of the present invention in which the raw material is heated by microwaves or alternatively the raw material is heated by microwaves and then heated by a hot blast, the moisture in the pseudo particles first absorbs the microwaves and heats up. Then the thus heated moisture first flows onto the surfaces of pseudo particles. Accordingly, the surfaces of pseudo particles are wet. These wet surfaces of pseudo particles are not collapsed. When the pseudo particles are heated by blowing a hot blast after the moisture in the pseudo particles has already been dried by the microwave heating, the pseudo particles are not collapsed because no moisture evaporates in the process of blowing a hot blast.

The reason why the surface layer of the raw material located between the raw material charging device and the ignition furnace is heated by microwaves to temperatures of 120 to 600°C is described as follows. In order to perfectly dry the blended raw material, it is necessary to heat it to temperatures of not less than 120°C. when the heating temperature exceeds 600°C, a portion of the blended raw material is overheated, so that the pseudo particles of the blended raw material start collapsing, and the gas permeability is deteriorated in the process of sintering.

In the case where both microwaves and a hot blast are successively used, the raw material is first heated by the microwaves to temperatures of 50 to 200°C and then heated by the hot blast to temperatures of 150 to 600°C. When heating is conducted by the microwaves, it is possible to heat the raw material quickly. On the other hand, when the raw material is heated by microwaves to temperature higher than 200°C, it is necessary to increase an amount of energy to be inputted. When the surface layer of raw material is heated by a hot blast after that, since the temperature rising speed is not so high, the pseudo particles from which the moisture has already been evaporated do not collapse, and it is possible to heat the pseudo particles to temperatures of 150 to 600°C by inputting a smaller amount of energy. The reason why the heating temperature of a hot blast is determined to be 150 to 600°C is described as follows. When the heating temperature is lower than 150°C, it is impossible to provide a sufficiently high effect corresponding to the inputted energy. When the heating temperature is higher than 600°C, the effect of heating reaches the upper limit.

The reason why the surface layer of raw material located between the raw material charging device and the ignition furnace is heated to temperatures of 150 to 600°C by both microwaves and a hot blast is that the drying and heating time can be further reduced when both microwaves and a hot blast are simultaneously used. When the surface layer of raw material is heated to temperatures not less than 150°C, the effect of combination of microwave heating with hot blast blowing is remarkably increased. However, when the surface layer of raw material is heated to temperatures lower than 150°C, the effect of combination of microwave heating with hot blast blowing is not so high. On the other hand, when the temperature of the surface layer of raw material exceeds 600°C, a portion of the blended raw material is overheated by the microwaves, so that the pseudo particles of the blended raw material start collapsing.

In any case, it is most preferable to heat the surface layer of raw material to temperatures from 200 to 450°C. Since the blended raw material is ignited after the surface layer of raw material has been uniformly heated, it is possible for the combustion zone to spread from the upper layer to the lower layer uniformly with respect to the width direction of the raw material layer. Accordingly, the quality of sintered ore can be enhanced.

Next, referring to the accompanying drawings, an example of the sintering machine to execute the present invention and its operation method will be explained below.

Fig. 1 is an arrangement view of a sintering machine illustrating its general construction in accordance with the present invention. Blended raw material 1 to be sintered is continuously fed from the surge hopper 2 onto the pallets 6 via the drum feeder 3 and raw material charging device 5. The thus fed raw material 1 is laminated on the pallets 6. While the raw material is fed in this way, the sprocket 4 arranged on the raw material feeding side is rotated so that the pallets 6 are moved at a predetermined speed. At the same time, on the lower side of the pallets 6, waste gas is sucked by the suction blower 13 via a plurality of wind boxes 8, the main duct 9 and the dust collector 12. In the ignition furnace 14, an upper surface of the raw material layer 7 is ignited, and operation is continuously conducted while the pallet speed is controlled so that the entire raw material layer 7 on the pallets 6 can be completely sintered before it reaches the ore discharging section.

Between the raw material charging device 5 and the ignition furnace 14 of the above Dwight Lloyd type sintering machine, there is provided a microwave generator 15, or alternatively there are provided a microwave generator 15 and a hot blast feeding device 16. In the case of microwave heating, the raw material layer 7 on the pallets 6 is heated in accordance with an amount of energy of the irradiated microwaves and the irradiation time. Into this hot blast feeding device 16, it is possible to introduce a hot blast discharged from the discharge pipe 18 of the cooling unit 17 composing a portion of the sintering process. Also, into this hot blast feeding device 16, it is possible to introduce a hot blast of gas at not lower than 100°C which has been discharged from the wind boxes 8 and passed through the waste gas introducing pipe 10, flow rate adjusting valve 11, waste gas dust collector 12' and suction blower 13'. Both the hot blast discharged from the cooling unit 17 and the waste gas of not lower than 100°C discharged from the wind boxes may be simultaneously fed to the hot blast feeding device 16. However, it is possible to feed one of than alone. It is also possible to feed the mixture of them, the temperature of which is adjusted to a predetermined value.

Concerning the state in which the microwave irradiation and the hot blast blowing are combined with each other, the following states may be adopted. It is possible to arrange the microwave generator 15 alone. It is also possible to arrange the microwave generator 15 and the hot blast feeding device 16 in series. Although not shown in the drawing, it is possible to arrange the microwave generator in the first half of the hot blast feeding device 16, or it is also possible to arrange the microwave generators at regular intervals in the longitudinal direction of the pallets 6. Concerning the temperature control method for heating the raw material layer 7 on the pallets 6 by the irradiation of microwaves, it is possible to adopt a method in which an amount of energy of irradiated microwaves is adjusted, and also it is possible to adopt a method in which an area of irradiation of microwaves onto the raw material layer moving at a predetermined speed is adjusted. This method may be adopted alone or combined with another method.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an arrangement view of an example of the equipment to execute the method of the present invention.

Fig. 2a is a graph on which the productivity, sintering time and product yield of examples and comparative examples are shown. Fig. 2b is a graph showing the shatter strength (SI), low temperature reduction degradation index (RDI) and consumption of generation of NO_x.

MOST PREFERRED EMBODIMENT

Referring to an example, the most preferred embodiment of the present invention will be explained below.

EXAMPLES

A specific example will be explained in detail in accordance with the above exemplary equipment and the operation method.

Table 1 shows a blending proportion of raw materials used in this example. Raw materials were blended in such a manner that various iron ores and miscellaneous raw materials such as limestone, quick lime, serpentine, scale and so forth were adjusted and blended so that SiO_2 and Al_2O_3 in the sintered ore could be respectively 5.8% and 1.8% and so that the basicity could be 1.7. In this case, a ratio of returned ore was determined to be a constant value of 15% with respect to new raw material. A coke breeze blending ratio was determined to be a constant value of 4.0% with respect to the total 100 of new raw materials.

Table 1

Brand of raw material	Blending proportion (%)
Newman fine ore	10.0
Roberiver fine ore	25.0
Yandicoogina fine ore	10.0
Rio-Dose SSF powder ore	5.0
Carol fine ore	10.0
Yampi fine ore	12.5
Iscole undersized ore	6.0
Scale	5.0
Serpentine fine	2.5
Limestone fine	12.0
Quick lime	2.0
Total of new raw materials	100.0
Returned ore (outer number)	15.0
Coke breeze (outer number)	4.0

Returned ore and coke breeze were blended with the above blended raw material, and then addition water of 6 to 7 wt% was added to the blended raw material and mixed by a mixer and pelletized. After that, it was put into a test pan, and the layer thickness was set at 500 mm and the negative pressure was set at a constant value of 1200 mmAq. Concerning the heating conducted by microwaves or the heating conducted by both microwaves and a hot blast, a simulating method was adopted in which the surface layer of raw material was dried and heated before the ignition in the Dwight Lloyd type sintering machine. In Example 1, the ignition time was set at 1.5 min. Before the ignition, microwaves, the intensity of which was 10 kW, were irradiated for 1.0 min, so that the surface layer of raw material was heated to

150°C before the ignition. In Example 2, microwaves, the intensity of which was 10 kW, were irradiated for 1.0 min before the ignition, so that the surface layer of raw material was heated to 150°C. After that, a hot blast of 300°C was sucked for 1.0 min, so that the surface layer of raw material was heated to 350°C before the ignition, and then the surface layer of raw material was ignited for 1.5 min. In Example 3, before the ignition, microwaves, the intensity of which was 10 kW, were irradiated for 1.0 min, and a hot blast of 300°C was simultaneously sucked for 1.0 min, so that the surface layer of the raw material was heated to 380°C and then ignited for 1.5 min. It should be noted that the temperature of a hot blast, the sucking time of a hot blast and the heating time of microwaves are not limited to the above specific values. It was more effective that the heating time of microwaves was 0.2 to 1.5 min. Also, it was more effective that a hot blast of 200 to 400°C was sucked for 0.5 to 3 min.

Comparative Example 1 was a conventional method in which drying and heating is not conducted before the ignition. Comparative Example 2 was a method in which a hot blast of 300°C was sucked for 1.0 min before ignition, and then microwaves, the intensity of which was 10 kW, were irradiated for 1.0 min so as to heat the surface layer of raw material.

In Comparative Example 2, with respect to Examples 1, 2 and 3, sampling was conducted on the raw material on the surface layer of raw material before the ignition which had already been dried and heated, and particles, the size of which was not more than 0.5 mm, were sifted out. The weight of thus sifted particles was measured and the ratio was computed. In Comparative Example 2, the ratio of particles, the size of which was not more than 0.5 mm, was 8.0 to 9.0%. However, in Examples 1, 2 and 3, the ratio of particles, the size of which was not more than 0.5 mm, was not more than 1.0 %.

Fig. 2a is a graph showing the productivity, sintering time and product yield obtained in the pan tests conducted in Examples 1, 2 and 3 and Comparative Examples 1 and 2. Fig. 2b is a graph showing the shatter strength (SI), low temperature reduction degradation index (RDI) and consumption of NO_x obtained in Examples 1, 2 and 3 and Comparative Examples 1 and 2.

As can be seen in Fig. 2a, the product yield in Examples 1, 2 and 3 of the present invention is higher than that in Comparative Examples 1 and 2 by 2 to 3%, and the sintering time including the heating time before the ignition in Examples 1, 2 and 3 of the present invention is shorter than that in Comparative Examples 1 and 2 by 1 to 3 minutes. Further, the productivity in Examples 1, 2 and 3 of the present invention is higher than that in Comparative Examples 1 and 2 by 0.1 to 0.25 $T/H/m^2$. As can be seen in Fig. 2b, the shatter strength (SI) in Examples 1, 2 and 3 of the present invention is higher than that in Comparative Examples 1 and 2 by 1 to 1.5%, and the low temperature reduction degadation indexes (RDI) in Examples 1, 2 and 3 of the present invention are higher than those in Comparative Examples 1 and 2 by 1 to 3%. Furthermore, it can be understood that the NO_x discharge consumption is improved by 0.02 to 0.06 Nm^3/t-s. As described above, according to the present invention, it is possible to remarkably enhance the product characteristic, and when the technique of the present invention is executed, it is possible to provide excellent effects in the fields of operation efficiency and environment protection.

The reason why an amount of NO_x to be discharged can be reduced is that NO_x generated in the sintering process is mainly composed of Fuel NO_x, and the generation of NO_x is suppressed when the temperature is raised, which is contrary to the phenomenon of Thermal NO_x. It is considered that the generation of NO_x can be reduced since the maximum temperatures of the upper and the intermediate sintering layer, which are layers from which a large amount of NO_x is generated, are raised according to the method of the present invention.

INDUSTRIAL APPLICABILITY

According to the method of the present invention, the following effects can be provided. The product yield can be greatly enhanced as compared with the method of the prior art. The productivity can be also enhanced, and SI and RDI can be improved. As a result, the consumption of an amount of NO_x to be discharged can be greatly reduced. It is possible to change the combination of electric power of microwaves, heating time, hot blast temperature and hot blast suction time in accordance with the instruction of operation. The above degree of freedom is one of the advantages of the method of the present invention. As described above, according to the present invention, it is possible to simultaneously provide effects which are not compatible with each other. Therefore, the present invention can provide great effects.

DESCRIPTION OF REFERENCE NUMERALS

1 Blended raw material to be sintered
2 Surge hopper
3 Drum feeder
4 Sprocket
5 Raw material charging device
6 Pallet
7 Laminated raw material

8	Wind box
9	Main duct
10	Waste gas introducing pipe
11	Flow rate adjusting valve
12	Waste gas dust collector
12'	Waste gas dust collector
13	Suction blower
13'	Suction blower
14	Ignition furnace
15	Microwave generator
16	Hot blast feeding device
17	Cooler
18	Waste gas pipe

Claims

1. A method of producing sintered ore comprising the steps of: charging raw material of sintered ore in the form of a layer; heating an upper surface of the layer of raw material to 120 to 600°C by microwaves generated by a microwave generator arranged between a raw material feeding device and an ignition furnace; igniting the upper surface of the layer of raw material in the ignition furnace; and sintering the raw material.

2. A method of producing sintered ore comprising the steps of: charging raw material of sintered ore in the form of a layer; heating an upper surface of the layer of raw material to 50 to 200°C by microwaves generated by a microwave generator arranged between a raw material feeding device and an ignition furnace; heating the upper surface of the layer of raw material to 150 to 600°C by a hot blast fed by a hot blast feeding device also arranged between the raw material feeding device and the ignition furnace; igniting the upper surface of the layer or raw material in the ignition furnace; and sintering the raw material.

3. A method of producing sintered ore comprising the steps of: charging raw material of sintered ore in the form of a layer; heating an upper surface of the layer of raw material to 150 to 600°C by microwaves generated by a microwave generator arranged between a raw material feeding device and an ignition furnace and simultaneously heating the upper surface of the layer of raw material to 150 to 600°C by a hot blast fed by a hot blast feeding device also arranged between the raw material feeding device and the ignition furnace; igniting the upper surface of the layer or raw material in the ignition furnace; and sintering the raw material.

Fig.1

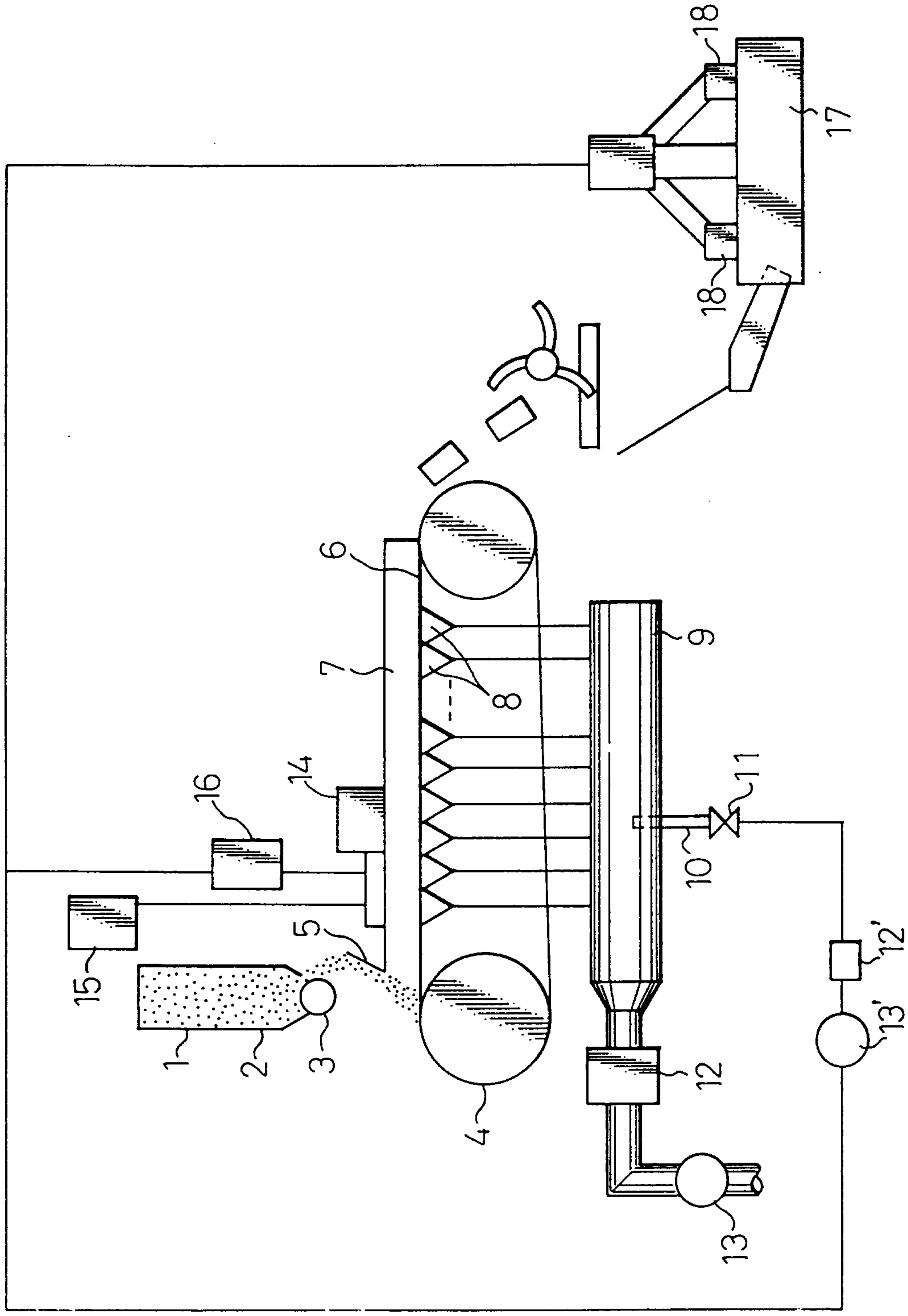


Fig.2a

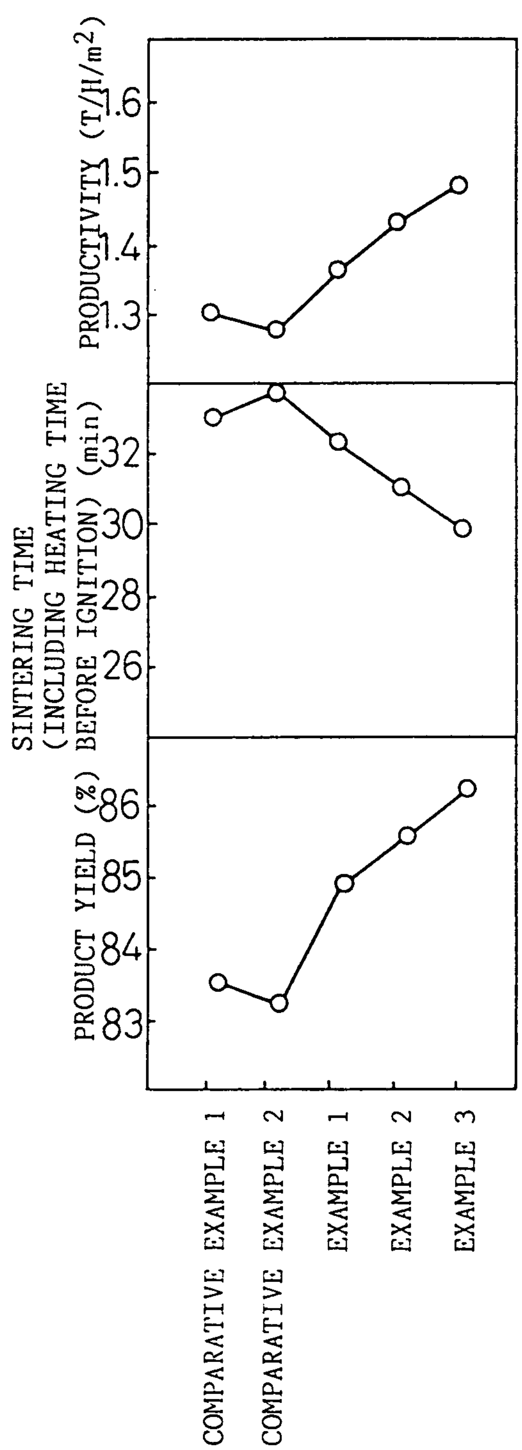
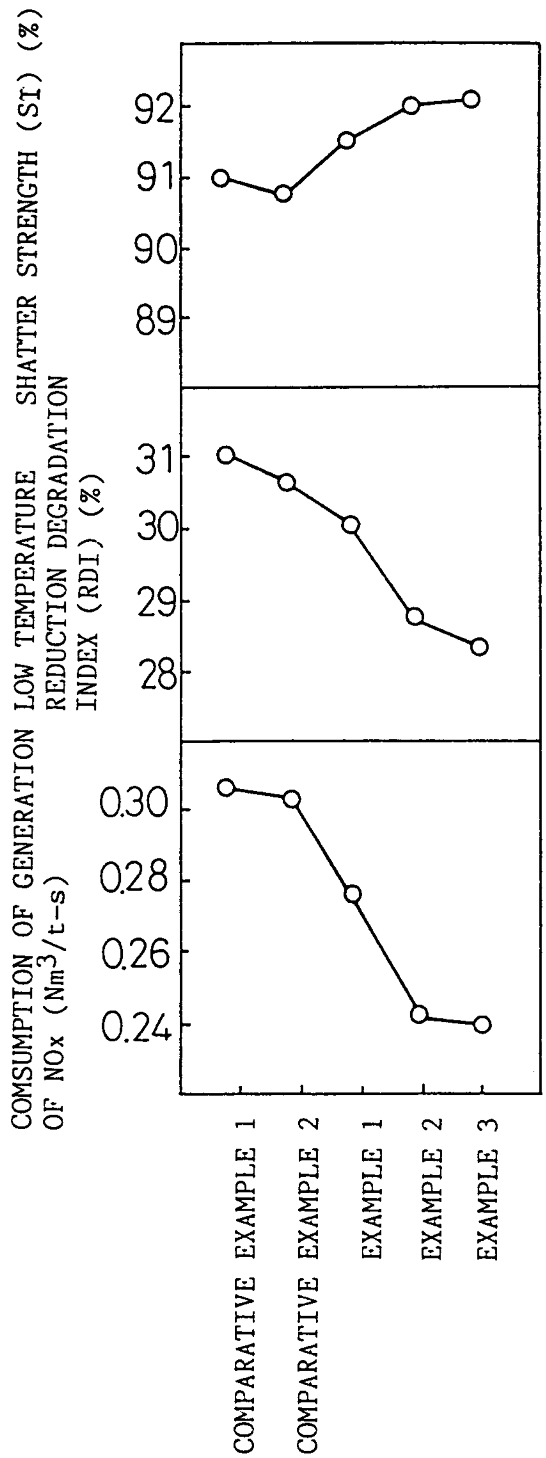

PRODUCTIVITY (T/H/m²)
1.3
1.4
1.5
1.6
SINTERING TIME (INCLUDING HEATING TIME BEFORE IGNITION) (min)
26
28
30
32
PRODUCT YIELD (%)
83
84
85
86
COMPARATIVE EXAMPLE 1
COMPARATIVE EXAMPLE 2
EXAMPLE 1
EXAMPLE 2
EXAMPLE 3

Fig.2b


SHATTER STRENGTH (SI) (%)
89
90
91
92
LOW TEMPERATURE REDUCTION DEGRADATION INDEX (RDI) (%)
28
29
30
31
COMSUMPTION OF GENERATION OF NOx (Nm³/t-s)
0.24
0.26
0.28
0.30
COMPARATIVE EXAMPLE 1
COMPARATIVE EXAMPLE 2
EXAMPLE 1
EXAMPLE 2
EXAMPLE 3

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP95/01301

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl^6 C22B1/20, F27B21/08

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^6 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 1971 - 1994
Kokai Jitsuyo Shinan Koho 1971 - 1994

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.
Y	JP, 54-24682, B2 (Nippon Steel Corp.), August 23, 1979 (23. 08. 79) & US, 4012011	1
Y	JP, 61-91798, U (Nippon Steel Corp.), June 14, 1986 (14. 06. 86) (Family: none)	1
P	JP, 6-212293, A (Nippon Steel Corp.), August 2, 1994 (02. 08. 94) (Family: none)	1 - 3

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

* Special categories of cited documents:
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"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
September 14, 1995 (14. 09. 95)	October 3, 1995 (03. 10. 95)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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